CENTRAL WELLAND RIVER WATERSHED PLAN

NOVEMBER 2010

NIAGARA PENINSULA CONSERVATION AUTHORITY
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Executive Summary

The Central Welland River watershed is a unique watershed for many reasons. The rich history of the Welland Canal has influenced and shaped the cultural and economic history of the area. The patterns of land use in the region are a result of the early construction of the Welland Canal and the strategic location of settlements and industries that took advantage of the accessibility to markets flourished throughout the last century and a half.

Aside from being rich in cultural history, the Central Welland River watershed study area is also rich in ecological diversity with 3 unique and provincially significant Areas of Natural and Scientific Interest such as the Wainfleet Bog and the Fonthill Kame-Delta Complex, as well as an additional 5 more regionally significant ANSI's. The study area also boasts 27 listed Species at Risk by the *Committee on the Status of Endangered Wildlife in Canada*, including the eastern massasauga rattlesnake which is the only venomous snake in Ontario. In addition, 17 provincially rare species, numerous provincially significant wetlands and natural areas can be found throughout the watershed.

The study area extends within the boundaries of the Township of West Lincoln, Town of Pelham, City of Welland and small portions of the Township of Wainfleet and City of Port Colborne. Numerous subwatersheds form the Central Welland River watershed including Beaver Creek, Black Ash Creek, Parkers Creek, Unnamed Creek, Sucker Creek, Coyle Creek, Drapers Creek, Little Forks Creek, Lyons Creek Drain, Indian Creek Drain, Biederman Drain #1 and Biederman Drain #2, as well as Welland River Between Canals, Welland Canal and a portion of Welland Canal North (Figure 1). Individual restoration strategies have been prepared for each of the main subwatersheds to protect the unique characteristics of each system.

Land use in the Central Welland River watershed is characterized mainly by agriculture with a focus on poultry and egg production, and grain and oilseed. Major concentrations of urban land uses (residential, commercial, industrial) are within the City of Port Colborne and the City of Welland with smaller residential areas in Fenwick and Fonthill of Pelham.

The Central Welland River study area offers numerous recreational opportunities throughout the watershed. There are 5 golf courses in the study area: Riverview Golf and Country Club, and Pelham Hills Golf and Country Club in the Town of Pelham; Lockness Links, The Water Park Golf and Country Club, and Sparrow Lakes Golf Course all of which are located in the City of Welland. Hiking and biking trails can be enjoyed throughout the area, including portions of the Welland Canal Trail, Regional Bicycle Network, Greater Niagara Circle Route and Scenic Bike Loops, and the Thorold-Welland Loop. In addition, there are four conservation areas in the Central Welland River watershed that offer passive recreational opportunities; Port Robinson Conservation Area, E.C Brown Conservation Area, Wainfleet Bog Conservation Area and Mud Lake Conservation Area. The latter two offer seasonal hunting with proper licensing and permits.

Upland forest covers 15 percent of the watershed, wetlands another 10 percent and approximately 43 percent of the watercourses have some riparian habitat. Guidelines set

by Environment Canada (2004) suggest minimum upland forest cover in a watershed should be 30 percent, wetlands 10 percent or to historic value, and at least 75 percent of the watercourses in the watershed should have riparian habitat with a 30 meter buffer on both sides being ideal. Therefore, measures to create new upland areas and establish riparian habitat, as well as protect existing upland and wetland areas should be implemented to ensure adequate upland, wetland and riparian habitat to sustain minimum viable wildlife populations and maintain ecosystem functions and attributes.

As mentioned, 27 *Species at Risk* as designated by the *Committee on the Status of Endangered Wildlife in Canada* fall within the study area boundaries. Six of these species are *endangered*, meaning that they are facing imminent extinction or extirpation in Canada; 11 of these species are *threatened* species, which means they are at risk of becoming endangered; and 10 of the species are of *special concern* which simply means that they have characteristics that make them sensitive to human activities or natural events. In addition, there are 17 provincially rare flora and fauna found within the Central Welland River watershed.

The unique environmental character of the subwatersheds has resulted in an assortment of issues related to water resources, fish and aquatic habitat, natural heritage resources, urban development, and communication. The watershed issues, which were derived from extensive public input and past studies, were used to form a set of watershed objectives that guided the development of subwatershed restoration strategies and an implementation plan.

The recommended management actions outlined include riparian, wetland and upland restoration and creation to enhance water quality, fish habitat, and wildlife habitat enhancement. The sites were derived from detailed restoration suitability mapping in conjunction with Regional Niagara's Core Natural Heritage Mapping and Carolinian Cores „Big Picture' mapping. In addition, project opportunities were identified on private and public lands, such as erosion control, and shading to reduce water temperatures in the headwaters through the NPCA Geomorphic Assessment.

The recommended management actions also propose 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 the Central Welland River Watershed study area.

The implementation plan identifies responsible stakeholders for each recommended management action as well as a detailed breakdown of each watershed plan objective, recommended action and associated funding (existing and required) and time frame of implementation (e.g. long term, short term) has also been provided.

Acknowledgments

The Niagara Peninsula Conservation Authority would like to extend our sincere gratification to everyone that had an active role in the creation of the Central Welland River Watershed Plan.

To the members of the public that attended the public open houses and workshops; your participation in these events and your input to the Watershed Plan has assisted the Conservation Authority in gaining a more intimate understanding of the study area and helped us to identify issues that we may not have been previously aware of.

A special thank-you also goes to the members of the Central Welland River Steering Committee for your commitment and dedication to the creation of the Central Welland River Watershed Plan. Your hard work and dedication to the project has resulted in the creation of a valuable and useful tool to be used as a resource for watershed managers and stakeholders that will aid in future planning decisions.

The Conservation Authority believes that stakeholder involvement in projects such as these are extremely important and we want you to know that the time you committed to the project is greatly appreciated.

Sincerely,

Tara Metzger
Watershed Planning Specialist

Central Welland River Steering Committee

Tara Metzger: Niagara Peninsula Conservation Authority; Watershed Planning Specialist
Suzanne McInnes: Niagara Peninsula Conservation Authority; Watershed Planning Coordinator
Brian Baty: Chair of the Steering Committee and Regional Councillor
Adam Huycke: Township of West Lincoln; Planning Technician
Henri Bennemeer: City of Port Colborne; Drainage Superintendent (current)
Rene Landry: City of Port Colborne; Drainage Superintendent (retired)
Valerie Cromie: Niagara River Remedial Action Plan Coordinator
Mike Dickman: Welland River Keepers
Tony Whelan: Welland River Keepers
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Cory Burant: Niagara Restoration Council
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Harold Kelly: Township of Wainfleet; Drainage Superintendent

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Introduction

The Regional Municipality of Niagara (RMN), Niagara Peninsula Conservation Authority (NPCA) and the Ministry of the Environment (MOE) formed a partnership to develop the foundation of a comprehensive water protection strategy for Niagara's watersheds. The result of this partnership was the *Niagara Water Quality Protection Strategy* (RMN 2003a), now known as the *Niagara Water Strategy* (*NWS*) (2006a). The *NWS* is a multi-jurisdictional strategy based on 32 Local Management Areas (LMAs) with the intent of guiding respective stakeholders on best management and protection strategies for Niagara's water-dependant resources. The strategy has identified the need to manage Niagara's watersheds in such a manner as to "*sustain healthy rural and urban communities in harmony with a natural environment, and rich in species diversity*". In 2005, the Regional Council of Niagara adopted new environmental policies for the Niagara planning area. These policies call for an integrated ecosystem approach to planning that includes the involvement of all respective stakeholders. An aspect of the framework for the environmental planning process under these policies is the preparation of watershed studies for Niagara's major watersheds.

Watershed Planning and the Central Welland River 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., Beaver Creek, Drapers Creek and Black Ash 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 (Ontario Ministry of Environment and Energy and Ontario Ministry of Natural Resources 1993). The Central Welland River 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.

Completed over a 36 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 *NWS* (RMN 2006a), and public events. Issues specific to agriculture were gathered through the *Land Management*

Issues and Agricultural Best Management Practices survey (NPCA 2006) (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.

The Central Welland River watershed is a unique watershed for many reasons. The rich history of the Welland Canal has influenced and shaped the cultural and economic history of the area. The patterns of land use in the region are a result of the early construction of the Welland Canal. The strategic location of settlements and industries that took advantage of the accessibility to markets flourished throughout the last century and a half.

Aside from being rich in cultural history, the Central Welland River watershed study area is also rich in ecological diversity with 3 unique and provincially significant Areas of Natural and Scientific Interest (ANSI) such as the Wainfleet Bog and the Fonthill Kame-Delta Complex, as well as an additional 5 more regionally significant ANSI's. The study area also boasts 29 listed Species at Risk by the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC), including the eastern massasauga rattlesnake which is the only venomous snake in Ontario. In addition, 17 provincially rare species, numerous provincially significant wetlands and natural areas can be found throughout the watershed.

A watershed management plan for the Central Welland River watershed will aid in protecting and enhancing these distinctive resources in the watershed.

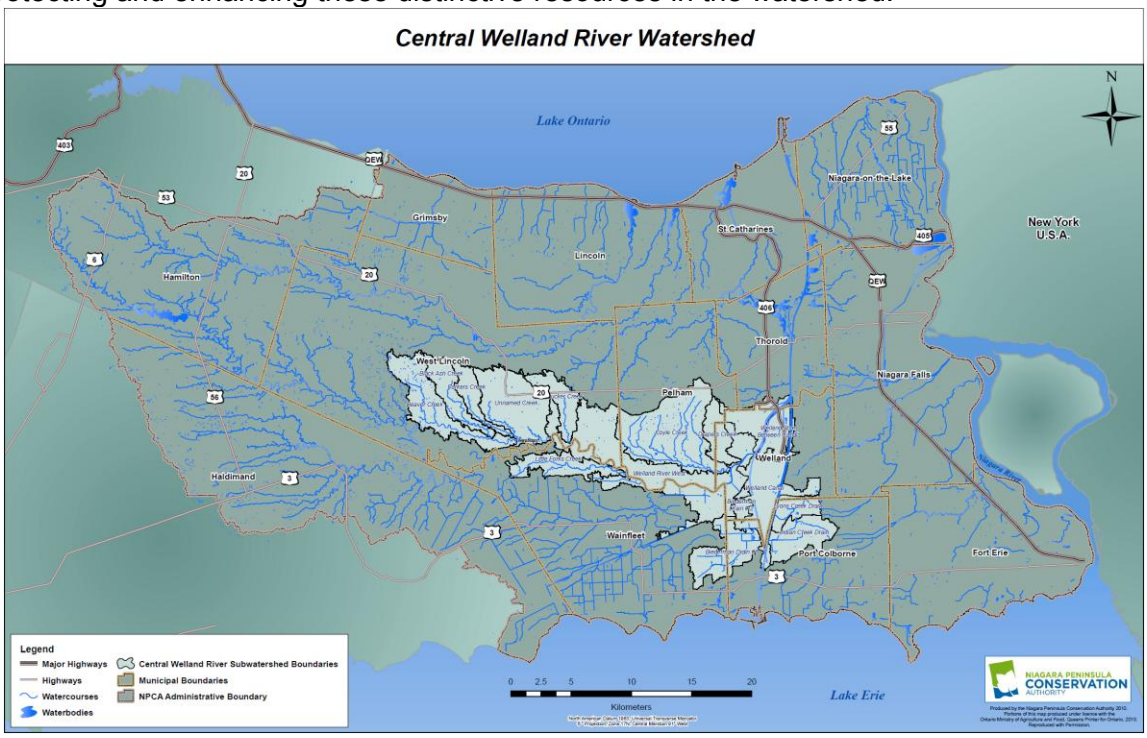


Figure 1: Geographic Location

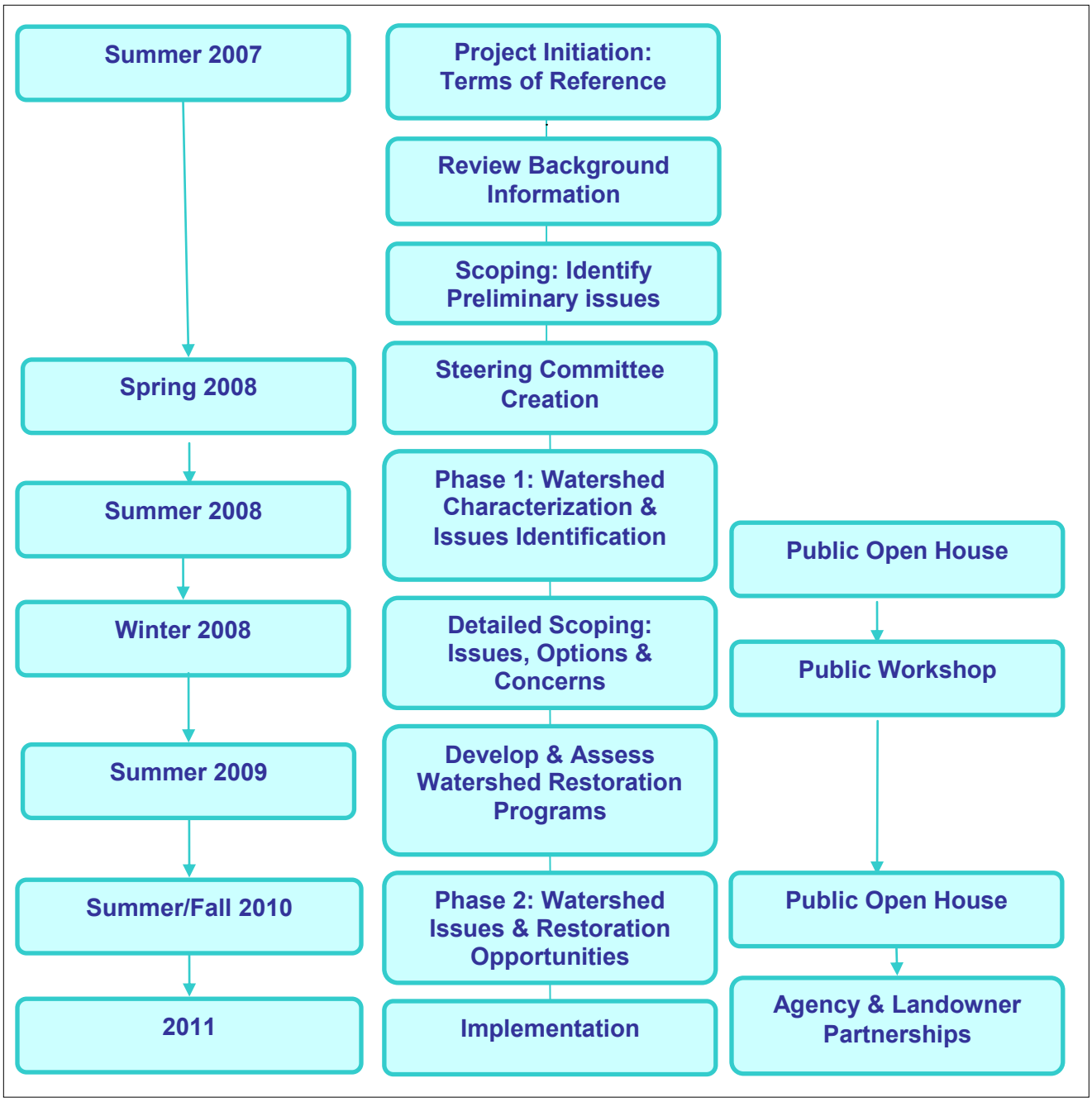


Figure 2: Watershed Planning Framework

Watershed Vision

Under the Conservation Authorities Act (R.S.O. 1990, c.C27), the mandate of the Niagara Peninsula Conservation Authority 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, *NWS* (RMN 2006a), and the watershed challenges and issues, residents of the Central Welland River watershed envision the following:

The Central Welland River watershed will support a balanced ecosystem with healthy watercourses, agricultural lands and natural areas while sustaining the needs of the community and providing habitat for a diversity of flora and fauna. The Central Welland River watershed will also support healthy communities with strong and sustainable economies that respect the natural environment and the cultural and traditional values of the communities served.

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 Central Welland River 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 (MMAH) 2005a], *Growth Plan for the Greater Golden Horseshoe* [Ontario Ministry of Public Infrastructure Renewal (MPIR) 2006], *Regional Policy Plan* (RMN 2007a) and public input, natural resources will be managed on a watershed scale in the Central Welland River watershed to:

Water Resources

- improve, enhance, maintain or protect water quality and/or natural stream processes to support human uses, agricultural needs and ecological functions in accordance with Provincial Water Quality Objectives;
- protect, improve or restore hydrologically sensitive areas (surface and groundwater features);
- ensure that storm water management practices minimize storm water volumes and contaminant loads;
- Manage and mitigate flooding risks to human life and property within acceptable limits;
- recognize the role of natural features and pervious features in minimizing the impacts of flooding; and
- find an ecologically compatible balance between drain maintenance and function

Fish and Aquatic Habitat

- protect, enhance and restore populations of native species and their habitats in the watershed; and
- eliminate barriers to fish migration

Natural Heritage and Resources

- protect, enhance and restore the health, diversity and integrity of the natural heritage systems in the watershed;
- create, maintain, protect, and enhance corridors and 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;
- restore and protect habitat for all species; and
- reach goals set by Environment Canada's recommended habitat targets (riparian, wetland and upland features)

Communication, Education and Recreation

- foster educational programs and awareness pertaining to urban and rural best management practices (e.g. water conservation practices, alternate farming practices, septic maintenance, buffers, value of local resources);
- inform public of current incentive programs; and
- enhance and develop partnerships between and amongst agencies, interest groups and landowners

Development

- Incorporate best management practices into land use and zoning decisions (e.g. buffers);
- Investigate and utilize incentive programs/packages for brownfield development;
- promote environmentally-sound land use decisions for current and future urban development and rural/agricultural land use;
- encourage stormwater management within municipalities to address existing development and future growth capacity projections; and
- encourage intensification of urban areas

Watershed Characterization

Location and General Description of the Central Welland River Watershed

The study area extends within the boundaries of the Township of West Lincoln, Town of Pelham, City of Welland and small portions of the Township of Wainfleet and City of Port Colborne. Numerous subwatersheds form the Central Welland River watershed including Beaver Creek, Black Ash Creek, Parkers Creek, Unnamed Creek, Sucker Creek, Coyle Creek, Drapers Creek, Little Forks Creek, Lyons Creek Drain, Indian Creek Drain, Biederman Drain #1 and Biederman Drain #2, as well as Welland River Between Canals, Welland Canal and a portion of Welland Canal North (Figure 1). The major concentration of urban land uses (residential, commercial, industrial) in the study area is within the City of Welland and a small portion within the City of Port Colborne; smaller residential areas of Fenwick and Fonthill in Pelham also fall within the study area.

The Central Welland River watershed includes Local Management Areas (LMA's) 2.6, 2.10, 2.12 and a large portion of 2.7 as identified in the *NWS* (RMN 2006a) (Figure 3). The *NWS* Land Management Areas provide a functional spatial unit based on subwatershed boundaries. The Watershed Planning Areas were subsequently created based on groupings of LMA boundaries resulting in larger geographic study areas.

Local Management Area 2.6

Local Management Area 2.6 covers the north-western portion of the Central Welland River watershed study area and encompasses the subwatersheds of Beaver Creek, Black Ash Creek, Parkers Creek, Unnamed Creek and Sucker Creek. The lower reaches of Beaver Creek, Parkers Creek, Unnamed Creek and Sucker Creek have been classified as critical fish habitat; the remainder of the watercourses in this portion of the study area have been classified as important fish habitat. A large portion of the main channel of Black Ash Creek has been designated as a municipal drain.

The topography in the area is relatively flat with a gentle slope towards the Welland River. Land use is characterized primarily by agriculture with a focus on poultry and egg, dairy, cattle, and grain and oilseed (RMN 2003b).

Natural heritage features in LMA 2.6 include provincially significant Life Science ANSI South St Anns Slough Forest and 2 regional Life Science ANSIs; West Bismark Slough Forest and North Bismark Slough Forest. In addition, numerous significant remnant wooded areas and provincially significant wetland complexes are scattered throughout the study area.

Local Management Area 2.7

A large portion of Local Management Area 2.7 falls within the Central Welland River watershed study area. Subwatersheds included in this portion are as follows: Little Forks Creek, Welland River West, Drapers Creek, Tow Path Drain, Welland River between Canals, and Biederman Drain #1 and #2. The lower reaches of Little Forks Creek and Drapers Creek, as well as the Welland River have been classified as critical fish habitat; the remainder of the watercourses in this portion of the study area have been classified as important fish habitat, aside from Biederman #1 and a small tributary of Welland River between Canals which have both been classified as marginal fish habitat. The main channels of Little Forks Creek and Biederman Drain #1 are both designated municipal drains. In addition, numerous tributaries throughout this portion of the study area are designated municipal drains.

The topography of the area is relatively flat throughout the Welland River floodplain and the southern portion that extends into the lowlands north of the Onondaga Escarpment. The northern section of LMA 2.7 encompasses the south-eastern slopes of the Fonthill Kame-Delta Complex adding texture to the topography of the area. Land use is a mix of

residential, commercial and industrial with agriculture on the outskirts of the built-up areas.

Natural heritage features in LMA 2.7 include the Wainfleet Bog Life Science ANSI and the Onondaga Escarpment regional Earth Science ANSI. Numerous provincially significant wetlands are present throughout the study area including the Welland River West Provincially Significant Wetland (PSW). In addition, 3 conservation areas, several remnant wooded areas, locally significant wetlands, and numerous other natural heritage areas are present in LMA 2.7.

Local Management Area 2.10

Local Management Area 2.10 contains only one subwatershed; Coyle Creek. The lower reaches of Coyle Creek have been classified as critical fish habitat; the remaining watercourses in this subwatershed are classified as important fish habitat. The majority of the main channel is a designated municipal drain as well as several of its larger tributaries.

The topography of the upper portion of the subwatershed consists of the steep slopes of the Fonthill Kame-Delta Complex that are drained by the headwaters of Coyle Creek. The remainder of the subwatershed is relatively flat with a gentle slope towards the Welland River. Land use is characterized by a mix of urban and agriculture. Urban areas in LMA 2.10 include portions of Fenwick, Fonthill and Welland. Agriculture includes grain and oilseed production, specialty crops and some greenhouse production (RMN 2003b). This portion of the study area also includes a small portion of an active quarry; the remainder of this operation extends outside of the study area boundary.

Natural heritage features in LMA 2.10 include a portion of the Fonthill-Kame Delta Complex Earth Science ANSI and Ridgeville Swamp regional Life Science ANSI. In addition, several wetland complexes and wooded areas are present in the subwatershed.

Local Management Area 2.12

The remainder of the Central Welland River subwatershed study area is located in Local Management Area 2.12. This portion of the study area includes Indian Creek Drain, Lyons Creek Drain and Welland Canal subwatersheds. The main channels of Lyons Creek Drain and Indian Creek Drain are designated municipal drains and classified as important fish habitat, and the Welland Canal has been classified as marginal fish habitat.

The topography of LMA 2.12 is relatively flat apart from the southern cusp of Indian Creek Drain which includes a portion of the Onondaga Escarpment. The Welland Canal and the Welland Canal bypass dissect this portion of the study area; cutting through in a north-south

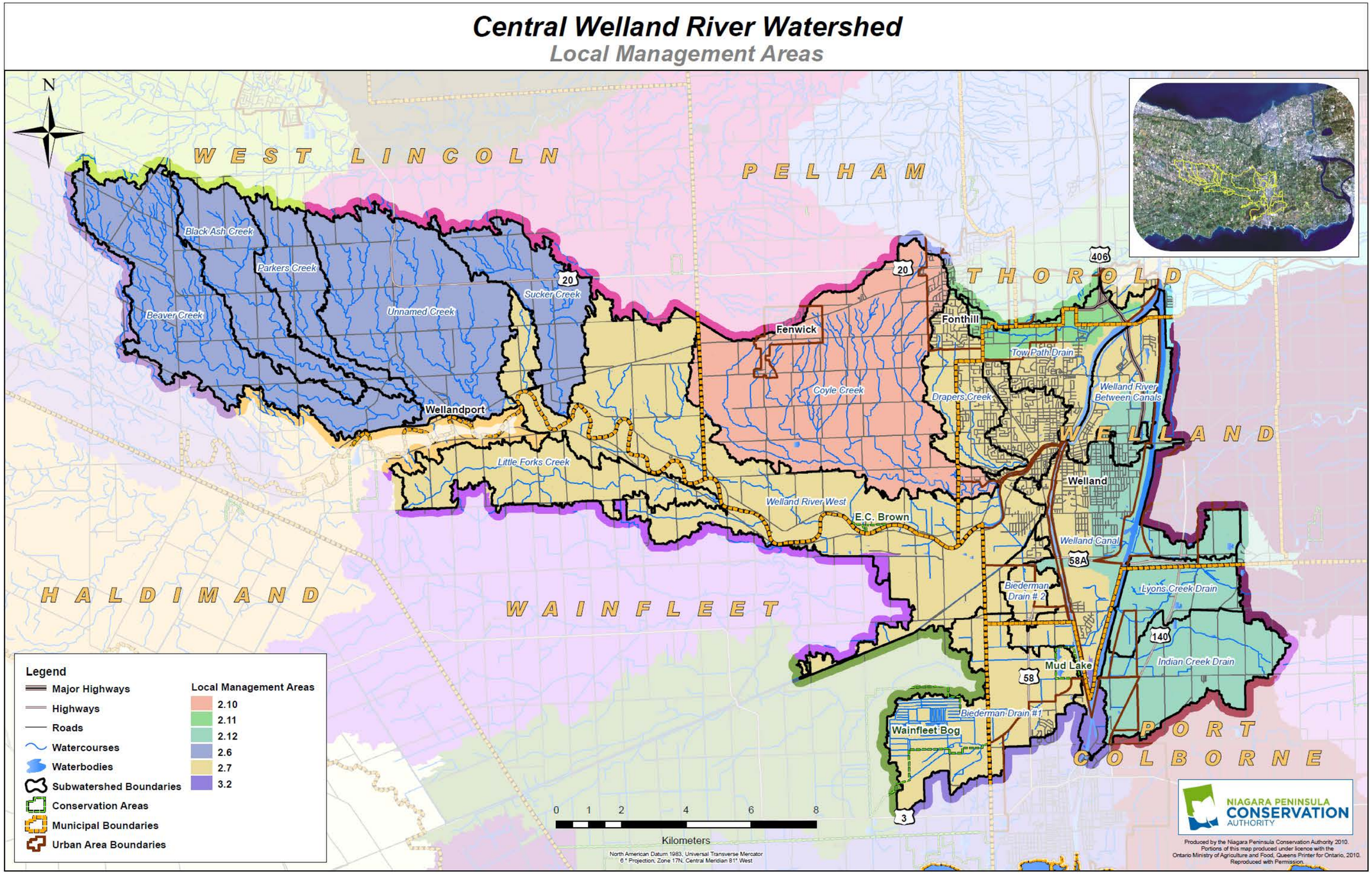


Figure 3: Local Management Areas

direction. Land use in this area is characterized mainly by industrial, commercial and residential land uses.

Natural heritage features in this portion of the study area include the Salina Formation, a regional ANSI; Mud Lake PSW and Conservation Area; numerous wetlands awaiting evaluations by the MNR; and several other natural areas including Babion Woods, a remnant natural heritage area.

Topography

Bordered by the Niagara Falls moraine on the north, the Welland River flows east from Ancaster, meandering through the central portion of the Niagara Peninsula to its outlet, the Niagara River. The mild gradient of the Welland River can be attributed to isostatic rebound, which is the rise of land masses that were depressed by the huge weight of ice sheets during the last ice age. The eastern half of the peninsula rose relative to the western end, resulting in a near flat gradient.

As isostatic rebound continued, the east flowing river slowed and flooding gradually began westward up the Welland River, flooding the surrounding land on the eastern extension of the river and flooding up Lyons Creek and Usshers Creek; gradually shifting the nature of the river. During the same time period, the level of Lake Erie rose, causing it to breach the Onondaga Escarpment and flood the lowlands to the north creating a temporary lake; Lake Wainfleet. The lake water levels eventually dropped in Lake Erie as the Niagara River was able to erode through the sill that was slowing its flow, and Lake Wainfleet gradually drained leaving behind a waterlogged depression that is now occupied by the Wainfleet Bog.

The topography of the Central Welland River watershed is illustrated on Figure 4.

Geology

The Central Welland River study area is predominately overlain with bedrock from the middle to upper Silurian period of roughly 425 to 410 million years ago; Guelph Formation, Salina Formation and a small portion of the Bertie Formation (Figure 5).

During the middle Silurian period the tropical sea that covered the Niagara Peninsula deepened and the Guelph formation was deposited. The Guelph Formation consists of reef and interreef deposits, characterized by tan, sugary, fossiliferous dolostone (Ministry of Northern Development and Mines No Date).

During the upper Silurian period, the seas become shallower resulting in land surfaces becoming more arid, and deposition of shale and fine grained dolostone occurred (Lewis 1991). Restricted circulation and increased evaporation of the sea resulted in deposition of evaporites (halite, gypsum, anhydrite), evaporitic carbonates and shales of the Salina Formation (Ministry of Northern Development and Mines No Date).

A small portion of the study area is overlain with bedrock from the end of the Silurian period roughly 410 million years ago; the Bertie Formation from which formed "*the main face of the „erroneously named', Onondaga Escarpment*" (Armstrong 2007). The dolostones and shales of the Bertie Formation were deposited in very shallow water as the sea gradually withdrew from the Niagara Peninsula.

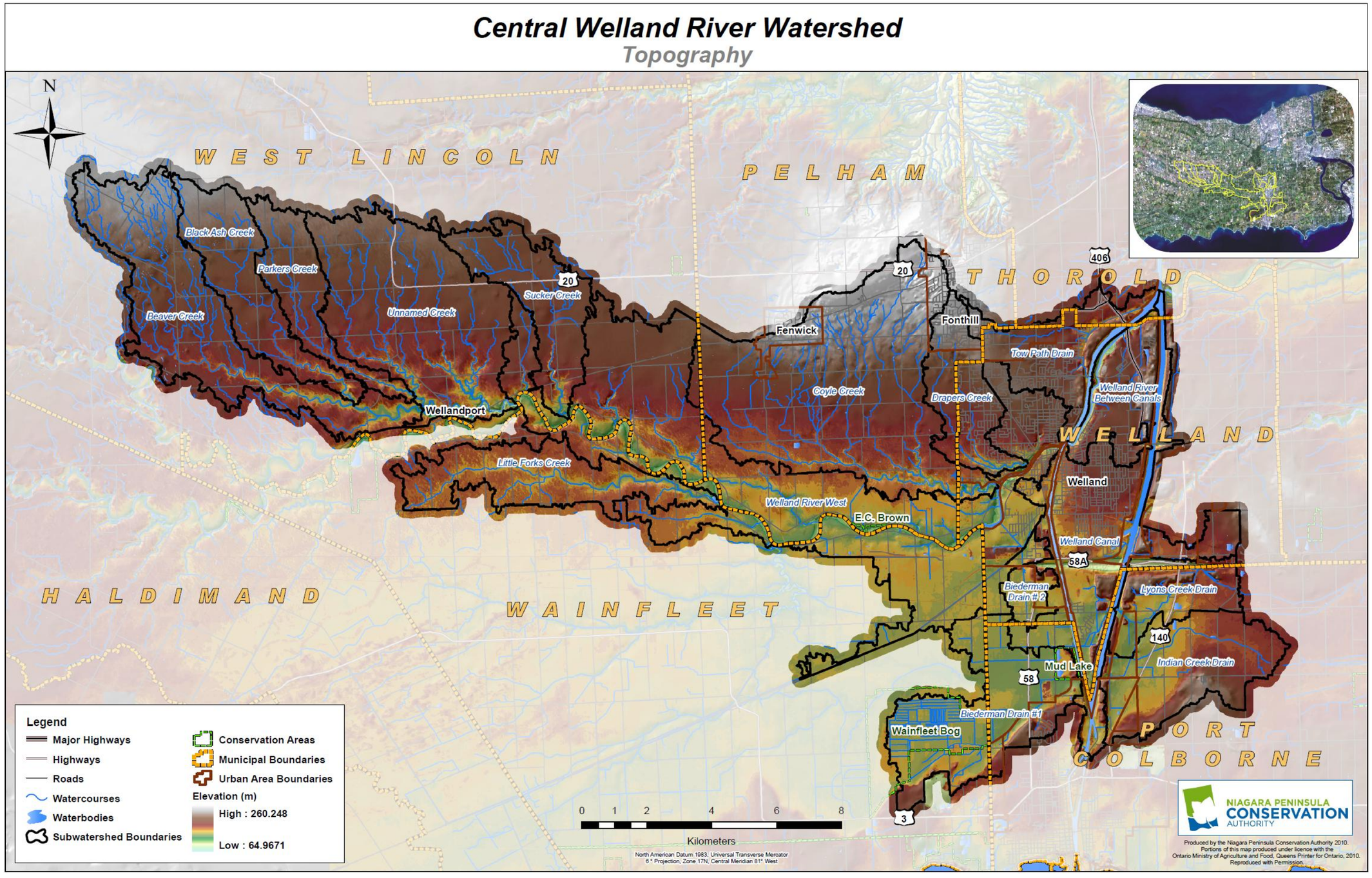


Figure 4: Topography

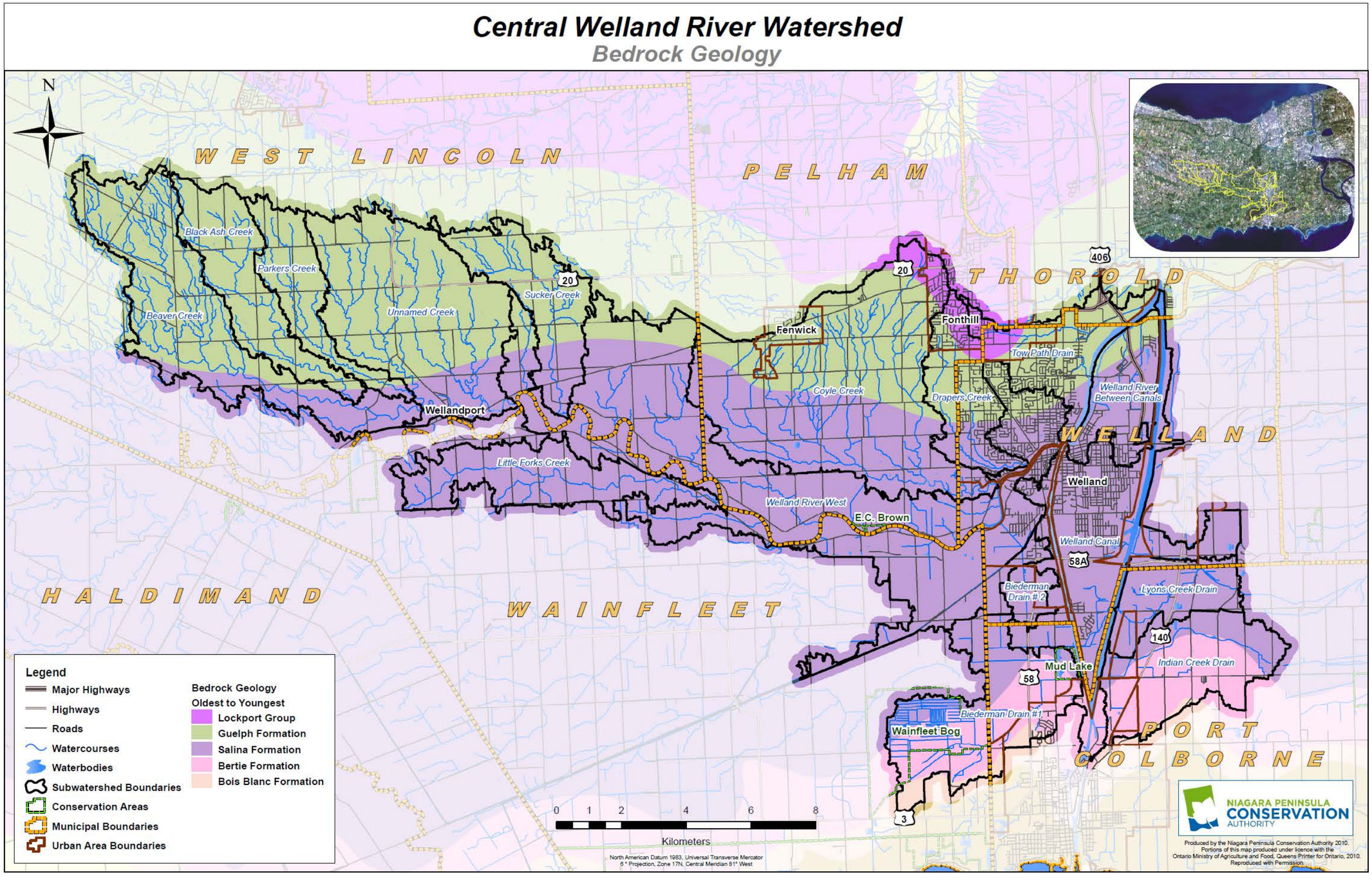


Figure 5: Geology

Physiography

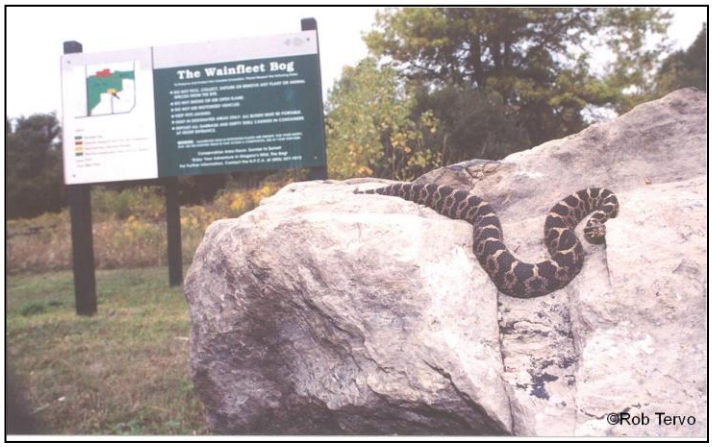
The physiographic region of the Central Welland River Watershed is the Haldimand Clay Plain which extends from the Niagara Escarpment to Lake Erie (Figure 6). The Haldimand Clay Plain was submerged by post-glacial Lake Warren and much of it is covered by lacustrine clay deposits. The gravelly beaches of the Fonthill Kame-Delta Complex, were however an isolated island of Lake Warren (Chapman & Putnam 1984), and only a touch of its southern slopes extend into the Central Welland River Watershed.

Wainfleet Marsh Basin/Wainfleet Bog:

Bounded by the Onondaga Escarpment on its south-eastern edge, the Wainfleet Marsh basin occurs on a broad, shallow depression on the poorly-drained clay and clay-loam soils of the Haldimand Clay Plain (Macdonald 1992). The area first began as a residual pond from Lake Wainfleet, and progressed through various vegetative successions until approximately 5000 years ago the area began to accumulate peat, "*a sure sign of waterlogged conditions in a blocked drainage system"* (Tinkler 1994).

With increasing and expanding human activities over the past 200 years, the bog has seen a significant reduction in size due to clearing and draining for agriculture, peat extraction, and the establishment of transportation networks that dissect the original extent. The original bog extended eastward and westward to include the now disjunct Humberstone Marsh and Grand River, encompassing an area no less than 21,119 hectares (Nagy 1992); today this wetland covers 1030 hectares with an additional 430 hectares of regenerating peat area (OMNR 1983b).

The Wainfleet Bog has gained recognition provincially, regionally and locally as a unique and valuable resource. It has been identified as the largest remaining Carolinian peatland in Canada, evaluated as a provincially significant wetland, and a portion has also been designated as a provincially significant Area of Natural and Scientific Interest. Through numerous surveys by various sources, a total of 475 species of vascular plants, 90 bird species, 20 mammal species, 8 species of amphibians and 13 reptile species have been recorded in the Wainfleet Marsh basin, including the federally endangered spotted turtle, and the federally and provincially threatened massasauga rattlesnake (OMNR 1992).



The need to protect this important ecosystem is quite evident to the Niagara Peninsula Conservation Authority and the Ministry of Natural Resources whom through land acquisition have secured much of the bog. Restoring the Wainfleet Bog to a healthy state is a common goal amongst the agencies (NPCA 1997).

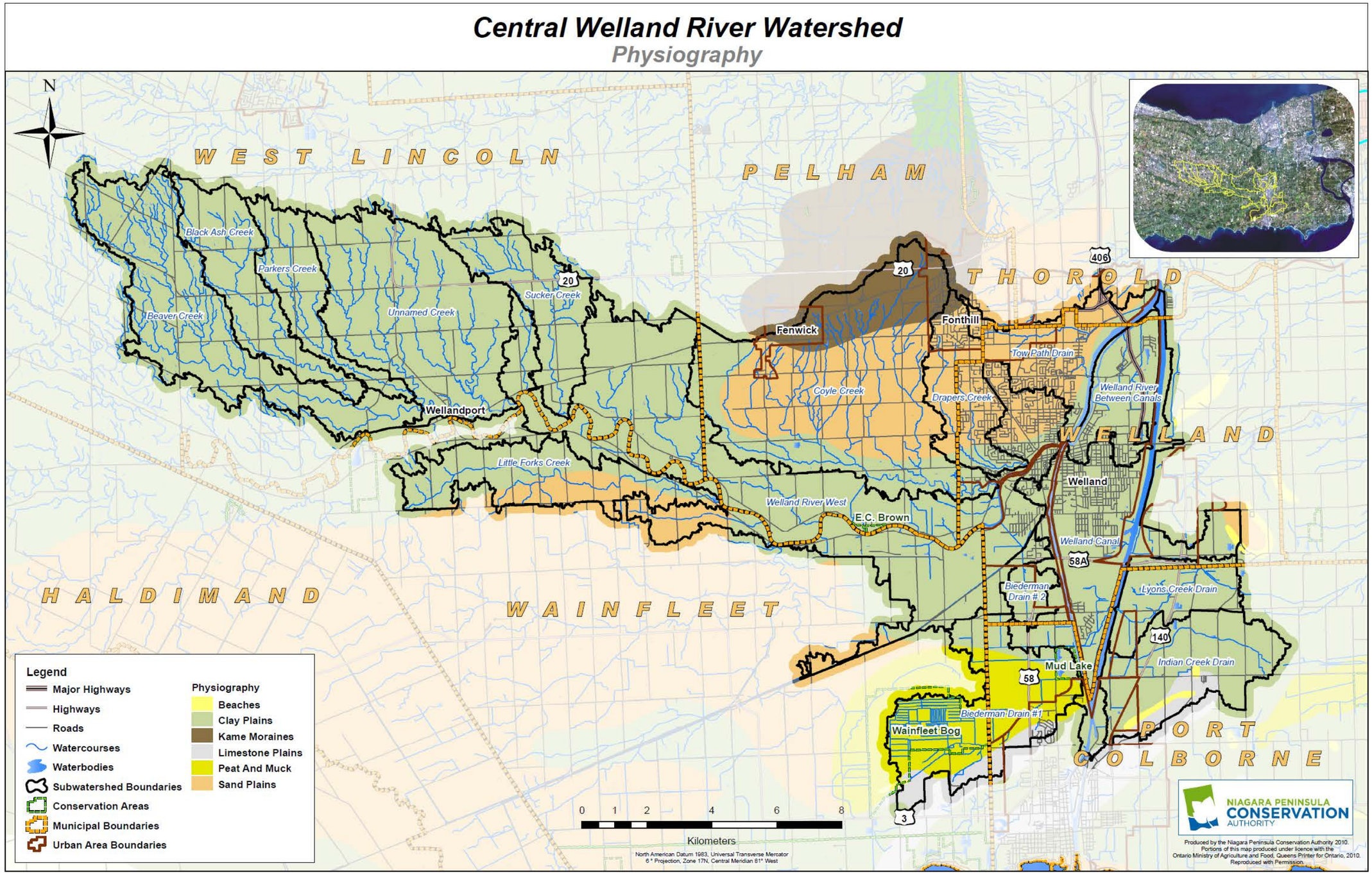


Figure 6: Physiography

Fonthill Kame-Delta Complex:

The Fonthill Kame-Delta Complex was created approximately 10,000 to 12,000 years ago by the last retreating glacier. The sand and gravel deposits that characterize the Fonthill Kame-Delta Complex were deposited by the melt water of the last glacier and consolidated into a series of mounds and linear ridges. This provincially significant feature straddles the subwatershed boundaries of Coyle Creek, Fifteen Mile Creek and Upper Twelve Mile Creek; the only cold water spring fed system on the Niagara Peninsula.

Soils

The soils in the Niagara Region were resurveyed and documented in a report entitled *The Soils of Regional Niagara* (Kingston and Presant 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 chart and map (Table 1 and Figures 7 and 8) are derived primarily from this document.

Numerous soil groups characterize the Central Welland River watershed; however, it is generally dominated by lacustrine clay soil groups. Lacustrine heavy clays of the Haldimand and Lincoln soil groups dominate the upland northern boundary of the Welland River and east of the Welland Canal, while lacustrine silty clays of the Beverly and Toledo soil groups dominate the Welland River valley and the lowlands north of the Onondaga Escarpment.

Haldimand soils are imperfectly drained, slowly permeable with a medium to high capacity to hold water; however they can be droughty during dry periods. Typically, there is some temporary perching of groundwater during seasonal high groundwater levels. They are commonly associated with Lincoln soils. Lincoln soils are poorly drained and like Haldimand soils, are slowly permeable, have a high water holding capacity and can be droughty during dry season. Care must be taken with both soil groups when using heavy equipment to avoid compaction. Both soils groups are commonly used for field crops.

Beverly soils, like Haldimand soils are imperfectly drained. Their permeability is moderate to slow, and they have a medium to high water holding capacity. For a period each year, groundwater occupies the surface horizons. Saturation periods tend to be prolonged in cultivated fields where the subsoil has been overcompacted from use of heavy equipment. This soil group is commonly used for small grains, corn and forage crops. Commonly associated with Beverly soils are Toledo soils. Toledo soils are poorly drained and typically slowly permeable with a high capacity to hold water. Like Beverly soils, groundwater levels tend to stay near the surface much of the year. Due to the high degree of subsoil compaction with these soil groups, tile drainage and continued maintenance may be required.

Organic soils of the Quarry and Wainfleet soil groups dominate the Wainfleet Marsh lowland area. These organic soils are very poorly drained. They are rapidly permeable, but are usually saturated with groundwater. They also have a high capacity to hold water and a very slow surface runoff. Typically, before these organic soils can be used for agriculture, extensive clearing and drainage is necessary as well as continued

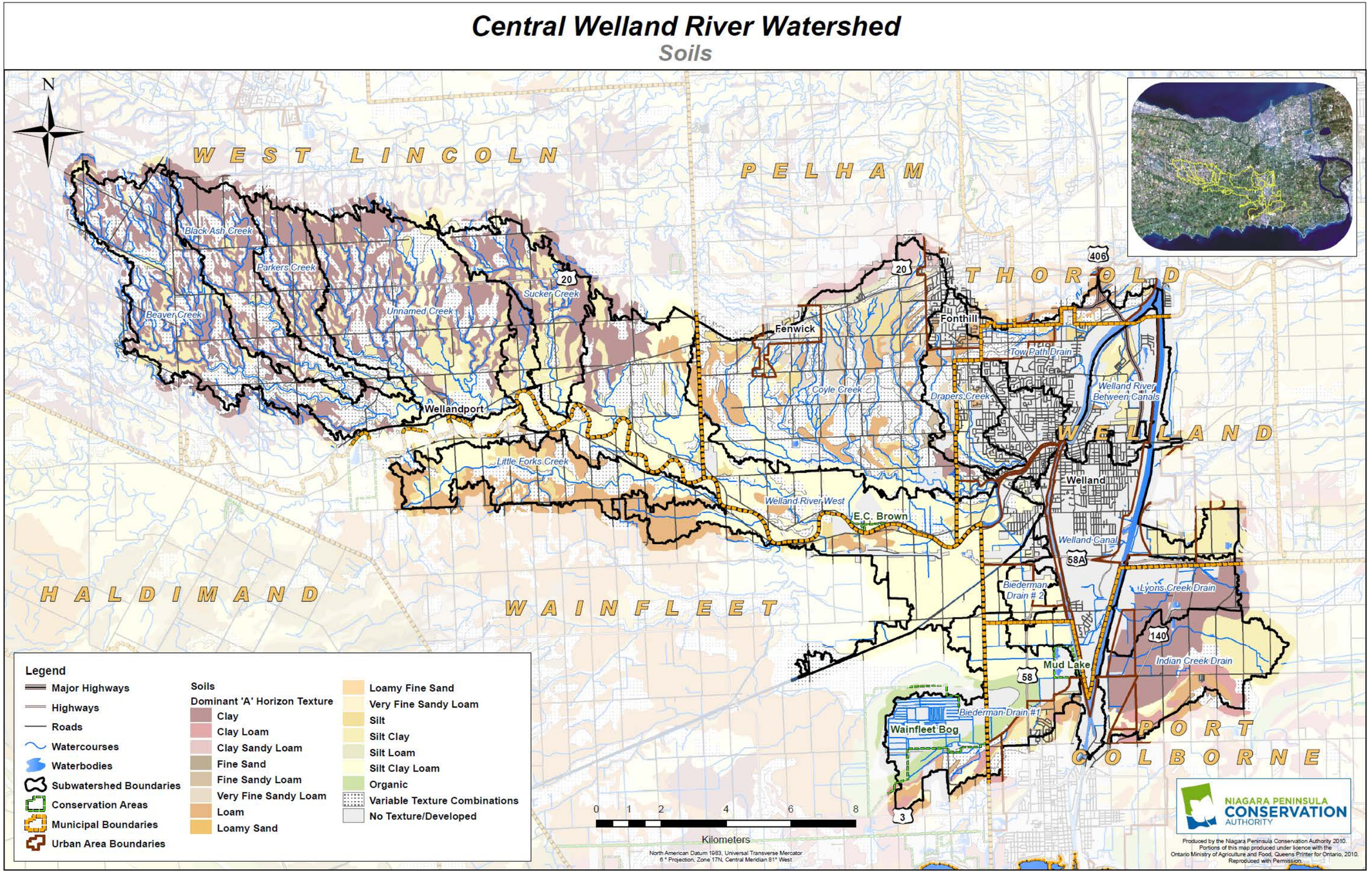


Figure 7: Soils

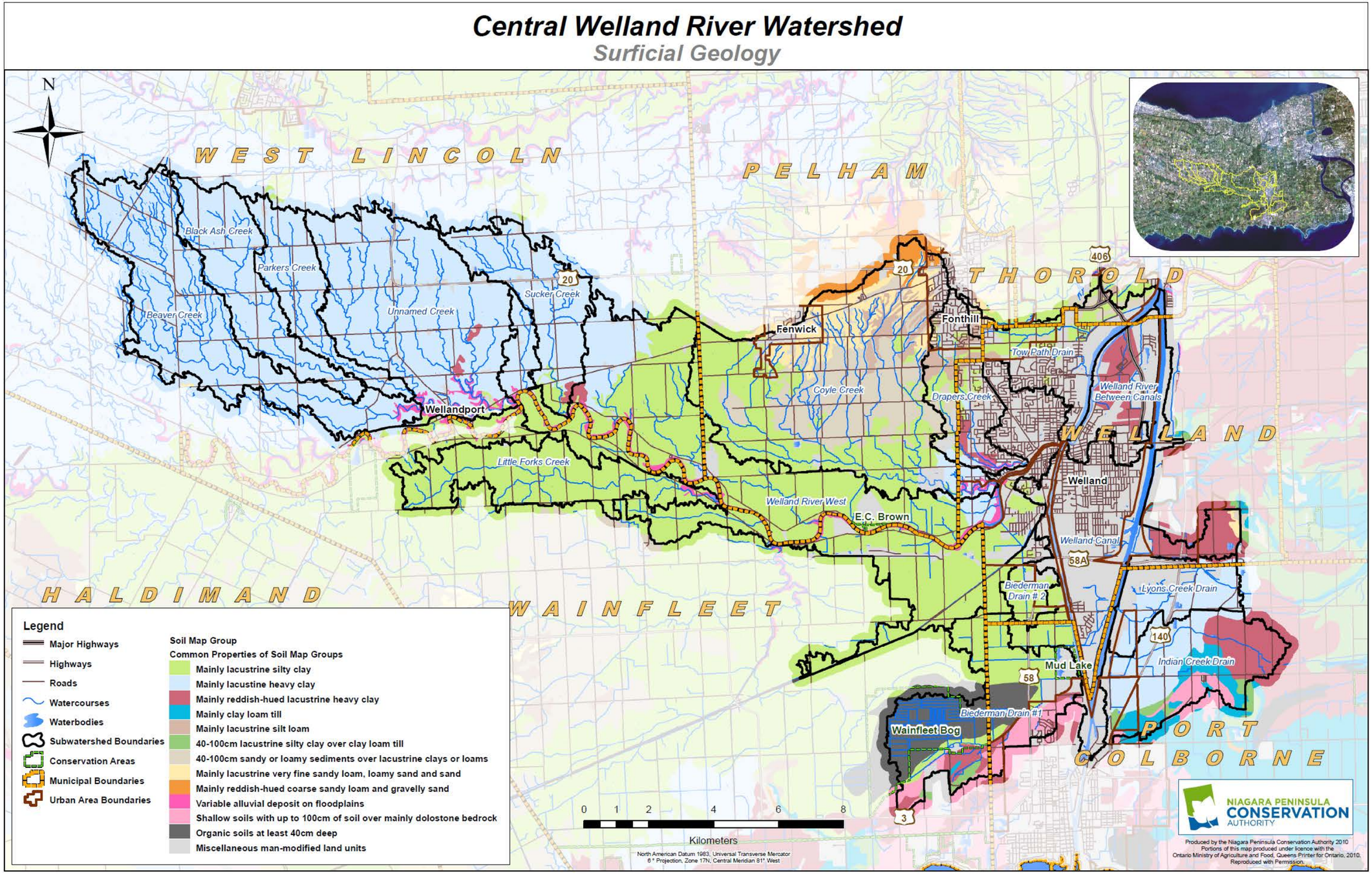


Figure 8: Surficial Geology

maintenance to control the subsurface water level and prevent the loss of the organic surface horizon through wind erosion. When drained these soils are suitable for common field crops and vegetable crops such as broccoli, potatoes, celery and onions.

The nature of the organic material in Quarry soils is dominantly woody forest peat with occasional sedge fen peat layers and a texture variation from silty clay loam to silty clay. These soils are associated with swamps and forested wetlands. The nature of the organic material in Wainfleet soils is primarily woody sedge fen peat. This soil group is limited to the main portion of the Wainfleet Bog

Table 1: Soils of the Central Welland River Watershed Plan Study Area

Soil Series	Geologic Deposits	Natural Drainage	Water Holding Capacity	Permeability	Surface Runoff	Class	Land use Comments
Mineral Soils							
Haldimand Soils (HIM)	Deep water lacustrine heavy clay	Imperfect	Medium to High	Slow	Rapid	3D	Capable of producing acceptable yields if certain precautions are taken (e.g. tile drainage)
Lincoln Soils (LIC)	Deep water lacustrine heavy clay	Poor	High	Slow	Slow to Rapid	3WD	Unsuitable for most horticultural crops
Toledo Soils (TLD)	Deep water lacustrine silty clay and clay	Poor	Relatively High	Slow	Moderate to High	3W	Require artificial drainage to be useful for agriculture
Beverly Soils (BVY)	Deep water lacustrine silty clay and clay	Imperfect	Medium to High	Moderate to Slow	Moderate to High	2D	Used mainly for corn, small grains and forage crops.
Organic Soils							
Quarry Soils (QRY)	Organic swamp sediments 40-160cm over loamy mineral sediments	Very Poor	High	Rapid	Very Slow	2HL-3H	Extensive clearing & drainage necessary before suitable for agriculture
Wainfleet Soils (WAF)	Organic sediments that extend to a depth greater than160cm	Very Poor	High	Rapid	Very Slow	3K	Extensive clearing & drainage necessary before suitable for agriculture

Current Land Use

The Central Welland River watershed extends into the municipalities of the Township of West Lincoln (35%), Township of Wainfleet (14%), Town of Pelham (20%), City of Welland (19%) and the City of Port Colborne (12%).

Land use in the study area is characterized mainly by agriculture, with major concentrations of urban land uses (residential, commercial, industrial) in the City of Port Colborne and the City of Welland with smaller residential areas in Fenwick and Fonthill (Figure 9).

Agriculture

The location of the Niagara Peninsula between the moderating influences of the Great Lakes and the Niagara Escarpment creates a unique microclimate that supports a viable agricultural community. In fact, the combination of geography and climate make parts of Niagara a thriving tender fruit district (Planscape 2003). In 2001, the Region of Niagara

commissioned a study to assess the nature of agriculture in Niagara; *Regional Agricultural Economic Impact Study 2003.* The study confirmed that "*agriculture is of tremendous importance to the Niagara economy both directly and indirectly"* (Planscape 2003). According to the study, in 2001 the agricultural industry generated over $511 million in gross farm receipts in Niagara.

As described earlier, the mineral soils in the area are rated as Class 2 and Class 3 according to the Canada Land Inventory (CLI) Classification System for Agricultural. These soil classes have limitations that restrict the range of crops and/ or require moderate or special conservation practices. The limitations with Class 2 soils are moderate, and the soils can be managed and cropped with little difficulty. The limitations with Class 3 soils are more severe than Class 2 and can affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation (Kingston and Presant 1989). The organic soils in the study area range from Class 2 to Class 3. According to the CLI Capability Classification for Organic Soils Class 2 soils have one minor limitation; this limitation may be woodiness, reaction, flooding, topography, depth or climate. Class 3 soils have moderately severe limitations that restrict the range of crops and/or require special management practices (Kingston and Presant 1989).

Outside of the Urban boundaries, the lands in the Central Welland River watershed are considered Good General Agricultural Lands, aside from Pelham north of Foss Road, which is considered Unique Agricultural Areas by the Region of Niagara.

According to Statistics Canada 2006 Agricultural Profile, the main agricultural commodity groups based on the North American Industry Classification System farm-typing categories for each municipality within the Central Welland River watershed are:

- Township of West Lincoln: cattle ranching and farming, poultry and egg production, and grain and oilseed farming;
- Township of Wainfleet: grain and oilseed farming, animal production, and greenhouse, nursery and floriculture production;
- Town of Pelham: fruit and tree-nut farming, greenhouse, nursery and floriculture production, and animal production;
- City of Welland: greenhouse, nursery and floriculture production, animal production, and grain and oilseed production; and
- City of Port Colborne: grain and oilseed production, animal production, and cattle ranching and farming.

The Central Welland River study area offers numerous recreational opportunities throughout the watershed. There are 5 golf courses in the watershed: Riverview Golf and Country Club and Pelham Hills Golf and Country Club in the Town of Pelham; Lockness Links, The Water Park Golf and Country Club, and Sparrow Lakes Golf Course all of which are located in the City of Welland.

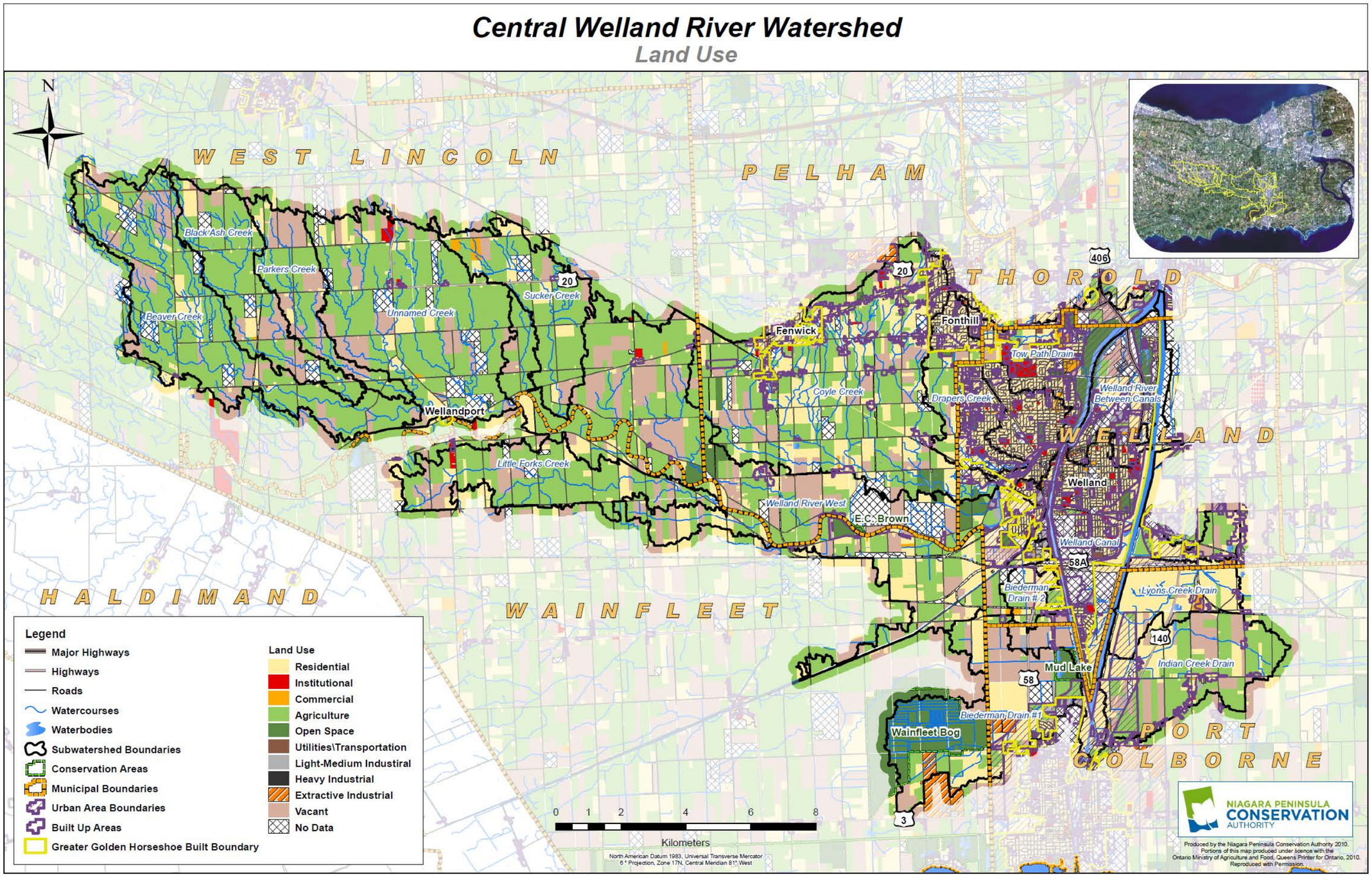


Figure 9: Current Land Use

Hiking and biking trails can be enjoyed throughout the area, including portions of the Welland Canal Trail, Regional Bicycle Network, Greater Niagara Circle Route and Scenic Bike Loops; and the Thorold-Welland Loop. In addition, There are four conservation areas in the Central Welland River watershed that offer passive recreational opportunities; Port Robinson Conservation Area, E.C Brown Conservation Area, Wainfleet Bog Conservation Area and Mud Lake Conservation Area. The latter two offer seasonal hunting with proper licensing and permits.

Future Land Use

In Ontario planning decisions are influenced by all levels of government: federal, provincial, regional and local (e.g. municipal). Although each tier has an appropriate role in planning decisions, co-ordination between tiers is necessary for effective planning and management of respective jurisdictions. For example, in Niagara the federal government would be responsible for regulating railroads, the Welland Canal, and the defense of our international boundary; whereas the provincial government's major responsibilities are primarily concerned with matters of provincial interest, for example, provincial transport routes, utilities, property assessment, land use planning, and protection of the environment, as well as numerous aspects of municipal development. Regional governments are responsible for planning, waste management, regional roads, treatment and distribution of water, and community services (e.g. police, health and welfare). Municipalities are primarily responsible for their respective jurisdictions in areas of physical, economic and social development while adhering to provincial and regional policies. However, some of the aforementioned responsibilities are shared with respective municipalities with some direction from the provincial government; areas such as treatment and distribution of water, waste management, planning and land use regulation.

Therefore, implementation of the Central Welland River Watershed Plan should be integrated into planning initiatives and roles of regulation by all levels of government. Land use changes in the Central Welland River watershed should also consider recommendations put forth by the Watershed Plan and supporting studies and documents where appropriate.

Provincial Tier

In Ontario, the *Growth Plan for the Greater Golden Horseshoe* [(GGH) MPIR 2006] has been prepared under the *Places to Grow Act* (MPIR 2005), to help guide land-use planning decisions in the Greater Golden Horseshoe area. The Plan provides a framework for managing the projected future growth in the region by guiding decisions on a wide range of important planning aspects such as future transportation needs and infrastructure, natural heritage and resource protection, land use planning and housing

requirements. The *GGH* promotes intensification of existing built-up areas and revitalization of urban growth centres while recognizing the vital economic and cultural importance of our rural communities. The *GGH* works with other government initiatives such as the *Provincial Policy Statement* [(PPS) MMAH 2005a], which provides overall direction on matters related to land use and development in Ontario, and municipal official plans by providing growth management policy direction.

The *PPS* recognizes that sustainability of Ontario's natural and cultural heritage resources over the long term is of key provincial interest given that that they provide significant social, economic and environmental benefits; "*Strong communities, a clean and healthy environment and a strong economy are inextricably linked"* (PPS 2005). Accordingly, while providing direction on appropriate development, the policies of the *PPS* provide protection for; resources of provincial interest, quality of the natural environment, and public health and safety by focusing growth within existing settled areas and away from sensitive or significant natural resources or areas that may pose as a threat to public health and safety.

The *PPS* calls for the wise use and management of resources by imposing stringent limitations on development and site alteration for numerous natural settings, including, but not limited to; significant and /or sensitive natural areas (terrestrial and aquatic), lands adjacent to significant and /or sensitive natural features, and areas of fish habitat. The *PPS* also calls upon planning authorities to "*protect, improve or restore the quality and quantity of water"* (Section: 2.2.1) by for example, using the watershed as the ecological scale for planning activities; ensuring stormwater management practices have minimal negative impacts; and linkages and related functions between terrestrial/aquatic features are maintained.

In terms of agricultural areas, the *PPS* calls for the protection of prime agricultural areas for long-term agriculture and related usage, and for respective planning authorities to designate specialty crop areas in accordance with provincial evaluations. In regards to extraction of mineral aggregate resources, the *PPS* requires extraction to be *"undertaken in a manner which minimizes social and environmental impacts* (Section: 2.5.2.2)', and rehabilitation of the extraction area is required to „*accommodate subsequent land uses, promote land use compatibility, and to recognize the interim nature of extraction"* (Section 2.5.3.1).

In addition to requiring the wise use and management of resources, the *PPS* calls for promotion of healthy, active communities by for example, providing public accessibility to natural settings for recreation, including "*parklands, open space areas, trails and , where practical, water-based resources"* (Section: 1.5.1) including shorelines.

The *PPS* policies may be complemented by other provincial (e.g. *GGH*), regional (e.g. Regional *Policy Plan)*, and municipal policies (official plans) regarding matters of regional and municipal interest. Together, provincial plans, and regional and municipal official plans provide a "*framework for comprehensive, integrated and long-term planning that supports and integrates the principles of strong communities, a clean and healthy environment and economic growth, for the long term"* (PPS 2005).

Region of Niagara: Upper Tier

The *Planning Act* (MMAH 1990) designates the *Policy Plan: Regional Strategy for Development and Conservation* (RMN 2007a) as the paramount planning document for Niagara Region as stated in *Section 27.1* of the *Planning Act*: "*The council of a lower-tier municipality shall amend every official plan and every by-law passed under section 34*

[addresses zoning by-laws]*, or a predecessor of it, to conform with a plan that comes into effect as the official plan of the upper-tier municipality".* Additionally, the *Planning and Conservation Land Statue Law Amendment Act, 2006 [(Bill 51)* MMAH 2007] provides direction for updating municipal official plans and zoning by-laws by requiring that municipalities assess the need for official plan updates every five years and update the respective zoning by-laws no later than three years after the official plan revisions are made as part of the five year review (Section 26.1; 9).

In accordance with the *GGH, PPS* and other provincial policies, the *Policy Plan* outlines numerous regional policies and strategies addressing local interests. For instance; land use and development, agriculture, cultural and natural heritage and aquatic resources, tourism and recreation are a few of the areas of interest addressed in the *Policy Plan*.

In 2009, Region of Niagara updated the Urban Areas policies in the *Policy Plan* (Amendment 2-2009) to implement strategic directions of an extensive 5-phase growth management strategy. It is the intent of the Region of Niagara to "*promote an integrated land use planning framework for decision making"* that involves all respective stakeholders, and it is the position of the amended policies to "*represent an opportunity for Niagara to affirm its commitment to building sustainable, complete communities"* [(Section 2) RMN 2009]. Accordingly, objectives of the Urban Policies include strategies that are intended to guide decisions related to "*land use planning, infrastructure development, natural and cultural resource management and fiscal planning"* (Section 2.2). Strategies in the *Policy Plan* for implementing this balance include policies related to for example, urban structure, intensification, Greenfield areas and transportation corridors.

The *Policy Plan* also outlines a number of objectives and strategies to maintain and foster a viable agricultural industry by preserving Niagara's agricultural lands and production through a multi-tier government coordinated effort by supporting the following policies; tariff/quota protection from imports (federal); adequate marketing and protection of unjustified taxes (provincial and local); and financial assistance and protection of unique and good agricultural lands are some of the local policies that the *Policy Plan* outlines.

The environmental policies apply an ecosystem approach to the environmental policy framework by employing proactive sustainable principles. Some of these principles include: stewardship plus regulation; environmental protection plus enhancement; and ecosystem health and sustainability. These principles are also applied to the mineral extraction sector to ensure that these resources are not only available for future use, but the extraction and "*management is compatible with the natural and human environment" (Section 7.E.)*

Extensive trail systems such as the Trans Canada Trail, Welland Canal Trail and The Greater Niagara Circle Route not only provide an abundance of recreational opportunities for residents and tourists, but these trail systems link Niagara Regions history and cultural heritage with its natural heritage. It is the intent of the *Policy Plan* to promote and coordinate further development of recreational trails in Niagara to promote recreational opportunities and encourage healthy lifestyles while fostering the expansion of the tourism industry.

The *Policy Plan* also recognizes that successful planning and environmental conservation requires coordination and cooperation involving all levels of government and respective stakeholders (e.g. municipalities, landowners, environmental agencies and interest groups). Accordingly, the *Policy Plan*, which adheres to provincial policies,

provides an overall framework for development and planning in Niagara Region that the respective municipalities are to adhere to with further detail at a municipal level.

Municipalities: Lower Tier

In the Central Welland River watershed, the *GGH* identifies the City of Welland and City of Port Colborne as a Gateway Economic Centre. Its proximity to the United States border and its location on the Welland Canal provide an opportunity for economic diversity and increased opportunities for trade and tourism with the United States. The *GGH* also identifies the area surrounding the built-up areas adjacent to the Welland Canal in Port Colborne and Welland as designated greenfields areas, making them the focus area of future intensification with an overall minimum density target of 50 jobs and residents per hectare.

Accordingly, the RMN in partnership with the province and local municipalities commissioned a study to develop an action plan for the implementation of the *Gateway Economic Zone and Centre* (GHK 2008) in Niagara Region. The Gateway Economic Centre in the Central Welland River watershed includes all the settlement areas within Welland and Port Colborne and the linkage between the two municipalities, as well as the Welland Canal. The Gateway Economic Zone does not fall within the Watershed Plan study area.

City of Welland

Almost 20 percent of the Central Welland River watershed falls within the municipality of the City of Welland. The land use in this portion of the municipality is predominately residential and commercial with some agricultural lands outside of the urban boundary. In 2007, the City of Welland adopted a *Brownfield Community Improvement Plan* (CIP) (RCI Consulting) to address the municipality's high number of brownfield areas. The *CIP* provides incentive programs, strategies and actions that will promote brownfield remediation, rehabilitation and redevelopment in the City of Welland (RCI Consulting 2007). Currently it is estimated that over 200 hectares of brownfield sites exist along the canal and throughout the city (City of Welland 2007).

As indicated, Welland has been identified by the province in the *GGH* as a Gateway Economic Centre. An economic gateway "*is a place of interaction, opportunity and interface; a place where opportunities for economic development are leveraged by proximity and geography*" (Dillon 2010). In the City of Welland's *Official Plan* (subject to approval by Regional Niagara [Dillon 2010]) numerous strategic directions are outlined to support economic diversity and promote increased opportunities, including for example, encouraging "*cross-border trade and the efficient movement of people and goods*" and by encouraging "*the provision of land and infrastructure for continued sustainable development and tourist facilities*" (Section 2.4.2 Dillon 2010).

It is the intent of Welland's *Official Plan* to focus all urban development within the Urban Boundary; which is comprised of the Built-Up Area (already developed lands) within the Built Boundary and Greenfield Area. The lands within the Urban Boundary are intended to accommodate the majority of Welland's projected growth. These lands are already or intended to be serviced major roads, transit and piped sewer and water services (Section 3.4.2.2).

Welland's Built Boundary was determined by the province through the *GGH*. This boundary represents the limits of existing development within the existing Built-Up Area. The provincial Built Boundary is important for "*measuring and monitoring intensification rates*"(Section 3.4.2.3) as all growth within this zone is considered as intensification. The lands between these two boundaries are Greenfield Areas which are not built-up. However, as indicated earlier, the *GGH* has identified these designated Greenfield areas as the focus area of future intensification with an overall minimum density target of 50 jobs and residents per hectare.

The *Draft Official Plan* also outlines strategies with regards to the Employment Areas within Welland. Employment Areas include the Gateway Economic Centre, General Industrial Areas and Light Industrial Areas. Planning objectives for these areas include for example, ensuring "*land use policies reflect an appropriate range of uses for its Employment Areas*", and protection of the Employment Areas and the requirement of "*extensive justification for any proposed conversion to non-employment uses*" (Section 4.3).

In terms of agricultural lands, it is the intent of the City of Welland through the *Official Plan* to "*protect prime agricultural lands by appropriately designating them and discouraging their redesignation or severance*" (Section 5.1.1.1). In addition, the City will limit the land uses within this designation to farming and agriculturally-related activities (section 5.1.2).

City of Port Colborne

Over 11 percent of the Central Welland River watershed study area falls within the City of Port Colborne. Land use in this portion of the study area primarily consists of a mix of industrial lands and agriculture. In 2006, the City of Port Colborne's Council adopted *The City of Port Colborne New Official Plan* (2006). In 2010, the City of Port Colborne completed recommended changes and the document is currently under review by the Region of Niagara. The following references are taken from the *DRAFT 2010 City of Port Colborne Official Plan*.

Along with Welland, Port Colborne has been identified by the province in the *GGH* as a Gateway Economic Centre. Similar to Welland, the City of Port of Colborne has established objectives for the Gateway Economic Centre to "*create the best possible community for residents, workers and visitors, based on a high quality of life, sustainable development, economic diversity, superior tourist facilities and unique natural features*" (Section 2.3.2). Strategic objectives to achieve this include for example, "*providing land and infrastructure for continued sustainable development of tourist facilities*", and by actively "*promoting existing industrial lands along the east and west side of the Welland Canal*" (Section 2.3.2 b, e).

In addition, the *Official Plan* outlines several general policies regarding Port Colborne's Industrial/Employment lands including limiting land use within this zone to include such as activities as for example, manufacturing and fabricating, assembling, "*industrial activities related and proximate to the Canal and harbour such as ship dockage and repair*"(Section 3.10).

In terms of the agricultural lands within the study area, it is the intent of the *Official Plan* to "*preserve and protect the lands in the Agricultural Area for existing and future farming operations and to permit those uses that support or directly relate to agricultural*

activities" (Section 3.5.1a). The *Official Plan* outlines several general policies for Agricultural Lands with regards to restrictions of land use and development within this zone.

Township of West Lincoln

Approximately 35 percent of the Central Welland River watershed falls within the Township of West Lincoln. Land use in this portion of the study area is primarily agriculture with some rural residential. It is the intent of the *Official Plan for the Township of West Lincoln* (1998) to "*provide for sustained farming and related activities through the protection of prime agricultural lands and by preventing incompatible land uses"* [Section 2.4 (BLS Planning Associates 1998)]. Efforts to continue supporting the agricultural industry include limiting land use activities within areas zoned agriculture. Land uses permitted include specialty farm uses such as greenhouses and mushroom farms, forestry and conservation lands (Section 4.4). Also permitted in this zone are farm-related residential and small-scale uses that are directly related to the agricultural industry and need to be located within proximity of the farm operations (Section 3.4). Any non-agricultural land uses are encouraged to occur within existing settled areas. The *Official Plan* also intends to maintain the biological diversity and functionality of West Lincoln's important natural heritage ecosystems. Like the agricultural zone, the policies of the *Official Plan* limit activities within the lands designated as Significant Natural Heritage Areas. The predominant land use "*shall maintain and preserve the significant attributes and functions of these lands"* (Section 6.4a). Compatible land use activities permitted include "*passive recreation, research, education, wildlife management, maple syrup extraction and low intensity forestry"* (Section 6.4a).

Town of Pelham

Another 20 percent of the Central Welland River study area falls within the municipality of the Town of Pelham. Land use in this portion of the study area consists of a mix of agriculture, rural residential with small urban settlements in Fenwick and Fonthill. Like other official plans, the *Draft Official Plan for the Town of Pelham* (Meridian Planning Consultants Inc. 2009) outlines a number of goals, objectives and strategies for future land use in the municipality. In terms of the natural environment, the intent of the *Official Plan* is to protect and, where possible, enhance significant natural heritage features through a number of strategies including for example, "*aspire to make planning decisions that contribute to the protection, conservation and enhancement of water and related resources on an integrated watershed management basis*" ; "*discourage the loss or fragmentation of significant woodland features and habitats and ecological functions they provide"*; and *encouragement of an open space system that links environmental and recreational resources*" (Section A.2.1.2).

In terms of the agricultural lands, it is the intent of the *Draft Official Plan* to "*protect and maintain land suitable for agricultural production and permit uses which support and/or are compatible with agriculture*" (Section B2.1.1) by limiting land uses and activities in these areas.

With regards to operations relating to aggregate extraction, it is the intent of the *Official Plan* to work with the aggregate industry and encourage "*extractive practices that are compatible with and respectful of the greater community and natural features and function*" (Section A.2.6.2). Any new operations or the expansion of existing aggregate extraction operations onto lands not designated as an Aggregate Extraction Area require

an amendment to the *Official Plan and Zoning By-law*. In addition, the application requires a number of studies that address the impact of the extraction operation on a number of aspects such as, for example, nearby communities; cultural and natural heritage features and functions; groundwater and surface water features; and significant geological features (Section B2.5.3.3).

According to Regional Niagara growth projections, it is anticipated that the Town of Pelham will grow by approximately 7300 people in the next 20 years, [(Section A1) Meridian Planning Consultants Inc. 2010]. The goal of the *Official Plan* is to encourage intensification of the forecasted growth to the current urban areas where full servicing (water and sewer) already exists; Fenwick and Fonthill. Strategies to achieve this goal include for example, prioritizing residential applications for existing urban areas; provision of a range of housing types to accommodate a broad range of income levels; and reinforce the function of downtown as the primary business, entertainment and commercial focal point (Section A2.2.2).

Township of Wainfleet

The remaining 15 percent of the Central Welland River watershed falls within the municipal boundary of the Township of Wainfleet. Land use in this portion of the study area is a mix of rural, agriculture and natural areas.

It is the intent of the *Draft Township of Wainfleet Official Plan* [Sorensen Gravely Lowes Planning Associates Inc. 2010] to "*properly manage growth of the municipality over the long term"* by providing strategic policies that outline "*the fundamental principles of the Township [to] help guide decisions on future land use changes*" (Section 2.0).

It is the intent of the *Draft Official Plan* to preserve Rural and Agricultural Areas for agriculture and agriculture-related uses and rural uses that support the rural community. The *Draft Official Plan* outlines numerous policies with the goal of preserving prime agricultural land for a wide variety of agricultural uses; promoting, protecting and maintaining the farming industry for future generations; and avoiding land use conflicts between agricultural and non-agricultural uses (Section 3.1). Policies include for example, restrictions on development, land uses and secondary land uses (Section 3.1.1)

In terms of natural features, it is the intent of the *Draft Official Plan* to "*ensure environmental implications of land use decisions be considered throughout the Township of Wainfleet to achieve a sustainable and healthy landscape*" (Section 4.1). General policies include for example, applying an "*eco-system based approach to planning and decision-making*" (Section 4.1.1); and in terms of development, "*First priority is to be given to avoiding negative environmental impacts*" (Section 4.1.2).

Conservation Authorities

Conservation Authorities are the governing body responsible for hazard lands in Ontario. Hazardous land, as defined in the *Conservation Authorities Act* [Section 28 (25)], is *"land that could be unsafe for development because of naturally occurring processes associated with flooding, erosion, dynamic beaches or unstable soil or bedrock"*. Accordingly, under the *Planning Act* (MMAH 1990), the Niagara Peninsula Conservation Authority is delegated provincial responsibility for reviewing natural hazard lands for respective municipalities on any proposed development within the NPCA jurisdiction. In

the NPCA jurisdiction, the NPCA has a Memorandum of Understanding with regional and local municipalities whereby all environment-related issues be reviewed by the NPCA. Comments provided by the NPCA outline implications of development proposals from a watershed perspective pertaining to natural hazard planning, natural heritage planning, or groundwater and surface water management [NPCA 2007b (Section 4.0)]. These comments not only reflect the goals and the objectives of the NPCA under the *Conservation Authorities Act* in terms of "*a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals"* (R.S.O. 1990, c. C.27, s. 20.), but also reflect the requirements of Niagara Region's environmental policies. The policies for NPCA's regulated areas are administered under the Ontario Regulation 155/06: *Development, Interference with Wetlands and Alteration to Watercourse Regulation.* The policies apply to all "*watercourses, floodplains, valleylands, hazardous lands, wetlands, the shoreline of Lake Ontario, Lake Erie and the Niagara River, and lands adjacent to each of these features/functions, within NPCA's jurisdiction"* (NPCA 2007b).

Niagara River Area of Concern (AOC)

In 1987 the International Joint Commission designated the Niagara River as one of 43 Areas of Concern (AOCs) around the Great Lakes Basin due to its degraded water quality impairing complete use of its resources. The AOC spans both the Canadian and American Niagara River watersheds. The Canadian Niagara River AOC includes the 58 kilometre long Niagara River to the international border and the Welland River drainage basin (Figure 10). The Welland River is the largest tributary of the Niagara River and its drainage basin accounts for approximately 80 percent of the AOC (Canada).

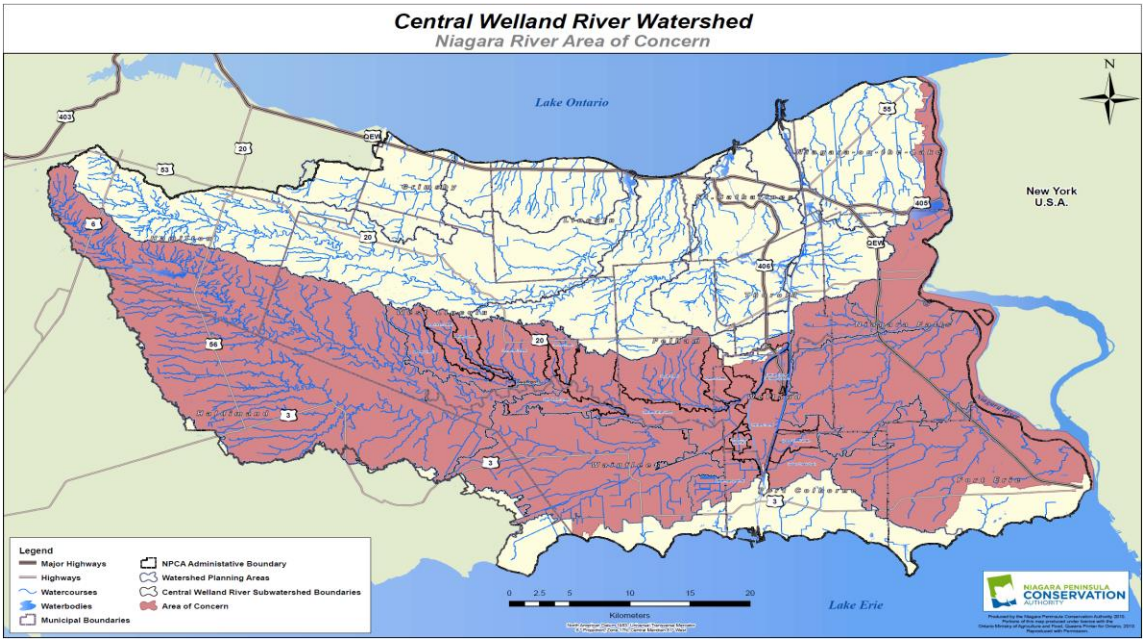


Figure 10: Area of Concern

Water quality issues in this AOC stem from sedimentation and toxic contaminants from industry, municipal sources of heavy metals, nutrients and other toxic pollutants, urban and rural runoff, and combined sewer overflows (NPCA 2002). As a result of the poor water quality many Beneficial Use Impairments (BUIs), as outlined in the Great Lakes Water Quality Agreement (1987), have been identified.

In response to concerns over the health of the entire Niagara River watershed and its ecosystem, a Remedial Action Plan (RAP) was created with representation from various stakeholders including the federal and provincial governments, resource agencies and the public (NPCA 2000). The Remedial Action Plan uses an ecosystem approach to environmental decision-making that involves three stages. The first stage, completed in 1993 (*Environmental Conditions and Problem Definition*), included a detailed assessment of environmental problems and their sources in the AOC and the extent of the impairments. In the Stage 2 report, (*The Cleanup Connection 1995*), the representatives of the RAP identified goals and objectives; made recommendations to achieve the goals; and proposed an implementation strategy to address the recommendations (Niagara River RAP 1995). In 2000, *Implementation Annex* (NPCA) was published and along with *The Cleanup Connection (*Niagara River RAP 1995) completed Stage 2 of the RAP. The *Implementation Annex* identified responsible stakeholders for the implementation of the recommendations; provided a schedule of activities, timelines and project costs (NPCA 2000).

Since the release of the 1995 Stage 2 report, and with various implementation activities completed or ongoing within the AOC, the outstanding questions that need to be addressed now are: "*What remains to be done in order to delist the Niagara River (Ontario) as a Great Lakes AOC?"* and *"How long will it take to achieve delisting?"* Many changes have occurred during that time with regard to environmental conditions within the AOC; remediation technologies; advances in analytical capabilities; advances in scientific understanding of environmental issues; and, the programs and priorities of RAP partners.

To answer these questions, government agencies and RAP partners felt it was necessary to review and update the RAP. With assistance from Technical Committees, a Steering Committee and a Public Advisory Committee, a full review of the Stage 2 report was initiated in 2004 to determine the status of implementation activities, identify any information gaps that require monitoring and assessment, and to focus all actions under the RAP towards delisting.

The Stage 2 Update report (2009) is a product of this review: it provides an update to the Stage 2 report and contains a summary of progress and several significant efforts which have taken place over the past nineteen years. It also contains the current status of impairments in the AOC and a new RAP work plan (2010-2015) that includes monitoring and assessment recommendations. It was clear from the Stage 2 review that there is still work to be done to address the remaining BUIs and achieve delisting of the AOC.

The *draft Stage 2 Update* report (2009) provides the following recommended status for the 14 BUIs:

No Longer "Impaired**":**

- Bird or animal deformities or reproduction problems
- Fish tumours & deformities

- Restrictions on fish and wildlife consumption (just the wildlife consumption component – the fish component continues to be impaired)
- Restrictions on dredging activities (this was originally incorrectly designated as impaired and has now been removed)

Continues To Be "Impaired":

- Restrictions on fish and wildlife consumption (just the fish consumption component)
- Degradation of benthos
- Beach closings
- Loss of fish & wildlife habitat
- Degradation of fish populations
-

From "Requires Further Assessment" To "Impaired":

- Degradation of fish & wildlife populations (just the degradation of wildlife populations component resulting in the entire BUI being listed as impaired)
- Eutrophication or undesirable algae (just the undesirable algae component resulting in the entire BUI being listed as impaired)

Continues To "Require Further Assessment":

- Degradation of Phytoplankton and Zooplankton populations

The Stage 2 Update report identifies priorities for remediation towards delisting the AOC (draft Stage 2 Update report 2009). These priorities include the following:

- Addressing sources of nutrients to eutrophication of the Welland River and its tributaries and develop a set of delisting criteria;
- Restoring and protecting fish and wildlife habitat, including unique habitats found rarely in other parts of the Great Lakes basin, and by mitigating the impacts of hydroelectric operations at the Sir Adam Beck Generating Station on the river upstream of the Chippawa Power Canal;
- Implementation of the monitored natural recovery strategy for PCB-contaminated sediment at Lyon's Creek East (e.g. administrative controls protocol);
- Complete assessments for Beneficial Use Impairment status for degradation of phytoplankton and zooplankton populations and implement appropriate actions for any other deemed impaired;
- Implementation of the updated monitoring plan which will help track progress of the Beneficial Use Impairments and ensuring that they don't backslide; and
- Complete assessment of Queens Royal Beach (not in study area) and implement required actions (Cromie 2010).

Initiatives to address these priorities are currently being coordinated by the lead RAP agencies through the new RAP implementation framework presented in the Stage 2 Update report. Implementation of the Niagara River RAP monitoring plan will allow comprehensive and defensible reports on the progress of ecosystem recovery, and will ultimately provide the evidence for delisting the Niagara River watershed as a Great Lakes Area of Concern (Cromie 2009).

Natural Heritage Resources

"One of the most fundamental principles of conservation is that there should be a system of natural corridors across the landscape, interspersed with large core natural areas" (Federation of Ontario Naturalists No Date). Not only does a natural heritage network provide a web of natural habitats that is crucial to the long-term survival and sustainability of biological diversity but this natural complex is critical in the maintenance of a healthy functioning ecosystem.

In southwestern Ontario, the Carolinian Life Zone is a rich and diverse network of cores and corridors that stretches from Toronto to Grand Bend extending southward to Lake Erie. Also known as the Eastern Deciduous Forest Region, this unique ecosystem boasts roughly one-third of Canada's rare and endangered species. Even though the Carolinian Life Zone makes up less than one percent of Canada's total land area, it contains a greater number of species than any other ecosystem in Canada and many of these species are not found anywhere else in the country (Johnson 2005). As part of its *Big Picture* project, Carolinian Canada identified considerable lands within the Central Welland River watershed as a „Carolinian Core Natural Area' (Figure 11).

A core natural area is defined as: "*an intact natural area with larger habitat blocks; regions with a high overall percentage of natural vegetation cover; viable occurrences of globally rare species and vegetation community types, and concentrations of rare species and vegetation; should exceed 200 hectares where possible with smaller high-quality sites in areas with lower amounts of natural vegetation cover; as well as having minimum corridor widths of 200 metres plus any adjacent areas of natural cover"* (Riley et al 2003).

Corridors provide an increase in functionality of core areas, even smaller or fragmented areas, by not only facilitating in the movement of larger mammals between natural areas, but "*they are also essential for the movement and maintenance of genetic diversity for virtually all species regardless of size or species-pollen and seeds and other genetic material are passed along corridors*" (Pim No Date).

In Ontario the *PPS* (MMAH 2005) calls for the wise use and management of resources, accordingly Section 2.1.2 of the *PPS* states: "*The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features."*

As previously indicated, Regional Niagara's *Policy Plan: Regional Strategy for Development and Conservation* (RMN 2007a), includes objectives for a healthy landscape in the environmental policies. For example, Policy 7.A.1b calls upon planning authorities to employ an ecosystem approach that address "*The health and integrity of the broader landscape, including impacts on the natural environment in neighboring jurisdictions"* when making decisions regarding planning and development or conservation.

The Central Welland River Watershed Plan Restoration Strategy (Tables 11 to 21) acknowledges and addresses linkages and potential corridors that extend outside of the study area. Large core areas that are present within and outside of the study area (e.g. Humberstone Marsh, Wainfleet Bog) play an integral role in the formation or enhancement of corridors.

Central Welland River Watershed Study Area Natural Heritage Resources

The percentages of upland forest cover, wetlands, and riparian habitat in Central Welland River watershed are recorded in Table 2. These figures will be assessed based on the guidelines set by Environment Canada (2004c) as part of the restoration strategies in the watershed plan. These statistics were generated from the data produced through the NPCA Natural Areas Inventory project and from the MNR's Ontario Wetland Evaluation System wetland layer.

All of the natural heritage areas including wetlands, woodlots, Areas of Natural and Scientific Interest and Environmentally Sensitive/Significant areas are illustrated on Figures 12 and 13 respectively, and described below.

Table 2: Natural Heritage Resources

Natural Heritage Resource	Current %	Guideline (minimum) %
Upland Forests	15	30 (of land cover)
Wetlands	10	10(of land cover in major watershed) 6 (of land cover in subwatershed) ***or to historic value***
Riparian Habitat	43	75 (of total stream length)

Life Science and Earth Science Areas of Natural and Scientific Interest

An Area of Natural and Scientific Interest "*is an area 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*" (MMAH 2005).The following natural areas are designated as provincially or regionally significant
ANSIs in the Central Welland River Watershed.

Wainfleet Bog Life Science ANSI (provincial)

The ANSI portion of the previously described provincially significant Wainfleet Bog extends over 207 hectares of the Wainfleet Marsh basin and is owned by the Ministry of Natural Resources. The primary objective of the MNR is to manage, protect and preserve the area's natural earth and life science features, as well as enhance its wildlife

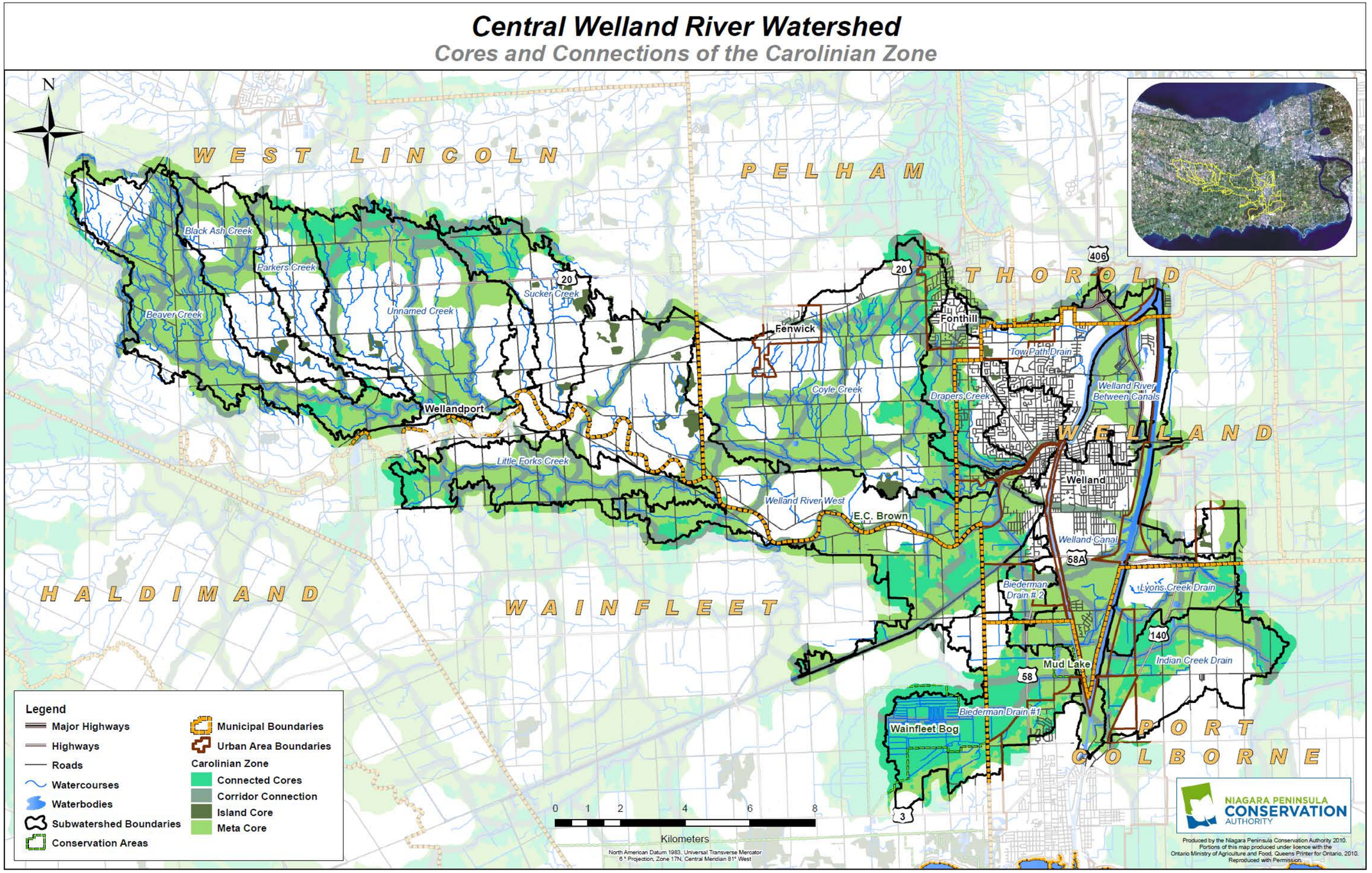


Figure 11: Carolinian Canada

and hydrological programs where there is non-compromising compatibility (OMNR 1992).

South St. Anns Slough Forest Life Science ANSI (provincial)

The provincially significant ANSI and provincially significant wetland South St. Anns Slough Forest is comprised of over 200 hectares of privately owned land in Unnamed Creek subwatershed located in the Township of West Lincoln. The slough and ridge patterns in this area are a good representation of the Haldimand Slough Forests. The sloughs in this area trend in a northwest orientation and regularly alternate with broad rolling ridges with amplitude of 2 to 5 feet. The area is unique due to its expansive size and well developed clay plain ridge and slough basin pattern. The ridges support rich Quercus-Acer-Fagus forests while the sloughs have well developed open ponds, marsh and scrub communities (Macdonald 1976). The boundaries of the ANSI and PSW fall within the boundaries of what is known as **Silverdale Woodlot**, a remnant natural area. Silverdale woodlot consists of 300 hectares that extends outside Unnamed Creek subwatershed, into the subwatersheds of Sixteen Mile Creek and Sucker Creek.

The Fonthill Kame-Delta Complex Earth Science ANSI (provincial)

The provincially significant Fonthill-Kame Delta Complex straddles the subwatershed boundaries of Coyle Creek, Fifteen Mile Creek and Upper Twelve Mile Creek; therefore only a portion falls within the study area of the Central Welland River watershed. This unique feature was formed at the edge of melting glacial ice during the last glacial retreat as large quantities of sand and gravel were deposited by the glacier as it melted. Most of the materials that the formed the Kame-Delta were deposited underwater like a river delta and spread southwards from the ice front (OMNR 1983).

North Bismark Slough Forest Life Science ANSI (regional)

The 60-hectare privately owned North Bismark Slough Forest is a regionally significant Life Science ANSI. This site has a well developed slough and rise formation, with the ridges supporting upland deciduous and the sloughs supporting lowland forests and slough zone communities. In an ESA study conducted on this site, it was recommended that this site receive immediate protection (Macdonald 1980). This site also encompasses provincially significant wetland complexes **Bismarck NW North Creek Tributaries, Bismarck NW 16 Mile Creek Tributaries** (which do not fall within the Central Welland River watershed) and, **Bismarck NW Beaver Creek Tributaries** (described below). In addition, this site is also known as **Bartell's Bush**, which in part is a managed woodlot through the Natural Resources Woodlot Improvement Program, which involves weeding out the american beech. The vegetation association on the east side of the site is sugar maple/white oak/white ash, while the west side is primarily sugar maple/american beech (Brady 1980). This site provides a rich diversity of habitats for flora and fauna due to the presence of a managed woodlot, natural mature forest and the wetland pockets.

West Bismark Slough Forest Life Science ANSI (regional)

West Bismark Slough Forest, like North Bismark Slough Forest, is also a regionally significant Life Science ANSI. This 55 hectare intracropland woodlot straddles the subwatershed boundaries of Unnamed Creek and Parkers Creek. This site also has a

well developed slough and rise formation with diverse slough zone communities and variously-aged upland deciduous supported on the ridges (Macdonald 1980). Also known as **Bismarck Bush**, the wetlands in this area support the headwaters for Parkers Creek and as well as provide habitat for great blue heron, ruffed grouse and deer (Brady 1980).

Ridgeville Swamp Forest Life Science ANSI (regional)

Also a regionally significant Life Science ANSI, the Ridgeville Swamp Forest is a wetland complex comprised of 6 individual wetlands that are composed of 19 percent swamp and 81 percent marsh (Littleton and Stuive 1985a). A portion of these wetland segments also composes part of the **Fonthill Kame Wetlands**, which has been designated provincially significant. Positioned on the south-facing slopes of the Short Hills Kame, the terrain consists of rolling sandland and slough and ridge formations with a broad basin supporting a poorly drained wetland. The vegetation communities include managed upland forest of maple-oak-beech and a well-developed swamp scrubland complex (Macdonald 1976).

Salina Formation (Welland Canal) Earth Science ANSI (regional)

A 20 foot section of the Salina Formation is visible from a road cutting beneath the new Welland Canal, making this site of a regionally significant Earth Science ANSI. The area displays a „grey, very finely crystalline, laminated, argillaceous dolostone with abundant shale partings and numerous gypsum veins and lenses with varying thicknesses' reaching up to 18 inches (Telford and Tarrant 1975).

Onondaga Escarpment Earth Science ANSI (regional)

The Onondaga Escarpment is capped with Bois Blanc from the Devonian period. In front of the Onondaga Escarpment is bedrock from the Silurian period; the Salina formation which is easier to erode than Bois Blanc. The location of this site is at a road cut on Highway 58, north of Port Colborne. The escarpment is approximately 5 meters high at this site (Telford and Tarrant 1975).

Wetlands

Wetlands are "*among the most productive and biologically diverse habitats on the planet*" (MNR No Date). Wetlands provide numerous beneficial water quality and ecological functions in a watershed, including naturally filtering water resources thereby improving water quality, act like sponges by slowing the flow of water which reduces the impact of flooding and allows for groundwater recharge, augments low flow by raising local water tables, which in turn contributes to base flows of the watercourses, and also provides valuable social and educational resources. In addition, "*a high proportion of Ontario's fish and wildlife species inhabit wetlands during part of their life cycle. Many of the species at risk of extinction in southern Ontario are highly dependent on wetlands*" [Environment Canada (EC) 2004].

The Ontario Wetland Evaluation System (OWES) is a science-based ranking system used by the Ministry of Natural Resources to assess wetland functions and societal values. Wetlands are evaluated and assigned a status of „provincially significant' or „locally significant'. To date, almost 65 percent of the wetlands in the Central Welland

River study area have been designated as provincially significant, approximately another 2 percent have been designated as locally significant and the remaining 33 percent are awaiting evaluations.

The following wetlands have been designated as Provincially Significant Wetlands (PSW) in the Central Welland River watershed:

The **Welland Swamp-Wetland** is a provincially significant wetland complex comprised of 11 individual wetlands consisting of 5.6 percent fen, 84.3 percent swamp and 10.1 percent marsh (Sarvis and Smith, 1985). Numerous wetland vegetation communities have been noted by Sarvis and Smith (1985), including for example, robust emergents such as cattails; narrow-leaved emergents such as grasses and sedges; free-floating plants such as duckweed; low shrubs such as willow and dogwood; and deciduous trees such as oak and elm.

Parkers Creek Headwaters is 23.6 hectares of provincially significant wetland. This wetland complex is composed of 54 percent swamp and 46 percent marsh (Thomas and Kwicinski 1987). No vegetation communities list is available to date for this site.

The **Bismark N.W Parkers Creek Tributaries Wetland** is approximately 10 hectares of provincially significant wetland made up of 16 individual wetlands composed of 36.9 percent swamp and 63.1 percent marsh (Harnden et al. 1987). The wetland segments of this complex fall within the boundary of what is also known as **Hardy's Woods**, a privately owned 130-hectare woodlot with a slough and ridge terrain. This site supports the headwaters of Parkers Creek, grouse and a variety of small birds. The vegetation associations of this site include sugar maple/American beech/white ash, and white pine/red oak/shagbark hickory (Brady 1980).

The **Bismark N.W Beaver Creek Tributaries Wetland** is a 24-hectare provincially significant wetland complex made up of 114 individual wetlands composed of 41.83 percent swamp and 58.17 percent marsh (Harnden and Hudson 1987). Numerous vegetation communities have been identified by Harnden and Hudson (1987), including for example, robust emergents such as cattails and jewelweed; broad-leaved emergents such as smartweed; low shrubs such as buttonbush, blueberry and dogwood; deciduous trees such as red maple, white elm and bur oak.

The **Beaver Creek Wetland** is a provincially significant wetland made up of 7 percent swamp and 93 percent marsh (Lorkovic et al. 1988). Lorkovic et al. have noted numerous vegetation communities, including for example, free-floating plants such as white water lily, duckweed and milfoil; narrow-leaved emergents such as grasses and sedges; and slow shrubs such as willow and buttonbush.

The **Vaughan Woodlots-Wetlands** straddle the border of Beaver Creek and Black Ash Creek subwatersheds. This 16-hectare provincially significant wetland complex is composed of 47 individual wetlands consisting of 74 percent swamp and 26 percent marsh (Kwicinski and Thomas 1987a).

The 49 hectare **Winslow North-East** provincially significant wetland complex is made up of 132 individual wetlands composed of 77 percent swamp and 23 percent marsh (Kwicinski and Thomas 1987b). The wetland segments fall within the boundary of what is also known as **Pot's Woodlot**, a 105-hectare woodlot with rolling terrain. This site acts as a water storage area for Beaver Creek, a tributary of the Welland River. The

vegetation associations of this site include American beech/sugar and silver ample/white pine/red, white and swamp white oak (Brady 1980).

Highway 20 & 24(also known as **Comfort's Bush**) straddles the subwatershed boundaries of Fifteen Mile Creek and Welland River West. This provincially significant wetland complex is comprised of 76 individual wetlands composed of 100 percent swamp (Litke and Santarella 1986). Numerous vegetation communities have been identified by Litke and Santarella (1986), including for example, narrow-leaved emergents such as grasse and sedges; free-floating plants such as duckweed and jewelweed; shrubs such as blueberry and buttonbush; ferns; and deciduous trees such as red maple and black ash.

The **Upper Coyle Creek Wetland Complex** is a provincially significant wetland complex that straddles the subwatershed boundaries of Welland River West and Coyle Creek in Pelham. Unfortunately, there is no description of the site as a whole; however, portions of this site are also known as **Sumbler Road Woodlot** in the north, **Riverview Woodlot** in the south and an eastern portion is known as **Welland Airport Woodlot**. Descriptions of these sites have been provided in part by Brady (1980). The **Sumbler Road Woodlot** is 56-hecatres of poorly drained slough and ridge terrain. The Ministry of Natural Resources has marked a small portion for stand improvement, and another portion is being considered for planting by a local interest group. The vegetation association of this woodlot is maple/beech. The 32-hecatre **Riverview Woodlot** consists of a flat terrain with scattered swamps, intermittent sloughs and eutrophic ponds. The vegetation associated with this site consists of oak/maple/beech. In addition, this area makes good grouse habitat. The **Welland Airport Woodlot** is 31-hectares of flat wetland surrounded by agricultural fields. Vegetation association of this site consists of maple spp/american beach. During the field inventory squirrels, numerous bird species and deer were noted.

The **Lower Coyle Creek Wetland Complex** also straddles the subwatershed boundaries of Welland River West and Coyle Creek. Unfortunately there is no description either for this wetland as a whole. However, like its upper counterpart, this site is also in part known under another name: **Highland Woodlot**. A description has also been provided by Brady (1980) for this site. This site consists of nearly 88 hectares of slough and ridge topography. Several small tributaries of the Welland River are supported by this site, making this area vital to the health of natural systems beyond its boundaries. During the field survey snakes, deer, numerous bird species and mice were noted. The vegetation association of this area consists of maple/beech and oak/ash.

The **Old Welland Feeder Canal** provincially significant wetland, like its name suggests, follows the route of the Feeder Canal. This wetland complex is made up of 7 individual wetlands composed of 100 percent marsh (Littleton and Stuive 1985b). Numerous vegetation communities were noted by Littleton and Stuive (1985b), including for example, robust emergents such as cattails and burreed; floating plants such as white water lily and duckweed; grasses; mixed herbs; and low shrubs such as willow and dogwood.

Mud Lake provincially significant wetland consists of approximately 69 hectares of swamp and marsh. The wetland is isolated by man-made berms that prevent water from naturally entering and exiting the wetland. Drennan and Mannella (1993) have noted six distinct vegetation communities in the wetland: emergent aquatic plants; submerged and free floating aquatic plants; wetland mixed hardwoods; mixed hardwoods; reforested areas; and scrubland. Approximately 63 hectares of Mud Lake is protected and owned by the Niagara Peninsula Conservation Area.

Conservation Areas

Wainfleet Bog Conservation Area

Over 800 hectares of the previously described Wainfleet Bog is owned and protected by the NPCA. A management plan has been implemented to help remediate and slow the factors that are degrading the ecosystem which are critical to improving and restoring the environment and its linkages. The recovery activities include re-establishing the development of the peat-dome formation and natural bog processes through ecologically self sustaining restoration techniques of limited to no human intervention (NPCA 1997)

Mud Lake Conservation Area

Mud Lake Conservation Area, previously described, is located in Port Colborne along the Old Welland Canal. This area offers excellent bird watching, limited hunting and nature trails.

E.C. Brown Conservation Area

E.C Brown Conservation Area located in the Town of Pelham is also situated along the Welland River. In 2007, the NPCA extended the boundary of this conservation area when the adjacent parcel of land (cornfield) was obtained and restored into a floodplain wetland that links to the Welland River. Vernal pools and nature trails were also created on site. This conservation area offers numerous passive recreational opportunities such as access to the water for fishing, picnicking, and hiking.


E.C. BROWN WETLAND
07/02/2008

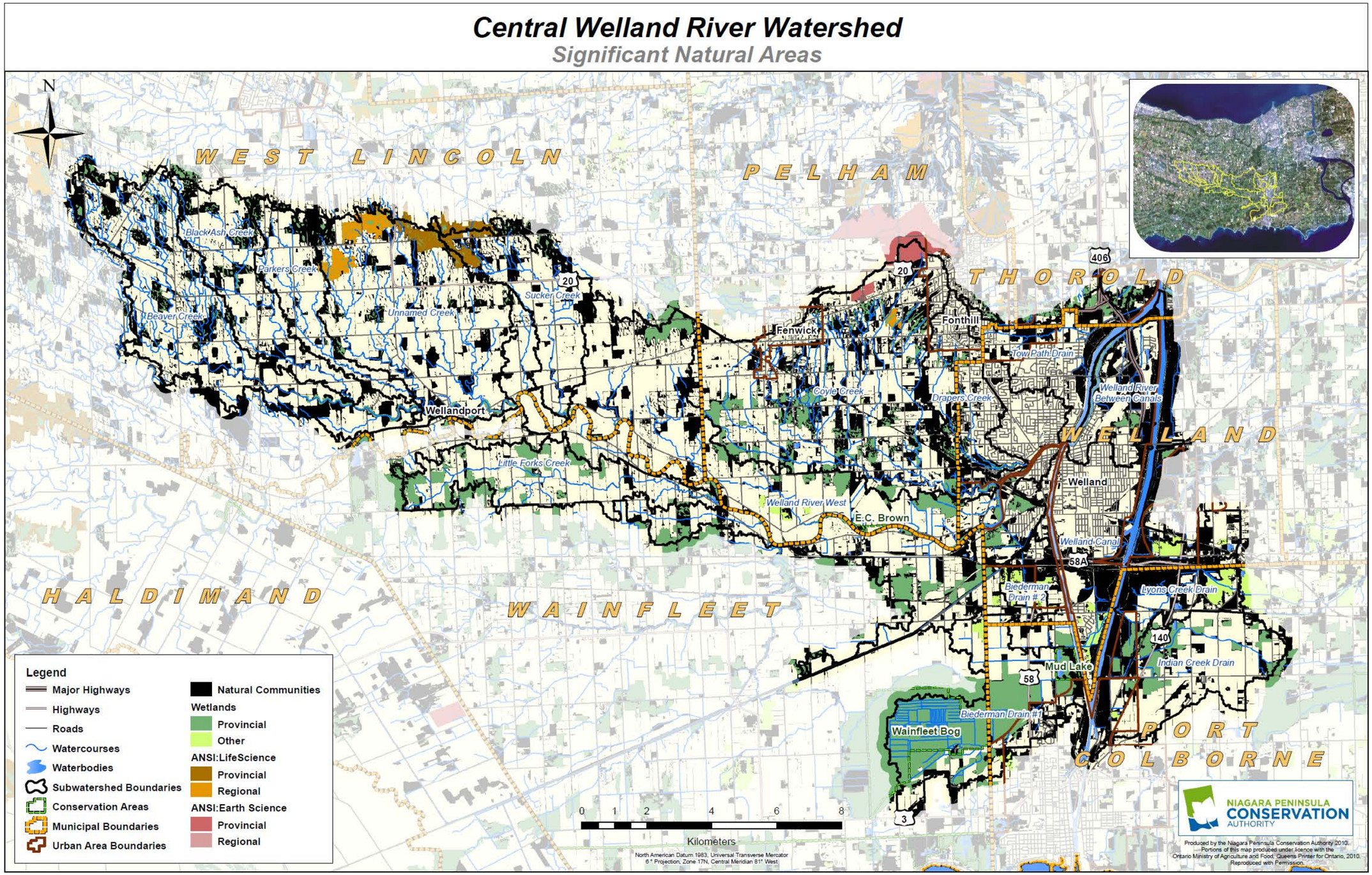


Figure 12: Significant Natural Areas

NPCA Natural Areas Inventory Sites

In 2006, the Niagara Peninsula Conservation Authority initiated a comprehensive Natural Areas Inventory (NAI) that was completed in partnership with the Regional Municipality of Niagara, local municipalities, Peninsula Field Naturalists and numerous other partners. The goal of the project was to use industry standard, scientifically-defensible protocols to inventory the natural areas in the NPCA watershed. The updated inventory provides a solid resource of information to aid in planning decisions, policy development, and the prioritization of restoration opportunities. Four major aspects comprise the Natural Areas Inventory project; these include a Community Series Ecological Land Classification (ELC) Mapping; field verifications of vegetative communities to Vegetation Type (ELC); faunal inventories of for example birds, lepidoptera and odonata, herpetofauna, and lichens; and education. In total, over 500 properties were visited for ELC vegetation type assessments.

The following descriptions of natural areas and associated mapping (Figures 13 and 14) have been derived directly from the NPCA *Natural Areas Inventory* (2010d) report. For more information regarding the faunal inventories conducted during this study, please refer to the NPCA *NAI Inventory* report.

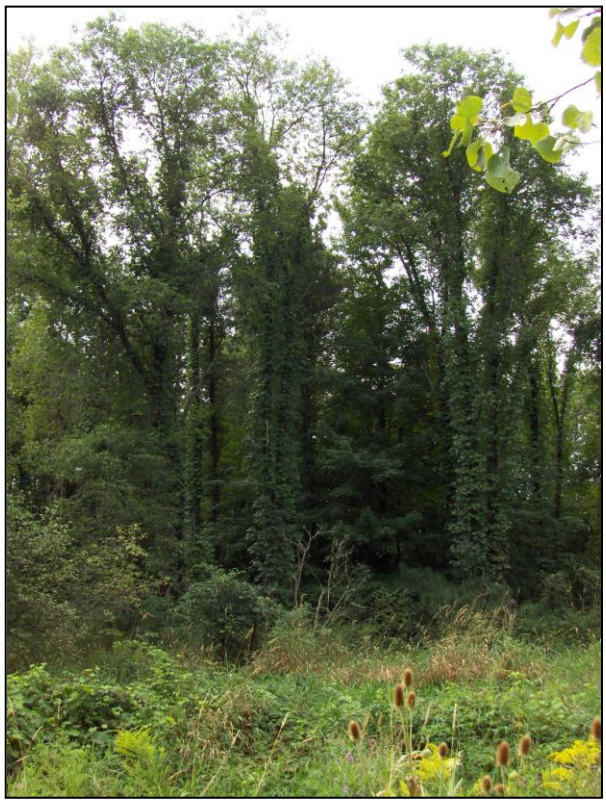
Name: Babion Woods
Formerly: Babion Woods (Brady, et al., 1980)
Site I.D. – PC-01-00-00-00-00
Municipality: City of Port Colborne
Approx. Size: 751 hectares
Subwatershed: The majority of this study site flows to the Indian Creek Drain with a small portion draining north/west to the Lyons Creek Drain.
General Summary: It is bound on the west by the Canal and extends to just east of White Road. The northern boundary is Forks Road and the southern boundary follows Third Concession Road and then Chippawa Road.
Summary: The relatively flat terrain of this study site contains intermittent sloughs and numerous drainage ditches. The extensive network of drainage ditches and the construction of the highway have lead to a drier community than would have existed historically.

The most common community noted was the Deciduous Swamp dominated by Swamp Maple and Green Ash. Associated species included, White Swamp Oak, Red Maple, Silver Maple, and White Elm. The understory consisted of Gray Dogwood, Blue Beech, Spicebush, Common Buckthorn, and Prickly-Ash. The herbaceous layer was a mix of Sedges, Fowl Manna Grass, Jumpseed, Panicled Aster, Wood Nettle, and Moneywort. There are a total of 176 recorded taxa for this study site.

This site is also in part designated as Babion Woods Wetland Complex PSW.

Name: Humberstone Marsh
Formerly: Humberstone Marsh (Brady, et al., 1980)
Site ID: PC-03-00-00-00-00
Municipality: City of Port Colborne
Approx. Size: 895 hectares
Subwatershed: The majority of this study site flows to Black Creek. There is a small portion in the west that drains to Indian Creek Drain and a portion in the south west that drains to the Beaver Creek Drain.

General Summary: This study site is located between White Road in the west and Point Abino Road North in the east. The northern boundary is the east-west rail line just south of Forks Road and the southern limit is just south of Second Concession Road.
Summary: This study site is known as the Humberstone Marsh. It is a very predominant feature in the Port Colborne area and serves as the source water for many tributaries that flow into Black Creek, and both the Welland Canal and Lake Erie. A small area of this large site was visited by NAI Field Crews. The following is a summary of the notations taken in the field.



The dominant community noted was Deciduous Swamp with Red Maple, Green Ash, and Swamp Maple as the dominant species. The understory was characterized as Green Ash, White Elm, and Choke Cherry. The herbaceous layer was a mix of Canada Mayflower, Spotted Touch-me-not, Wild Sarsaparilla, Rough Goldenrod, False Nettle, and various Sedge species. The higher ground between wet depressions in the swamps was categorized as Deciduous Forest dominated by Red Oak, White Oak, and Shagbark Hickory.

The Marshes for which this area is named were categorized as Sedge Marshes or Cattail Marshes. The Broad-leaved Sedge Marshes were dominated by a variety of sedges including Fox Sedge, Porcupine Sedge, and Bladder Sedge with Three-lobed Beggar-ticks, Spotted Touch-me-not, and Sensitive Fern. The Shallow Marsh community dominated by Broad-leaved Cattails and Rice Cut Grass included Narrow-leaved Meadowsweet, Three-lobed Beggar-ticks and Porcupine Sedge. There are a total of 286 recorded taxa for this study site.

This site is also in part designated as Humberstone Marsh PSW, and in part as Humberstone Muck Basin Swamp Forest Life Science ANSI.

Name: Bill's Bush
Formerly: Bill's Bush (Brady et al., 1980)
Site ID: PC-07-00-00-00-00
Municipality: City of Port Colborne
Approximate Size: 316 hectares
Subwatershed: The drainage for this study site is complex with portions flowing into Tee Creek (east), Lyon's Creek Drain (north and west) and Indian Creek Drain (south and west).
General Summary: This study site is bordered to the north by Townline Tunnel Road /Netherby Road and on the south by Forks Road. The eastern boundary is Brookfield Road and the rail line just east of Yagar Road is the western limit.

Summary: The Deciduous Swamp communities recorded for this study site were found in a slough and ridge terrain with a number of open marsh areas. The swamp communities were dominated by Freeman's Maple and Green Ash. The understory was a mix of the Freeman's Maple and Green Ash, with White Elm, Silky Dogwood and Spicebush. The groundcover is thick and includes Fern species, Northern Blue Flag, Lily species, Raspberry species and, Jack-in-the-pulpit. There are a total of 211 recorded taxa for this study site.

This site is also in part designated as Forks Road North East Slough Forest Locally Significant Wetland (LSW).

Name: Juard Woods – Ridgeville Swamp
Formerly: Juard Woodlot (Brady, et al., 1980)
Site ID: PL-03-00-00-00-00
Municipality: Pelham
Approx. Size: 333 hectares
Subwatershed: Coyle Creek.
General Summary: Study site is bound by Canborough Road to the north, Foss Road to the south, Cream Street to the west, and Haist Street in the east.
Summary: The most common community noted for this study site was the Deciduous Forest dominated by mature Sugar Maple growing over rolling hills of sand. Associated canopy species included American Beech, Tulip Tree, and Red Maple. The understory supported regenerating canopy species and in some areas, there was an amazing abundance of White Wood Aster throughout the ground layer.

There were also lowland areas with complex microtopography, or hummocks, which support similar Sugar Maple communities on the drier knolls. The lower lying areas were characterized as Deciduous Swamp dominated by Red Maple, Yellow Birch, Trembling Aspen, Black Cherry, and Green Ash.

The Marsh communities noted were rich with organics and were seepage-fed with a fast flowing stream meandering through it. There was a fringe of Black Walnut Lowland on the upland \ lowland interface.

The Open Water area recorded supported floating mats of Rice Cut Grass with the occasional Nodding Beggar-ticks. Also noted was a patch ringed by a fen-type sedge species (identification pending). Water flowed through this community, downstream, below the fen mat. There was a unique fen-like community with a floating mat over 80cm of a sheet flow of water\organic muck. There was no defined stream channel through this section, although the stream channel is defined upstream from this Rice Cut Grass mat. There are a total of 270 recorded taxa for this study site.

This site is also in part designated as Fonthill Kame Wetlands PSW, Ridgeville Swamp Life Science ANSI, and Fonthill Kame Delta and Fonthill Kame Delta North Slope Earth Science ANSI.

Name: Coyle Creek Headwaters
Formerly: Sumbler Road Woodlot, Riverview Woodlot, Welland Airport Woodlot (Brady et al., 1980)
Site ID: PL-04-00-00-00-00
Municipality: Town of Pelham
Approx. Size: 1038 hectares

Subwatershed: A small portion of the southern part of this study site drains to the Welland River West subwatershed, but the majority drains to Coyle Creek subwatershed.
General Summary: This site is bound by Canborough Road to the north, Welland River to the south, South Pelham Road to the east, Regional Road 24/Victoria Avenue to the west.

Summary: The Deciduous Forests of this study site are very rich with a canopy of Red Maple, Black Cherry, American Beech and Yellow Birch. The understory was a mix of regenerating canopy species with some Hop Hornbeam. The herbaceous layer contained Beechdrops, and in some areas, a carpet of New York Fern was noted. White Wood Aster was found occasionally throughout the forest floor on dry upland knolls and especially around the raised bases of large trees with Canada Mayflower.
Deciduous Swamps are very common in this study site. The slough ponds in areas were noted as so diverse that they support deeper open water pockets of submerged aquatic and floating-leaved communities. Complexed throughout the Deciduous Swamp communities of this large study site are sandy knolls (up to a meter in elevation above the wet pools and maple swamp communities). These areas support Deciduous Forest communities dominated by American Beech, or on the driest knolls.

Younger areas support Green Ash dominated communities while the many rich sloughs are lined with Red Maple and occasionally Swamp Maple. Most commonly Red Maple swamps have an abundance of Spicebush in the shrub layer. Northern Lady Fern is also abundant on the swamp / forest interface, or edge. Eastern Hemlock and occasionally Yellow Birch ring slough ponds and occur in the understory below the Red Maple swamp.

Rice Cut Grass marshes, forming quaking mats, developed in some of the slough ponds. Beggars-ticks were also common in areas surrounding deeper pockets of submerged aquatic vegetation such as, Common Bladderwort, and Duckweed.

Surrounding the rich slough ponds are mossy rims, and mossy bolsters (dead mossy stumps) throughout the ponds support knurled Blueberry shrubs. Species associated with these unique habitats include: Mosses, Highbush Blueberry, Swamp Dewberry, Starflower, Sedges, Royal Fern, Cinnamon Fern, Clubmoss and, Partridge Berry.

Sections of this study site are a mid-aged to mature regenerating forests with remnant conifer plantation still hanging on. Some have large expanses of open Bent Grass, Meadow Marsh complex throughout. Austrian Pine with its wetland tolerance is surviving in these wet areas as the dominant tree species, but seems to be doing best on slighter higher and drier sandy knolls.

The area between the naturalized plantation and open Meadow Marsh supports patches of Narrow-leaved Meadowsweet and young stands of Poplar swamp.

In the more open areas, communities such as the Raspberry thicket are common. These open thickets support a few scattered, young Trembling Aspen and Birch trees. Common Blackberry dominates in tangled patches surrounded by open meadows. An interesting thick carpet of mossy ground cover dominates with associated Common Cinquefoil. Rough Goldenrod, Gray Goldenrod, Grass-leaved Goldenrod, Poverty Oat Grass and, Kentucky Blue Grass are also abundant.

Bradshaw Park:
Bradshaw Park is a property owned by the Town of Pelham within this study site. The majority of the property is a Red Maple-Black Cherry successional forest. Sloughs and drainage swales, supporting Meadowsweet thicket swamp communities are found throughout. Adjacent to these wet areas, the uplands abruptly dry out and support thickets of Gray Dogwood and occasional patches of open meadow on the driest sandy knolls. Slough depressions with standing water, or vernal pools, support small stands of young Red Maple swamp

The wetland / upland edges in the open meadow or Gray dogwood thickets sustain a very interesting community with Foxglove Beard-tongue and Little Bluestem Grass.

A dense Meadowsweet Thicket Swamp area of the property supports an inner pocket of Bulrush Shallow Marsh.

In other areas along Coyle Creek, very open grass dominated swamps or floodplain forests support a dense cover of Asters, Snakeroot, Reed Canary Grass and, Sedges with an abundance of Wild Yamroot and Climbing Poison Ivy trailing over the dense shrub layer. An open canopy of Pin Oak, Red Maple or Green Ash partly shades a mix of Silky Dogwood and Grey Dogwood, Meadowsweet, and Ash saplings. There are a total of 504 recorded taxa for this study site.

This site is also in part designated as Upper Coyle Creek Wetland Complex PSW and Lower Coyle Creek Wetlands LSW.

Name: Rose Little Woods – Merritt Road Swamp
Formerly: Rose Little Woods (Brady et al., 1980)
Site ID: PL-10-00-00-00-00
Municipality: Most of this study site is located in the City of Thorold; however there are some significant sites that are within Pelham that is connected to this study site.
Approx. Size: 548 hectares
Subwatershed: The majority of this study site drains to the north/ east to the Welland Canal North subwatershed. There is a small portion that drains to the south/ west to Draper's Creek.
General Summary: This Study Site is by the Welland Canal to the east, Haist Street to the west, Highway 20 in the north to almost Woodlawn Road to the south.
Summary: The majority of the areas visited within this study site were dominated by Deciduous Swamps. It was common throughout this site to have dry meadows occurring along the rims and crests of slight sandy ridges alternating with standing water pools, or slough ponds. The Deciduous Swamps were characterized by Green Ash, Swamp Maple, and Red Maple in the canopy. The understory was largely Spicebush and Glossy Buckthorn. The ground layer was a mix of Spotted Touch-me-not, Fowl Manna Grass, Climbing Poison-ivy, and Rough Goldenrod.
On the drier ridges, Mixed Meadow dominated by Little Bluestem was present. Red Oak, White Elm and, Green Ash were found on the slopes. The wetland-terrestrial interface supported a mix of Foxglove Beard-tongue, Brown-eyed Susan, and Early Goldenrod. The interface of upland and lowland then graded into a typical Meadow Marsh community consisting of mainly Alpine Rush with a mix of Sedges. The deeper open water slough ponds were dominated by Bebb's Willow and Narrow-leaved Cattail with Purple Loosestrife, Sensitive Fern, Sedges and, Soft Rush. In disturbed areas it was noted that Glossy Buckthorn was the dominant species. There are a total of 211 recorded taxa for this study site.

This site is also in part designated as Niagara Street - Cataract Road Woodlot Provincially Significant Wetland.

Name: Port Robinson Duck Ponds
Formerly: Port Robinson Duck Ponds (Brady et al., 1980)
Site ID: TH-02-00-00-00-00
Municipality: City of Thorold
Size: 329 hectares
Subwatershed: The majority of this study site drains south/ east to the Welland Canal North subwatershed. There is a small area to the north that drains to the Lake Gibson system.
General Summary: This study site is located between Niagara St./Merrittville Highway to the west and the Welland Canal to the east. The northern boundary is Highway 20 and the southern boundary is Port Robinson Road.
Summary: Deciduous Swamp communities in this study site were dominated by Red Oak, Green Ash, White Elm, and Pin Oak with a few stands of Eastern White Pine on the driest ridges. The understory was largely Glossy Buckthorn, Grey Dogwood, Silky Dogwood and, Common Buckthorn. The herbaceous layer was a mix of Sedges, Avens, Goldenrod, and Asters. This bottomland and riparian areas supported a floodplain community with dense thickets of Glossy Buckthorn. An open canopied riparian Green Ash swamp with expansive marshes, along the creek channel and adjacent floodplain was noted. This community was dominated by Reed Canary Grass, Panicled Aster or One-sided Aster and Moneywort.

Also noted was the community for which this study site was originally named. Most of this study site is located on old canal excavation material. A railroad line prevents drainage creating large ponds. NAI teams did not visit the site however it was noted through air photo interpretation that the inundated valley wetlands were likely Duckweed ponds, Buttonbush Thicket Swamps, and Bur-reed and Cattail Marshes in a reoccurring pattern.

Steep and well drained valley slopes supported the drier Deciduous Forest communities dominated by Red Oak, Shagbark Hickory and White Oak. Occasionally, Sugar Maple or American Beech were also present. The understory was largely Hop Hornbeam, Black Cherry, Blue Beech and Downy Serviceberry. The herbaceous layer was a mix of Goldenrods and Asters with some Wild Leek. There are a total of 83 recorded taxa for this study site.

This site is also in part designated as Port Robinson Woodlot Wetland Complex PSW.

Name: Woodlawn Park
Site ID: WE-02-00-00-00-00
Municipality: City of Welland
Size: 12 hectares
Subwatershed: Draper's Creek
General Summary: This city owned park is located south of Woodlawn Road between Rice Road to the east and Silvan Drive to the west.
Summary: This area is known for its rich slough forests. The edges of the slough

ponds are lined with Green Ash dominated Deciduous Swamp communities. The provincially rare Black Gum grows on the margins of the Green Ash swamps. Patches of similar habitat also occurs throughout this study site in other low lying areas.

The higher knolls adjacent to the sloughs support Deciduous Forest communities characterized by Red Oak and Sugar Maple. The canopy is generally very high.
More open areas with deeper standing water supported Rice Cut-grass Meadow Marshes and the deepest pockets, or middle of some slough ponds supported Duckweed Shallow Aquatic pools with deep organic accumulations.

Moist sections in the shade of the forest canopy without much standing water were commonly Spotted Touch-me-not dominated communities. Disturbed areas are being overtaken with Purple Loosestrife and Moneywort. There are a total of 128 recorded taxa for this study site.

Name: Atlas Swamp / Wetlands
Site ID: WE-03-00-00-00-00
Municipality: City of Welland
Size: 42 hectares
Subwatershed: Welland River between Canals
General Summary: The study site is bound on the north and west by a rail line that runs north east to south west. The southern boundary is East Main Street and the eastern boundary is the Welland Canal.
Summary: The Deciduous Swamp communities noted for this study site were dominated by Red Maple, Pin Oak or Green Ash, with White Elm and/or Swamp White Oak. The understory was generally a mix of the above plus Blue Beech with Spotted Touch-me-nots, Canada Enchanter's Nightshade, White Avens, Rough Avens, Asters, and Goldenrods. The drier knolls or, suite of small moraine ridges (Menzies J., 2001) separated by slough ponds or wet depressions, supported high quality Oak-Maple forests.

Between the small moraine ridges, slight slough depressions supported wet areas of Red Maple Swamp co-dominated by Pin Oak, and occasionally Red Oak, rooted on areas with slightly raised microtopography. Other deeper sloughs and younger regenerating forested swamp/successional areas supported swamps of Pin Oak.

The deepest slough ponds, too wet to sustain tree species, most commonly supported Thicket Swamps dominated by Buttonbush with open water pockets ringed with Buttonbush, Rice Cut Grass, Star Duckweed and Bladderwort sp. or Pondweed. Buttonbush in some areas reached heights of 3-5m and looked almost tree-like. Black Gum was present in places around the rich and diverse Buttonbush thicket swamps. There are a total of 236 recorded taxa for this study site.

Name: Welland River / Merrit Island
Site ID: WE-04-00-00-00-00
Municipality: City of Welland
Size: 73 hectares
Subwatershed: Welland River between Canals
General Summary: This study site is located within Welland between the old and new Welland Canal; south of where the two merge and dissected by the Welland River. It includes a property owned by the City of Welland known locally as Merritt Island.

Summary: Silky Dogwood was the dominant species in the Thicket Swamp communities of the floodplain. Grey Dogwood was the dominant species on the drier areas or fill berms. The steep valleys and floodplain slopes were mostly Grey Dogwood thickets and a few areas along the slope support stands of White Elm.

Within the floodplain, especially along the top of bank on the Welland River, were regenerating stands of Green Ash with Poverty Oat Grass, Sedges and, Rushes.

One area supported a submerged aquatic community along the shoreline of the Welland River. This was dominated by Horned Pondweed with Curly Pondweed, Small White Water-lily and, Water-milfoil species. There are a total of 159 recorded taxa for this study site.

This site is in part designated as Central Welland River PSW.

Name: Highway 140/ Netherby Slough Forest
Site ID: WE-06-00-00-00-00
Municipality: City of Welland
Size: 163 hectares
Subwatershed: Half of this Study Site drains to the Welland Canal subwatershed and half to Lyon's Creek.
General Summary: This study site is located just east of the Welland Canal between Ridge Road in the north and Townline Tunnel Road in the south. It is bound on the east by Doan's Ridge Road.
Summary: Species rich Deciduous Swamp and Thicket Swamp complexes were common in more mature areas of this study site. Black Gum, Cut-leaved Grape Fern, and Flat-topped White Aster were commonly found with a canopy of Red Maple, and Green Ash. Early Goldenrod, Moss species, Lichens, Common Cinquefoil, and Common Speedwell were found on drier knolls in the successional swamp communities. There are a total of 122 recorded taxa for this study site.

Name: Canal Lands
Site ID: WE-07-00-00-00-00
Municipality: Portions of this study site are found in the municipalities of Welland and Port Colborne.
Size: 1081 hectares
Subwatershed: This study site spans many subwatersheds due to the very nature of the way in which it follows the canals. It spans the Welland Canal North, Welland Canal, Welland Canal South and Welland River between Canals subwatersheds.
General Summary: This study site follows the Welland Canal on both sides from the Welland River to Lake Erie.
Summary: This study site was characterized by poor soils due to the construction of the canals. The soil horizon in many areas is inverted and thus there are vast areas where no vegetation is present. Much of this study site is fenced off so access was an issue. Field crews did visit some vegetated areas of Deciduous Swamp communities with dominant Green Ash and Swamp Maple.

The understory was largely regenerating Green Ash and Swamp Maple with a ground cover of Fowl Manna Grass, Crested Sedge, Spotted Touch-me-not, and False Nettle. There are a total of 92 recorded taxa for this study site.

This site is also in part designated as St. Lawrence Seaway Authority Marsh LSW; and Salina Formation Earth Science ANSI.

Name: Railway Fen
Site ID: WE-08-00-00-00-00
Municipality: City of Welland
Size: 44 hectares
Subwatershed: Welland River West
General Summary: This study site is relatively small in an urban area extending between the rail line and Riverside Drive. The southern boundary is Broadway St., and it extends to a corridor owned by Transport Canada in the north.
Summary: The dominant wetland of this study site seems to have been formed by impounded water held back by the calcareous gravels of the railway bed. It was classified as a Shallow Marsh community characterized by a dense mat of Cattails in floating mats that quake over deep water (knee to waist deep). Sedges, Star Duckweed, Lesser Duckweed and, Liverwort were also found.

Also noted in this study site is a very nice Deciduous Swamp community with numerous; species rich slough ponds / vernal pools complexed throughout. It is dominated by Swamp White Oak with Pin Oak, and Green Ash.

The sloughs support a diverse Buttonbush Thicket Swamp community with some open water pockets dominated by species of Duckweed. A few knolls, or ridges, favour stands of White Oak or Red Oak, with carpets of Large-leaved Aster.

The community recorded for the open Transportation Canada corridor follows an abandoned railway line and rail yard. The regenerating vegetation is dominated by a mixture of open meadows and thickets of Gray Dogwood, and occasional patches of Staghorn Sumac, or areas that have succeeded to open stands of Poplar species. There are a total of 150 recorded taxa for this study site.

This site is also in part designated as Welland Swamp PSW.

Name: Old Growth Pin Oak Sloughs
Site ID: WE-12-00-00-00-00
Municipality: City of Welland
Size: 194 hectares
Subwatershed: This study site is divided almost in thirds. The western portion drains to the Welland River West subwatershed, The central third drains to Beiderman Drain #2, and the eastern portion drains to the Welland Canal directly.
General Summary: This study site is located between the east-west rail line in the north to south of Concession 4 Road. The western boundary is the Feeder Canal/ Morog Road and the eastern limit is the Welland Canal.
Summary: A very small percentage of this study site was visited by NAI teams. Of the area covered, Deciduous Swamp communities were the most common. The first was a Green Ash dominated community with Red Maple and Bur Oak.

The understory was largely Gray Dogwood and Raspberry species. The ground layer was a mix of Sedges, Asters, and Thicket Creeper. The second swamp community noted was dominated by old growth Pin Oak with Red Maple, White Elm, and Green Ash. The understory was largely Gray Dogwood with some Narrow-leaved Meadowsweet and Choke Cherry. The ground layer was a mix of Spotted Touch-me-not Asters and Sedges. There are a total of 65 recorded taxa for this study site.

This site is also in part designated as Chambers Corners Clay Plain PSW.

Name: Chippawa Creek Wetlands
Formerly: Chippawa Creek Conservation and Wildlife Management Area (Brady, et al., 1980)
Site ID: WF-01-00-00-00-00
Municipality: Township of Wainfleet
Size: 500 hectares
Subwatershed: The drainage for this study site is split between Wolf Creek Drain, Welland River West and an unnamed Creek.
General Summary: This study site is located between Sideroad 42 in the east and Marshagan Rd/ Sideroad 50 in the west. It extends from the Welland River in the north to the Wainfleet/ Haldimand Townline in the south.
Summary: This is a typical slough forest with the deepest areas of the swamp supporting Deciduous Swamps and Shallow Marshes and the driest knolls supporting a complex of terrestrial forest communities.

The Deciduous Swamps were dominated by Red Maple, Green Ash, and White Elm.
The drier knolls were slightly rolling with some microtopography. These were dominated by Sugar Maple, Red Oak and, Blue Beech. A few supported small stands of Largetooth Aspen. The understory was a mix of Asters and Goldenrods.

There were a few inclusions of Naturalized Conifer Plantations which were dominated by Norway Spruce.

The Shallow Marsh communities noted were largely dominated by Broad-leaved Sedges and surrounded by Red Osier Dogwood, or Buttonbush. There are a total of 531 recorded taxa for this study site.

This site is also in part designated as Chippawa Creek Slough Forest PSW and encompasses Chippawa Creek Conservation Area.

Name: Myer's Woods
Formerly: Myer's Woodlot (Brady et al., 1980)
Site ID: WF-02-00-00-00-00
Municipality: Wainfleet
Size: 255 hectares
Subwatershed: Little Forks Creek and Wolf Creek Drain East subwatersheds.
General Summary: This study site is bound by Creek/River Road to the north, Gracey and Smith Roads to the east, Willford Road to the south, and Sideroad 42 to the west.
Summary: Study site WF-02 is highly variable with many complexes and inclusions noted. The dominant community type was Deciduous Swamp characterized by Silver Maple, with Red Maple and Green Ash. The understory was largely regenerating Silver Maple and Green Ash with Blue Beech, and Choke Cherry.The herbaceous layer was a mix of Goldenrod species and Mosses.

The areas of deep organic deposits were classified as either Winterberry Thicket Swamps, or Willow Thicket Swamps. The areas with standing open water supported Cattail Shallow Marshes, or, Reed Canary Grass Shallow Marshes with Beggar-ticks as an associate. There are a total of 138 recorded taxa for this study site.
This site is also in part designated as South Welland Port Slough Forest and Chippewa Creek Slough Forest PSW.

Name: Little Forks Creek
Formerly: Henderson Road Woodlots (Brady, et al., 1980)
Site ID: WF-03-00-00-00-00
Municipality: Township of Wainfleet
Size: 225 hectares
Subwatershed: Welland River West and also to the south and east by Little Forks Creek to the Welland River.
General Summary: This study site is located between Gracey Road to the west and Vineland Townline Road in the east. The southern boundary is Concession 6 Road and Little Forks Creek while the Welland River is the northern boundary.
Summary: This study site exhibits gently undulating slough and ridge topography. The Deciduous Swamp communities were noted as being very wet. They were dominated by Freeman's Maple and Green Ash with some Sugar Maple and Red Maple. The understory was a mix of Common Clearweed, Thicket Creeper, Cinnamon fern, and Royal fern. The drier areas of this study site were noted as Deciduous Forest with a dominance of Sugar Maple, Black Walnut, and Red Oak.

The understory in these areas was characterized by Spicebush, Maple-leaved Viburnum, and Witch-hazel with Large-leaved Aster. Also noted for this study site were several small swamps with sections of open marsh. These areas were largely dominated by Buttonbush, Winterberry and Highbush Blueberry and an herbaceous layer of Beggar-ticks and Spotted Touch-me-nots. The associated tree species where they existed were Freeman's Maple, Yellow Birch, and some Black Gum. There are a total of 266 recorded taxa for this study site.

This site is also in part designated as Little Forks Creek and Little Forks Creek Wetland Complex PSW.

Name: Elsie Road Woods
Formerly: Elsie Road Woodlot (Brady, et al., 1980)
Site ID: WF-05-00-00-00-00
Municipality: Wainfleet
Size: 415 hectares
Subwatershed: Welland River West subwatershed and Big Forks Creek River.
General Summary: This study site is located between Concession Road 6 in the north and the rail line in the south. It is bound on the west by Putman Road and extends to just east of Gents Road.
Summary: The most dominant community noted for this study site was Deciduous Swamp. These areas were characterized by Freeman's Maple, Red Maple, and Green Ash with some Basswood, Red Oak, White Elm, Yellow Birch, and Black Gum. The understory of these areas was a mix of Spicebush, Narrow-leaved Meadowsweet and Highbush Blueberry. The herbaceous layer was largely Ferns, Sedges, Mosses, and Thicket Creeper. A second Deciduous Swamp community had Poplar species as a co-dominant.

The Thicket Swamps noted were mostly Yellow Birch and White Elm dominated with Winterberry and Highbush Blueberry, or Trembling Aspen and Willow. The wetter depressions supported stands of Narrow-leaved Cattails. There are a total of 215 recorded taxa for this study site.

Name: Tunacliffe Road Woods
Formerly: Tunacliffe Road Woods (Brady et al., 1980)
Site ID: WF-08-00-00-00-00
Municipality: Township of Wainfleet
Size: 116 hectares
Subwatershed Big Forks Creek
General Summary: This study site is located between Hewitt Road in the west and Deeks Road in the east. The northern boundary is River Road and the southern boundary is Forks Road.
Summary: Deciduous Swamp dominated by Pin Oak with Swamp Maple, and Bur Oak was recorded for this site. The understory was mostly regenerating canopy species with Green Ash, Blue Beech, and Choke Cherry.

Small dry knolls within the swamp supported Red Oak, Eastern Bracken Fern, and Large-leaved Aster. Successional Thicket Swamp communities recorded had many smaller open Meadow Marsh areas. The Thicket Swamps were characterized by either Buttonbush, or Gray Dogwood, with Soft Rush, Goldenrod species and Sedges.The open water communities were dominated by Greater Duckweed. There are a total of 153 recorded taxa for this study site.

Name: Farr Road Woods
Formerly: Farr's Road Woods (Brady et al., 1980)
Site ID: WF-09-00-00-00-00
Municipality: Township of Wainfleet
Size: 380 hectares
Subwatershed: Big Forks Creek and Welland River West subwatersheds.
General Summary: This study site located between the Welland River to the north and the abandoned Feeder Canal to the south. The western boundary is Tunacliffe Road and the eastern boundary is the intersection of the feeder Road East and Lambert Road.
Summary: The most dominant community noted for this study site is Deciduous Swamp. There were two types delineated. The first was dominated by Red Maple, with Red Oak, Green Ash, and American Beech. The second Deciduous Swamp noted was dominated by Pin Oak, with Red Maple, White Elm, and Trembling Aspen.

The understory in both cases was mostly Narrow-leaved Meadowsweet, Silky Dogwood, and Choke Cherry. The herbaceous layer was a mix of Lakebank Sedge, Spotted touch-me-not, Hairy Solomon's Seal, Sessile-leaved Bellwort, Canada Mayflower, and Virginia Spring Beauty.

The Thicket Swamps recorded were largely Narrow-leaved Meadowsweet with Silky Dogwood and a scattering of Green Ash, Red Maple and Pin Oak. The understory was a mix of Sedges, Asters and Sensitive Fern. The Shallow Aquatic community noted was characterized by Pondweed species and Willow. There are a total of 231 recorded taxa for this study site.

This site is also in part designated as Marshville Clay Plain East PSW.

Name: Jersey Woods (Mill Race Creek)
Formerly: Jersey Woodlot (Brady et al., 1980)
Site ID: WF-12-00-00-00-00
Municipality: Township of Wainfleet
Size: 181 hectares
Subwatershed: This study area drains west to East Kelly Drain and to Big Forks Creek to the east (not in study area)
General Summary This study site is located north of the feeder canal and south of Forks Road. It stretches to just east of Overholt Road and is bound on the west by Johnson Road.
Summary: The dominant community throughout this study site is Deciduous Swamp dominated by Green Ash with White Elm. The understory was a mix of regenerating canopy species, Silky Dogwood, Western Poison-ivy, and Spotted Touch-me-not. There are variations in canopy cover and soils due to the presence of deeper areas in the swamp where water is retained for longer periods of time. Some of these areas had standing water at the time of survey or bare soil which is generally an indicator of longer retention time for standing water.
The upland Deciduous Forests recorded were dominated by Red Oak and Sugar Maple, with American Beech and Shagbark Hickory. The understory was mostly regenerating canopy species with a herbaceous layer of Large-leaved Aster, Thicket Creeper, and Canada Mayflower. A total of 193 taxa were recorded for this study site.

This site is also in part designated as **Headwaters of Big Forks Creek Provincially Significant Wetland**

Name: Wainfleet Bog
Formerly: Wainfleet Bog (Brady et al., 1980)
Site ID: WF-13-00-00-00-00
Municipality: Township of Wainfleet, City of Port Colborne
Size: 2080 hectares
Subwatershed: The majority of this study site is part of the Biederman Drain subwatershed with a portion in the west draining to the Mill Race Creek subwatershed.
General Summary: It is bordered on the east by the Welland Canal, on the west by Dixie Road. It is located south of the feeder canal and stretches to south of Highway 3
Summary: This large study site can be subdivided into three areas; the Onondaga Escarpment, Mud Lake, and the remnant marsh locally known as the Wainfleet Bog. (Brady et al., 1980)

Onondaga Escarpment Sites:
In places along the Onondaga Escarpment, vertical, open cliff face is periodically exposed. The most impressive spot to view the Onondaga Escarpment is along Ridge Road in the Township of Fort Erie as the elevation change including the talus slope is approximately 6-7 meters.
The Onondaga Escarpment contains the wooded scarp itself, which is surrounded by agriculture, and is the southern boundary of the Wainfleet Bog. The community occurring in large patches along the drier escarpment rim supports large, spreading Red Oaks that dominate the canopy with Sugar Maple as a close co-dominant. Associates include Bitternut Hickory, American Beech, Black Cherry and occasionally, Red Elm. The subcanopy is dominated by Sugar Maple with Hop Hornbeam, Black Maple and American Elm occasionally occurring. White Ash and Choke Cherry form a very sparse shrub layer. On the ground layer, Blue Cohosh, Wild Leeks, Herb Robert, Running Strawberry and False Solomon's Seal *cover* between 25-60% of the rocky\stony shallow

soil. However, particularly in areas further back from the escarpment rim, Sugar Maple forms the canopy.

Red Maple swamp dominates the land at the base of the escarpment and out towards the Barrick Road area. This community does include many Red Oaks on the hummocks with Wild Leek, Choke Cherry and Red Elderberry as associates. The soils here are very rocky\stony with bedrock exposed in places. As the Onondaga Escarpment makes its way westward, it forms the southern boundary of the Wainfleet Bog. In the area immediately outside of the Wainfleet Bog Conservation Area, a very high quality forest grows along the rocky escarpment slope. There are numerous large, old Sugar Maple and Red Oak trees. It also supports a very rich ground layer with a beautiful display of spring ephemerals growing out of the rocky, bedrock exposed substrate.

Along an unopened road allowance that ends at the Wainfleet Bog Conservation Area, the escarpment gently rolls north from agricultural fields down to the wetland soils of the bog. In this area, Grey Dogwood thicket is the dominate community. Also found here but far less abundant is the community consisting of Black Walnut and Basswood with Choke Cherry in the shrub layer.

On the tableland of the escarpment, the successional woodland has an abundance of White Ash, Basswood and Bitternut Hickory. This community grades into a linear band of Black Maple\Sugar Maple –Hop Hornbeam– Red Oak forest on the upper edge of woods before a grassy Black Walnut savannah \woodland.

Mud Lake Sites:

The Mud Lake area is also part of this study site since the natural area is continuous. Mud Lake is a manmade reservoir owned by the Niagara Peninsula Conservation Authority. There is a band of wetland marsh defined by a berm of fill on the upland side and, the shallow water edge of the impounded reservoir that creates Mud Lake. The mineral sediment at the bottom of the Lake is very deep.

A band of shallow Mineral Meadow Marsh dominated by Spotted Touch-me-Not and Purple Loosestrife is found along the fringe of the upland boundary. The deeper water and seasonally exposed mud flats support a Forb Mineral Shallow Marsh community dominated by patches of Smartweed, Purple Loosestrife and occasionally, Bittersweet Nightshade, Narrow-leaved Cattail or Flat Sedge sp.

In places, Willow, Dogwood, Spirea or Buckthorn species dominate a narrow fringe along the interface between the weedy upland berm and wetland edge.

A second community ranges from dry, impoverished open meadow with only patches of shrubs to very shrubby, (45-80% shrub cover). The shrub cover is comprised of Grey Dogwood and Buckthorn with scattered Red Cedars and occasionally, Eastern Cottonwood, European Birch or, remnant cultivated White Cedar.

Ground cover is predominately Poverty Oat Grass with an abundance of Field Strawberry, Wild Carrot with Grey Goldenrod, sedges and, Hawkweed as associates. In some areas, crusty lime green patches of lichens also co-dominate the ground layer.

The topography of the Mud Lake Conservation Area (CA) is very complex with piles of fill forming raised berms (spoils from the digging of the Welland Canal), with tableland depressions and linear drainage channels below the berms that support forested swamp communities.

The community located on the fill berms is sparse in areas with impoverished sub soil. This soil condition greatly slows succession of woody species. There is a small, more mature section of Maple Swamp in the southern portion of the property.

Green ash swamp dominates the lower areas around the spoil piles and the depressions on top of the fill berms. Additional swamp communities occur along the perimeter of the CA boundary in and around the drainage channels. Complexes of Green Ash Swamp are found as a mosaic throughout the eastern edge of the property.

More open successional areas support wet patches of Creeping Bent Grass or, grassy meadow patches of Grasses, Garlic Mustard, Dame's Rocket and Burdock.

The community on the western-most edge of the property follows the raised berm. Buckthorn dominates in two layers; the shrub layer and a taller sub canopy layer where it forms a canopy with Common Apple. Scattered trees of Bird Cherry, Green Ash, Black Cherry, Crack Willow and White Elm form a sparse canopy above. Weedy species like Dame's Rocket, Garlic Mustard, Burdock and grasses occurring in the ground layer in patches as on other parts of the property.

In the center of the property is a large cattail marsh dominated by Narrow-leaved Cattail. Complexed within this marsh, sedges and Cyperus create distinct patches where they are the dominate cover. Below this layer, Smartweed and Beggarstick's occur.

Near the eastern boundary of the property is a pond dominated by Water Meal and Lesser Duckweed. This pond is fringed with Burreed, Cattails, Jewelweed and Purple Loosestrife. Between this pond and the Cattail Marsh is a patch of sedge dominated shallow marsh which supports living trees and dead snags of Green Ash and Willow.

***Wainfleet Bog Sites*:**

Much attention has been paid to the Wainfleet Bog over the years, our field crews did not collect data within the boundaries of the Conservation Area, however we visited several privately-owned properties in the area surrounding the publicly-owned properties.

The most common communities noted for this area were Deciduous Swamps dominated by Poplar species. The mix of species was almost equal Eastern Cottonwood and Trembling Aspen with

occasional Pin Oak.

Of great concern in this area is the invasive European White Birch that has taken over many parts of the Bog to the detriment of the native swamp communities. The Niagara Peninsula Conservation Authority and its partners have been involved in pilot projects aimed at removal of the invasive Birch and restoring these areas.

The understory in these communities was a mix of Silky Dogwood, Gray Dogwood, Riverbank Grape, Common Buckthorn, Willows, Wild Red Raspberry, and, Narrow-leaved Meadowsweet.
The herbaceous layer was characterized by Mosses, Spotted Touch-me-not, Common Strawberry, Tall Buttercup, Fowl Manna Grass and Asters.

In addition to the Deciduous Swamps, Thicket Swamps were common in this part of the study site. They were characterized by Narrow-leaved Meadowsweet, Gray Dogwood and Silky Dogwood, with Black Chokeberry, and Common Elderberry. The ground layer was mostly Mosses with Slender Stinging Nettle, Common Blackberry and, Southern Arrow-wood. A total of 620 taxa were recorded for this study site.

This site is also in part designated as Mud Lake and Wainfleet Bog PSW, Wainfleet Bog Life Science ANSI, and Wainfleet Bog Conservation Area and Mud Lake Conservation Area.

Name: Welland River
Site ID: WF-29-00-00-00-00
Municipality: City of Hamilton, Township of West Lincoln, Township of Wainfleet, and City of Welland
Size: 357 hectares
Subwatershed: Welland River West
General Summary: This study site includes the main channel of the Welland River, and its closely associated woodlands from the headwaters near Sinclairville Road in the City of Hamilton, to the Welland Canal in the City of Welland.
Summary: This study site is unique in that its boundaries are based on the floodplain of the Welland River and the closely associated woodlands. Most of the communities recorded were fresh-moist Deciduous Forests with some Thicket Swamps and Shallow or Meadow Marsh communities.
The Deciduous Forests were dominated by Black Walnut, Red Oak, Silver Maple, and Green Ash. The associated understory contained Choke Cherry, Hawthorns, Basswood, and Gray Dogwood. The herbaceous layer was characterized by a mix of Grasses, Sedges, Asters, and in some cases, Garlic Mustard.

The Thicket Swamp communities were dominates by Red Maple, Poison Sumac, and Yellow Birch with Hawthorn, Winterberry, Highbush Cranberry, and Buttonbush. The herbaceous layer was commonly a mix of Ferns, Mosses and Sedges.

The Shallow Marsh communities were characterized by Reed Canary Grass and Broad-leaved Cattails with

associated Rice Cut Grass, Devil's Beggar-ticks, and Sedges.

The Meadow Marshes were largely Common Elderberry, Gray Dogwood, and Reed Canary Grass with scattered Green Ash and White Elm.
The successional meadow areas were dominated by Kentucky Blue Grass, New England Aster, Tall Goldenrod, and Grass-leaved Goldenrod.There are a total of 373 recorded tax) for this study site.

This site is also in part designated as Welland River West PSW and E.C. Brown Conservation Area.

Name: Silverdale Woods – South St. Anne's Slough Forest
Formerly: Silverdale Woodlot (Brady et al., 1980)
Site ID: WL-08-00-00-00-00
Municipality: West Lincoln
Size: 440 hectares
Subwatershed: This study site is split into three parts. The south/west drains to an unnamed creek while the south/east drains to Sucker Creek. The northern section drains to Sixteen Mile Creek and eventually they all flow to the Welland River.
General Summary: This study site is located between the east-west rail line to the north and Highway 20 to the south. It extends from Wellandport Road in the west to Silverdale Road/ Schram Road in the east.
Summary: A small portion of this study site was visited by field crews. The most common community noted was Deciduous Swamp dominated by Red Maple with White Elm, Swamp White Oak, Green Ash and Black Gum.

The understory was characterized by Winterberry, Swamp Dewberry, and Blue Beech with a ground layer of Spotted Touch-me-not, Asters, Canada Mayflower, and Sessile-leaved Bellwort.

The higher ground between the sloughs was a drier community of American Beech, Birch, Black Cherry, and Trembling Aspen.

The understory was largely regenerating canopy species with Witch-hazel, and a ground layer of Canada Mayflower and Wintergreen. There are a total of 133 recorded taxa for this study site.

This site is also in part designated as St. Ann's Slough Forest PSW and South St. Ann's Slough Forest Life Science ANSI.

Name: Sucker Creek
Site ID: WL-09-00-00-00-00
Formerly: Sucker Creek (Brady, et al., 1980)
Municipality: Township of West Lincoln
Size: 79 hectares
Subwatershed: The drainage for this study site is split into three parts. The entire eastern portion drains via Fifteen Mile Creek while the western portion is split between Sixteen Mile creek in the north and Sucker creek in the south.
General Summary: This study site is located near the West Lincoln and Pelham border between Silverdale Road in the west and Rosedene Road in the east. The northern boundary is Fifteen Road while Highway 20 makes up the southern boundary.

Summary: A small percentage of this study site was visited by project field crews. The sites visited were characterized by complex microtopography where the drier knolls supported Deciduous Forests while the lower lying areas were classic Deciduous Swamps.

The Deciduous Forests were dominated by Red Oak, Sugar Maple, Eastern White Pine, and Basswood. Occasionally, Hop Hornbeam, Green Ash, and Choke Cherry were noted for the understory.

The herbaceous layer was a mix of Large-leaved Aster, Mayapple, and Rough Goldenrod.

The Deciduous Swamps were largely Red Maple and White Swamp Oak, with Green Ash and White Elm. The understory was Blue Beech and Highbush Blueberry, with Canada Mayflower, Swamp Dewberry, and Rough Goldenrod. A naturalized Eastern White Pine plantation was also noted for this site. There are a total of 120 recorded taxa for this study site.

This site is also in part designated as Silverdale PSW.

Name: Vaughan Forest
Formerly: Vaughan Forest (Brady, et al., 1980)
Site ID: WL-12-00-00-00-00
Municipality: West Lincoln
Size: 117 Hectares
Subwatershed: The majority of this study site drains to the Beaver Creek subwatershed with a portion in the east that drains to Black Ash Creek.
General Summary: This study site extends from Bismark Road in the north to just south of Vaughan Road in the south. Its western boundary is Caistor/ Gainsborough Townline Road and the eastern boundary is Port Davidson Road.
Summary: Field crews visited a small portion of this study site.

Drier areas were noted as Deciduous Forests dominated by White Oak, Sugar Maple, Red Oak, and White Ash. The understory was largely regenerating canopy species with Hop Hornbeam, and Maple-leaved Viburnum.

The herbaceous layer was characterized by Large-leaved Aster, Grasses, and Goldenrod. The wetter communities noted were classified as Deciduous Swamps and Thicket Swamps. The Deciduous Swamps were largely Green Ash and Red Maple, with Shagbark Hickory and White Elm.

The understory was mostly regenerating Green Ash with some Blue Beech. The ground layer was a mix of Spotted Touch-me-nots, Asters, and Goldenrod.

The Thicket Swamp communities were dominated by Buttonbush and Winterberry with occasional White Elm, Green Ash and Swamp White Oak.

The understory was Devil's Beggar-ticks and Narrow-leaved Meadowsweet with a ground layer of Liverwort, and Mosses. There are a total of 126 recorded taxa for this study site.

This site is also in part designated as Silverdale PSW.

Name: Garber's Grove
Formerly: Garber's Grove (Brady, et al., 1980)
Site ID: WL-15-00-00-00-00
Municipality: West Lincoln
Size: 291 hectares
Subwatershed: The northern portion of this study site drains to North Creek and the southern portion flows to Black Ash Creek. There are small slivers of this site that flow east to Parkers Creek and west to Beaver Creek.
General Summary: This study site is located between Townline Road to the north and Concession Four Road to the south. It extends from Caistor/ Gainsborough Townline Road in the west to Port Davidson Road in the east.
Summary: The most common community noted for this study site was Deciduous Swamp dominated by Red Maple or Swamp White Oak. Associated species included Green Ash, White Elm, and Shagbark Hickory.

The understory was a mix of regenerating canopy species with Blue Beech, Highbush Blueberry, Winterberry, and Serviceberry. The herbaceous layer consisted of Spotted Touch-me-not, Sedges, Asters, Swamp Dewberry, and Woodrush species.

The drier knolls and the upland communities within this study site were classified as Deciduous Forests dominated by Red Oak and White Oak, with American Beech, Sugar Maple, and the occasional Hop Hornbeam.

The understory was largely regenreating canopy species with Grey Dogwood. The ground layer was dominated by Large-leaved Aster, Pennsylvania Sedge, and Goldenrod species. There are a total of 221 recorded taxa for this study site.

This site is also in part designated as Winslow NE PSW.

Name: Comfort's Bush
Formerly: Comfort's Bush (Crady et al., 1980)
Site ID: WL-20-00-00-00-00
Municipality: West Lincoln
Size: 447 hectares
Subwatershed: The majority of this study site flows to the Fifteen Mile Creek subwatershed with a very small portion draining south to Welland River West.
General Summary: This study site is located between Sixteen Road to the north and Canborough Road to the south. It extends from Boyle Road/ Rosedene Road/ Moote Road in the west to Vineland Townline Road in the east.
Summary: The most common community noted for this study site was the Deciduous Swamp dominated by Red Maple, Swamp White Oak, Green Ash, and Pin Oak.

The understory was characterized by Blue Beech, Serviceberry, Winterberry, and Highbush Blueberry. The herbaceous layer was a mix of Spotted Touch-me-not. Reed Canary Grass, Canada Mayflower, Swamp Dewberry, Sessile-leaved Bellwort, Eastern Bracken Fern, and Large-leaved Aster.

The upland communities were Deciduous Forests dominated by White Oak, Red Oak, Red Maple, and Shagbark Hickory. The understory was characterized by Highbush Blueberry, Hawthorn, and Witch-hazel. The ground layer was a mix of Large-leaved Aster and Rough Goldenrod. There are a total of 156 recorded taxa for this study site.

This site is also in part designated as Highway 20 & 24 PSW.

Name: Beaver Creek
Site ID: WL-26-00-00-00-00
Municipality: West Lincoln
Size: 387 hectares
Subwatershed: The majority of this study site drains to the Beaver Creek subwatershed. There is a very small portion that drains north to an unnamed creek, and south to Welland River West.
General Summary: This study site closely follows Beaver Creek between Vaughn Road in the north and Canborough Road in the south. It extends from Caistor/Canborough Townline Road in the west to Wellandport Road in the east.
Summary: This study site is characterized by Deciduous Swamps that are associated with the floodplain of Beaver Creek. These swamp communities were dominated by Swamp White Oak, Swamp Maple, and Green Ash with some White Elm. The understory was a mix of Hawthorn, Gray Dogwood, Buttonbush, Winterberry, Narrow-leaved Meadowsweet, Blue Beech, and Willow.

The herbaceous layer was mostly Spotted Touch-me-not, Asters, Avens, and Reed-canary Grass. The transition zones between the swamp communities and the drier Deciduous Forests were classified as Meadow Marshes dominated by Reed-canary Grass.

The Deciduous Forests were largely dominated by Green Ash and White Elm with the same basic understory of Gray Dogwood, Hawthorn and Tartarian Honeysuckle. The ground cover was a mix of Avens and Goldenrod, with Garlic Mustard. There are a total of 74 recorded taxa for this study site.

This site is also in part designated as Winslow West Woodlot Area 3 and Beaver Creek PSW.

Name: Beaver Creek Headwaters
Site ID: WL-27-00-00-00-00
Municipality: West Lincoln
Size: 153 hectares
Subwatershed: This study site drains to an unnamed creek.
General Summary: The northern boundary of this study site is Vaughan Road and the southern boundary is Canborough Road. It extends from just west of Wellandport Road in the west to Heaslip Road in the east.
Summary: A very small portion of this study site was visited by NAI teams.

The most common community noted was Deciduous Swamp dominated by Red Maple, Basswood, Shagbark Hickory, and Green Ash. The understory was characterized by regenerating canopy species with Blue Beech. The herbaceous layer was a mix of Fowl Manna Grass, Asters, Spotted Touch-me-not, and Spotted Crane's-bill.

Other communities of note were Thicket Swamps dominated by Buttonbush, and Shallow Marsh communities dominated by Beggar-ticks.There are a total of 151 recorded taxa for this study site.

This site is also in part designated as Parker's Creek Headwaters PSW.

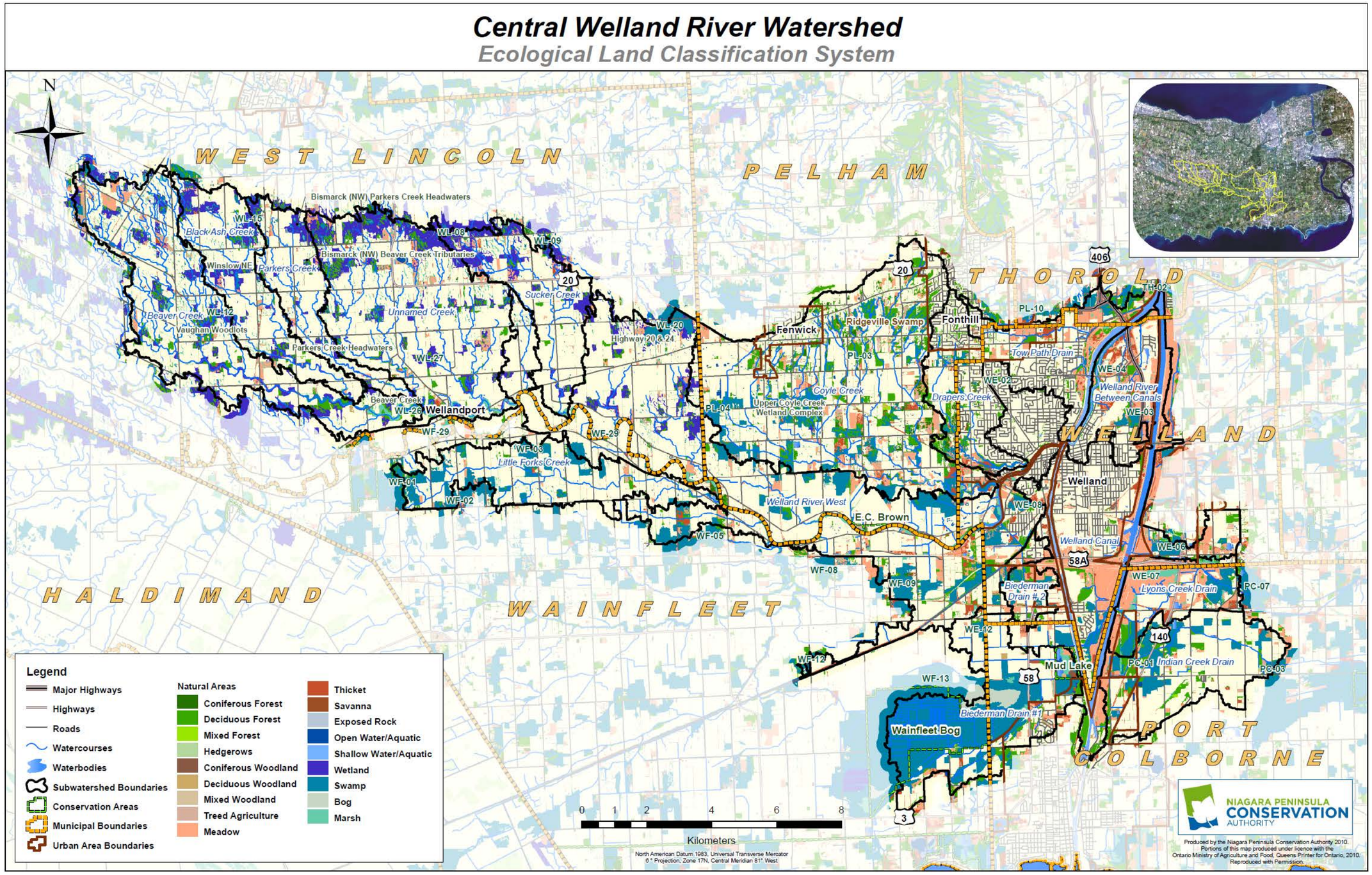


Figure 13: Ecological Land Classification System

Species at Risk

A Species at Risk is "*any plant or animal threatened by, or vulnerable to extinction"* (MNR No Date). In Ontario, species at risk are governed by two bodies; *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) and the *Committee on the Status of Species at Risk in Ontario* (COSSARO).

COSEWIC is an independent body responsible for identifying species that are considered to be at risk in Canada. COSEWIC reports their findings to the federal government. The federal government then determines which at-risk species qualify for protection under the *Species At Risk Act* (EC 2003). COSSARO is an independent review body made up of up to 11 members from the public and private sectors; at least 5 of the members must be non-OMNR members. A species status designation may differ from COSEWIC and COSSARO because their vulnerability changes depending on the geographic scale. All species status designations given by COSEWIC will also be given an equal or greater status designation by COSSARO; a higher status indicates that there is a greater concern for a species province-wide than nation-wide. In addition, a species may have been given a status designation by COSSARO and not from COSEWIC because there may only be a province-wide vulnerability.

In Ontario, over 185 native species have been given official status designations by the OMNR (OMNR No Date). Currently, several legislative and policy tools protect species at risk in Ontario. For instance, the *Provincial Policy Statement* (MMAH 2005) affords habitat protection for listed species by stating "*Development and site alteration shall not be permitted in: significant habitat of endangered species and threatened species"* (Section 2.1.3).

In May 2007, *Bill 184,* Ontario's new *Endangered Species Act, (*MNR 2007) made it to Royal Ascent in Ontario. It replaced Ontario's previous *Endangered Species Act* (1971) in June 2008. *Bill 184* states:

"*If a species is listed on the Species at Risk in Ontario List as an endangered or threatened species, the Bill prohibits damaging or destroying the habitat of the species. This prohibition also applies to an extirpated species if the species is prescribed by regulations. The regulations may specifically prescribe an area as the habitat of a species but, if no habitat regulation is in force with respect to a species, "habitat" is defined to mean an area on which the species depends, directly or indirectly, to carry on its life processes*".

The OMNR status definitions for species designations range from extinct (no longer exists anywhere) to data deficient (insufficient information for status recommendation). In the Central Welland River Watershed Plan study area, endangered, threatened and species of special concern have been documented by the OMNR and the NPCA (Table 3).

Table 3: Listed Species at Risk in the Central Welland River Watershed				
COSEWIC Status (Federal)	**COSSARO Status (Provincial)**	**Taxon**	**Common Name**	**Scientific Name**
Endangered-R	Endangered-R	Vascular Plants	Spotted Wintergreen	*Chimaphila maculata*
Endangered	Endangered-R	Vascular Plants	Cucumber Tree	*Magnolia acuminata*
Endangered	Endangered	Vascular Plants	Butternut	*Juglans cinerea*
Endangered	Endangered	Vascular Plants	Flowering Dogwood	*Cornus florida*
Endangered	Endangered	Vascular Plants	American Chestnut	*Castanea dentata*
Endangered	Special Concern	Reptiles	Spotted Turtle	*Clemmys guttata*
Threatened	Threatened	Vascular Plants	Common Hop Tree	*Ptelea trifoliata*
Threatened	Threatened	Reptiles	Eastern Ratsnake	*Elaphe obsoleta*
Threatened	Threatened	Birds	Least Bittern	*Ixobrychus exilis*
Threatened	Threatened	Reptiles	Massasauga Rattlesnake	*Sistrurus catenatus*
Threatened	Threatened	Vascular Plants	Round-leaved Greenbrier	*Smilax rotundifolia*
Threatened	Threatened	Reptiles	Stinkpot	*Sternotherus odoratus*
Threatened	Threatened	Vascular Plants	White Wood Aster	*Eurybia divaricata*
Threatened	Threatened	Reptiles	Blanding's Turtle	*Emydoidea blandingii*
Threatened	Threatened	Reptiles	Eastern hog-nosed Snake	*Heterodon platirhinos*
Threatened	Threatened	Mammals	Grey Fox	*Urocyon cinereoargenteus*
Threatened	No Status	Molluscs	Mapleleaf Mussel	*Quadrula quadrula*
Special Concern	Special Concern	Fishes	Bigmouth Buffalo	*Ictiobus cyprinellus*
Special Concern	Special Concern	Vascular Plants	Broad Beech Fern	*Phegopteris hexagonoptera*
Special Concern	Special Concern	Reptiles	Eastern Ribbonsnake	*Thamnophis sauritus*
Special Concern	Special Concern	Reptiles	Eastern Milk Snake	*Lampropeltis triangulum*
Special Concern	Special Concern	Fishes	Grass Pickerel	*Esox americanus vermiculatus*
Special Concern	Special Concern	Vascular Plants	Swamp Rose-mallow	*Hibiscus moscheutos*
Special Concern	Special Concern	Mammals	Woodland Vole	*Microtus pinetorum*
Special Concern	Special Concern	Birds	Yellow-breasted Chat	*Icteria virens virens*
No Status	Special Concern	Birds	Black Tern	*Chlidonias niger*
Special Concern	Special Concern	Birds	Short-eared Owl	*Asio flammeus*

The definitions for these status designations by the OMNR are as follows:

- **Extirpated:** *A native species that no longer exists in the wild in Ontario, but still exists elsewhere*
- **Endangered (Regulated)**: *A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act*
- **Endangered (Not Regulated)**: *A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's Endangered Species Act*
- **Threatened:** *A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed*
- **Special Concern:** *A species with characteristics that make it sensitive to human activities or natural events*

Eastern Massasauga Rattlesnake

The massasauga rattlesnake was designated as a *threatened* species in 1991 by COSEWIC. The massasauga rattlesnake is the only venomous snake in Ontario. It is brownish red to grey in colour with dark brown to black markings along its back and side with a black belly and a rattle at the tip of its tail. Threats to its survival include habitat loss, including fragmentation of habitat caused by development, accidental killing by farming activities and human persecution. This species can be found in the Wainfleet Bog area; one of only 4 areas where they can be found in Ontario. Efforts are being made by numerous organizations to help protect the small isolated Wainfleet Bog populations and the Wainfleet Bog. Recovery initiatives include for example, data collection; restoration of bog water table and water level monitoring; restoration of bog plant communities and bare peat extracted communities; and public education (Canadian Eastern Massasauga Rattlesnake Recovery Team 1996)

In addition to the listed endangered, threatened and species of special concern, numerous provincially rare species have also been documented by the OMNR and the NPCA within the Central Welland River Watershed Plan study area (Table 4).

Table 4: Provincially Rare Species in the Central Welland River Watershed	
Common Name	**Scientific Name**
Black Gum	*Nyssa sylvatica*
Cyrano Darner	*Nasiaeschna pentacantha*
Halbeard-leaved Tear-thumb	*Polygonum arifolium*
Honey Locust	*Gleditsia triacanthos*
Northern Water Snake	*Nerodia sipedon*
Panicled Hawkweed	*Hieracium paniculatum*
Perfoliate Bellwort	*Uvularia perfoliata*
Pin Oak	*Quercus palustris*
Red-root Flatsedge	*Cyperus erythrorhizos*
Shellbark Hickory	*Carya laciniosa*
Southern Tickseed	*Bidens trichosperma*
Toadflax	*Nuttallanthus canadensis*
Tufted Titmouse	*Baeolophus bicolor*
Unicorn Clubtail	*Arigomphus villosipes*
White-eyed Vireo	*Vireo griseus*
Yellow Ladies'-tresses	*Spiranthes lucida*
Yellow Screwstem	*Bartonia virginica*

Aquatic Habitat

In Canada, the *Fisheries Act* [Department of Fisheries and Oceans (DFO) R.S. 1985, c. F-14] was established to protect and manage Canada's fisheries resources. The Act applies to all fishing zones; territorial and inland waters. As federal legislation, should a conflict arise between the *Fisheries Act* and provincial legislation, the *Fisheries Act* takes precedence. Although management of fish habitat falls under the authority of the federal government, the federal government has *„essentially no control over the use of inland waters, beds of watercourses or shorelines which fall under provincial jurisdiction. Alternatively, the provinces cannot make regulatory decisions concerning fish habitat* (DFO 1999)*'*.

Section 35 of the Fisheries Act is the prime focus of the Fisheries Act. This section is a *„general prohibition of harmful alteration, disruption or destruction (HADD) of fish habitat'*. Therefore, any project, work or undertaking that results in a HADD situation would result in a breach of this section of the Act and could result in a fine up to one million dollars, imprisonment or both.

Fish Community Studies

The Ontario Ministry of Natural Resources conducted fish community surveys from 2003 to 2007 throughout the Niagara River watershed, of which the Welland River and its tributaries are a part of. The purpose of the study was to characterize the resident fish community within the Niagara River and its tributaries. The Niagara River Watershed is divided into 10 Aquatic Resource Areas (ARA) as a result of natural and anthropogenic influences. Two ARA's fall within the Central Welland River watershed; Welland River Between the Canals, and Welland River West.

The Welland River Between Canals ARA is 5.4 km long and is situated between two river diversion structures called siphons, one at each end (Yagi and Blott 2008). The summer habitat in this ARA is characterized by clear, Lake Erie water flow supplied from

the bottom of the canal, clear discharge water from the municipal water treatment plant, and discharge from the sewage treatment plant (Yagi and Blott 2008).

According to Yagi and Blott (2008) this section of the Welland River is unique because it is connected to the Lake Erie system at 2 locations; at the Fourth Canal syphon and through the new syphon to the confluence of the Power Canal and Chippawa canal. Yagi and Blott also report that this double connection means Lake Erie fish can theoretically enter the river actively or passively via the holes in the bottom of the Fourth Canal or actively by swimming upstream through the new siphon. The Lake Erie connection is reflected in the fish community (Table 5).

The Welland River West ARA extends from the Fourth Welland Canal upstream to the Port Davidson weir. The connection with the Fourth Welland Canal, as previously described, allows Canal water (Lake Erie water) to flow into the Welland River. Yagi and Blott (2008) report that the "*ebb and flow of water from the canal acts to improve water quality through dilution for a 2 km section of river just west of the canal. It also acts to prevent upstream flows and sediments from discharging during the summer months for the remaining 28km of channel because there is insufficient channel flow to offset the augmented canal flow and keep a positive downstream gradient during the low flow seasons (summer and winter)"*. The fish community differences are evident in this unique ARA (Table 5).

Significant Fish Species

One of the fish species identified in the Central Welland River watershed is considered "at risk"; river redhorse. River redhorse has been designated as species of *„special concern'* by COSEWIC and COSSARO.

Fish Habitat

Fish habitat falls into 1 of 3 categories in Niagara: Type 1, Type 2 or Type 3 (OMNR 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 (OMNR 2000).

Fish habitat type in the Central Welland River watershed has been delineated according to the MNR stream classification data. These areas are depicted on Figure 14 as critical habitat (Type 1), important habitat (Type 2) and marginal habitat (Type 3). As illustrated, the main channel of the Welland River, a portion of Coyle Creek and the western branch of Drapers Creek have all been classed as critical fish habitat. The majority of the remaining watercourses in the Central Welland River watershed have been classed as important fish habitat, aside from the Welland Canal and the network of drainage ditches in the Wainfleet Bog which have been classes as marginal fish habitat.

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Table 5: Identified Fish Species in Central Welland River Watershed							
	Welland River Between Canals				Welland River West		
	November 2007	August 2005	August, September 2004	Late October 1997	August 2005	August 2004	August 1997
Bowfin	●		●	●	●	●	●
Gizzard Shad	●	●		●	●	●	●
White Sucker	●	●	●	●	●		●
Bigmouth Buffalo	●			●	●	●	●
Golden Redhorse		●					
Shorthead Redhorse		●	●	●	●	●	●
Greater Redhorse				●			
River Redhorse *SC*	●						
Redhorse sp.	●					●	
Black Bullhead	●		●				
Banded Killfish				●			
Yellow Bullhead					●	●	●
Brown Bullhead	●	●	●	●	●	●	●
Channel Catfish		●		●	●	●	●
Tadpole Madtom					●		
Johnny Darter	●		●	●	●		
Logperch	●				●		●
Brook Silverside	●	●			●	●	●
Freshwater Drum		●		●	●	●	●
White Perch				●	●	●	●
Golden Shiner	●	●	●	●	●	●	●
Emerald Shiner	●	●		●	●	●	●
Common Shiner	●		●			●	
Spottail Shiner		●	●	●			
Bluntnose Shiner	●	●	●	●	●	●	●
Fathead Minnow		●	●				
Rock Bass	●	●	●	●	●	●	●
Green Sunfish	●	●	●	●	●	●	●
Pumpkinseed	●	●	●	●	●	●	●
Bluegill	●	●	●	●	●	●	
Northern Pike	●	●	●	●	●	●	●
Smallmouth Bass	●	●	●	●			
Largemouth Bass	●	●	●	●	●	●	●
White Crappie			●	●	●	●	●
Black Crappie	●	●	●	●	●	●	●
Yellow Perch	●	●	●	●	●	●	●
Muskellunge	anecdotal						
Walleye	●				●	●	
Rainbow Trout	●						
Alewife				●			
Round Goby			●				
Rainbow Smelt				●			
Goldfish					●	●	●
Common Carp	●	●	●	●	●	●	●
Rudd							
Total	***28***	***23***	***23***	***29***	***29***	***27***	***25***

Source: Niagara River Watershed Fish Community Assessment (2003 to 2007)

Native Minnow Family
Sunfish Family (Other than sportfish)
Native Sportfish
Exotic Species, including exotic sportfish
Sucker Family
** Species at Risk

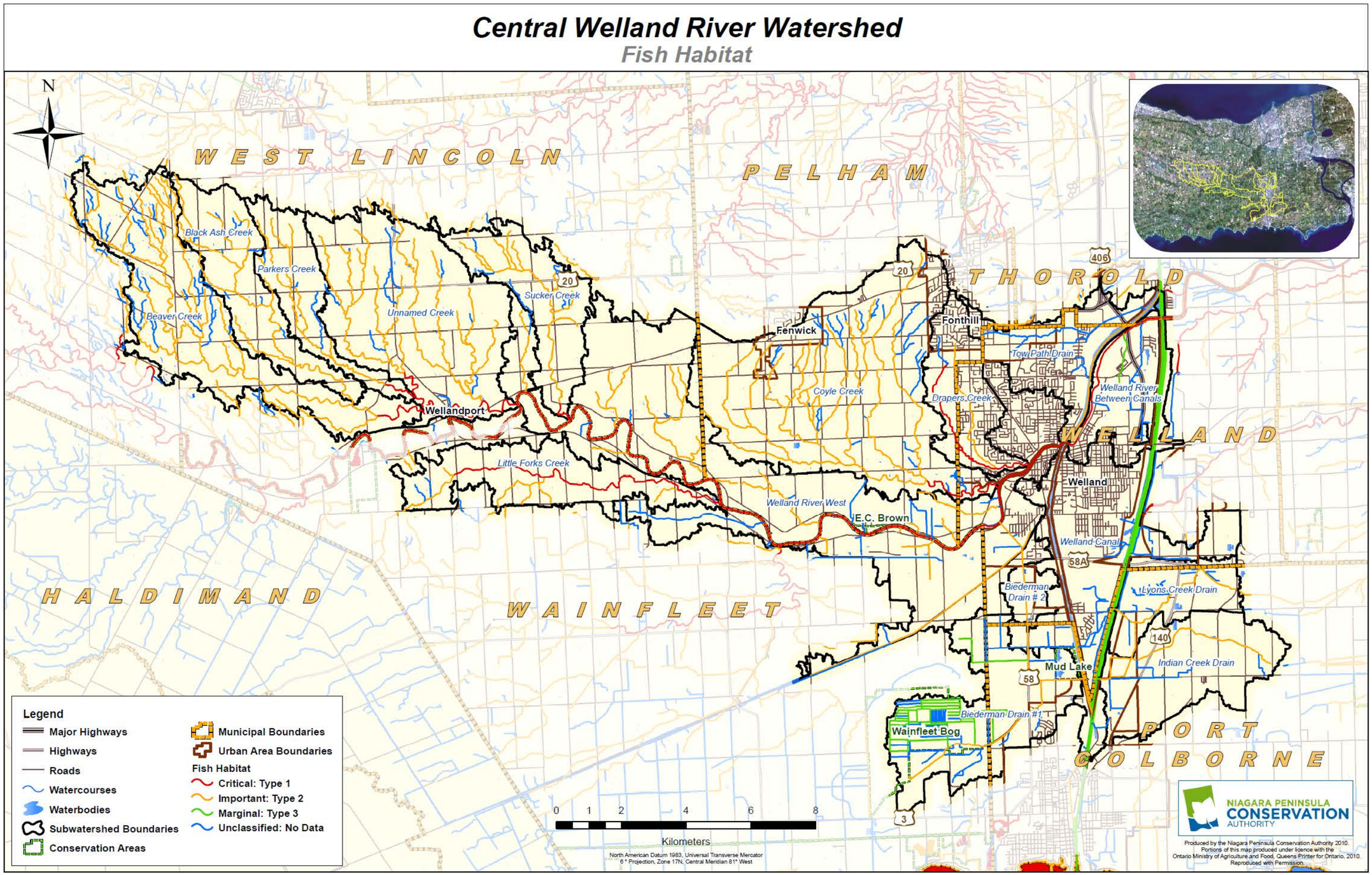

Figure 14: Fish Habitat

Some watercourses have not been formally classified in terms of significance for fish habitat, and therefore have been assigned an unclassified designation. Despite the unclassified designation, these watercourses still may provide or contribute to fish habitat and should be formally classified as required for development applications

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*."

Numerous municipal drains exist in the Central Welland River watershed (Figure 15). 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 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.

In the Central Welland River watershed, over 100 kilometres of watercourses have been classified as municipal drains. The drainage classifications range from Class B to Class F; the majority have a Class F designation (Table 6).

Table 6: Municipal Drains

Class	Drain Name	Subwatershed
B	Little Forks Creek Drain (east of Robertson Road)	Little Forks Creek
B	Biederman Drain South Branch A	Biederman Drain #1
C	Swayze Drain(south of Foss Road)	Coyle Creek
E	Biederman Drain and South Branch B	Biederman Drain #1
E	Black Ash Creek Drain	Black Ash Creek
E	Big Creek Drain	Coyle Creek
E	Ridgeville Drain East Branch and West Branch	Coyle Creek
E	Ridgeville Drain West Branch(south of Foss Road)	Coyle Creek
F	Little Forks Creek Drain (west of Robertson Road)	Little Forks Creek
F	George Traver Drain, Indian Creek Drain	Little Forks Creek
F	Ridgeville Drain West Branch(north of Foss Road)	Coyle Creek
F	Disher Drain, Nunn Drain	Coyle Creek
F	Swayze Drain (north of Foss Road)	Coyle Creek
F	Wilson Drain and Skelton Drain	Biederman Drain #1
F	Cooks Drain	Welland Canal
F	Bridgewater Drain	Welland River West
F	Hilbing Drain	Welland River West
F	Lyons Creek Drain	Lyons Creek Drain
F	Indian Creek Drain, Ramey Drain, Haun Drain	Indian Creek Drain

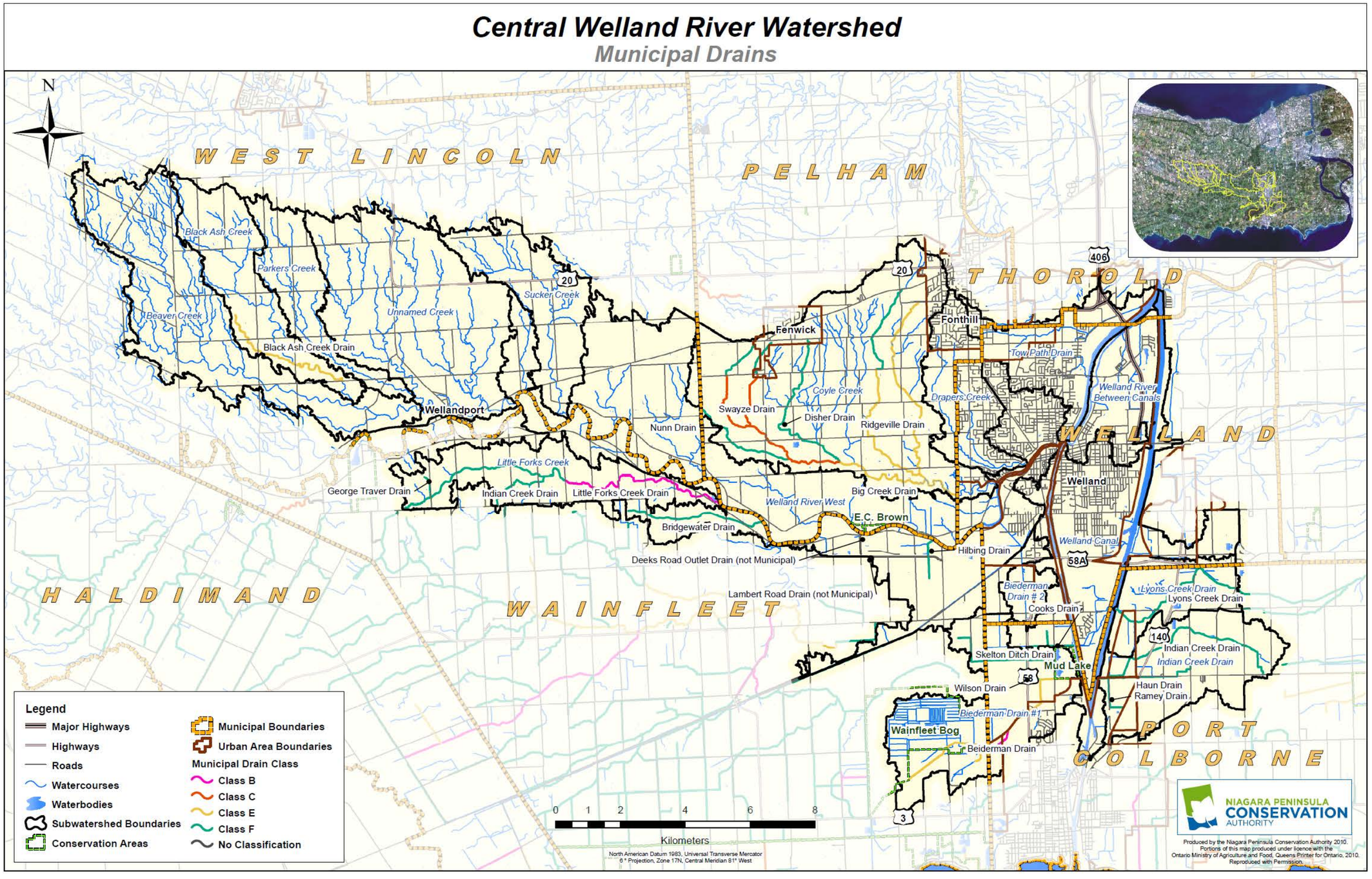

Figure 15: Municipal Drains

Water Quality

NPCA Water Quality Monitoring Program

The Ontario Ministry of Environment has established a set of *Provincial Water Quality Objectives* (PWQO) that are intended to be used to guide respective agencies when making water quality management decisions. The surface water quality management goal is "*To ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation"* [MOE 1994 (Section 3.1)]. Table 7 summarizes indicator parameters that are the most useful in assessing relative stream water quality. They include: total phosphorus, nitrate, copper, lead, zinc, *Escherichia coli*, chloride, suspended solids and benthic invertebrates (NPCA 2010c). These parameters are useful indicators but other non-chemical factors such as for example, loss of habitat, sedimentation, and indigenous species must also be considered when assessing ecosystem health.

Table 7: Water Quality Parameters (as modified from NPCA 2010c)

Category	Indicator Parameter	Objective	Reference
Nutrients	Total Phosphorus	0.03 mg/L	PWQO (MOE 1994)
Nutrients	Nitrate	13 mg/L	CWQG (CCME 2007)
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 2005)
Other	Suspended Solids	25 mg/L	BC MOE (2001)
Biological	Benthic Invertebrates	Unimpaired	BioMAP (Griffiths1999)

The Water Quality Index (WQI) is used by the NPCA to summarize water quality data collected from NPCA surface water quality monitoring stations for reporting and communication purposes. The WQI was developed by a sub-committee established under the Canadian Council for Ministers of the Environment (CCME) Water Quality Guidelines Task Group to provide a convenient means of summarizing complex water quality information and communicating it to the public (CCME 2001). The WQI incorporates the number of parameters where water quality objectives have been exceeded, the frequency of exceedances within each parameter, and the amplitude of each exceedance (NPCA 2010c). The index produces a number between 0 and 100 which represents the worst and best water quality, respectively. These numbers are divided into five descriptive categories that range from *poor* to *excellent* (Table 8).

Table 8: CCME Water Quality Index Categories (CCME 2001)		
Category	**Water Quality Index**	**Description**
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Surface water quality is monitored at 5 stations by the NPCA in the Central Welland River watershed through the collection of grab samples on a monthly basis during the ice-free season (Figure 16). Welland River monitoring stations WR007 and WR010 are operated in partnership with the MOE as part of the Provincial Water Quality Monitoring Network. Tributary stations BV001, CO001, and DR001 are located at the watershed outlets to capture the cumulative water quality impacts for their respective drainage areas. Benthic invertebrate samples are collected during the spring and fall using the BioMAP protocol to assess water quality.

The summarized water quality data from 2001 to 2009 reports a water quality rating of poor for the Beaver Creek BV001 and Drapers Creek DR001 stations with concentrations of *E. coli* that routinely exceed provincial objectives for surface water quality (Table 9). Samples obtained from Coyle Creek station CC001 indicate that water quality is marginal with frequent exceedances of total phosphorus, *E. coli* and suspended solids. This is an improvement from the 2006 sample season at station CC001 which reported a poor water quality rating (NPCA 2007a). Sources of *E. coli* in these subwatersheds include runoff from urban and agricultural land use, sewage discharges, and the presence of waterfowl (NPCA 2010c).

Samples obtained from Welland River station WR007 received a water quality rating of poor with exceedances of nitrate and total phosphorus. Algae is observed at this site during summer months and this site is also invaded by non-native zebra mussels. Samples obtained from Welland River station WR010 received a water quality rating of marginal with concentrations of total phosphorus and *E. coli* that exceed the applicable federal and provincial guidelines and objectives for surface water quality. The best water quality rating for the Welland River is observed at this station where water quality is improved by direct mixing of water from inflow from the Niagara River as it is redirected up the Welland River as part of the hydroelectric operations (NPCA 2010c).

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.

For the analysis, the number and assortment of animals found at each site are used to calculate the biological metrics and indices for the biological assessment. These indices and metrics are used to convert biological data into a measure of water quality. This allows for the determination of water quality at a sample site and for cross comparison against other equivalent watercourses. Water quality results can then be classified as *impaired* or *unimpaired*. *Unimpaired* sites consist of animals that are susceptible to environmental pressures; in turn finding these animals in a water system implies the system has limited environmental stresses. *Impaired* sites consist mainly of organisms that are more tolerant to environmental stressors and typically do not include animals that are historically found. A *grey-zone* designation is for those sites which cannot be clearly defined as *impaired* or *unimpaired*

Benthic invertebrate samples are collected during the spring and fall at 4 of the 5 stations in the Central Welland River Watershed study area using the BioMAP protocol to assess water quality. Results from all stations report impaired water quality (Table 9). Sediment loading, lack of instream habitat, and nutrient enrichment are the primary causes of impairment at all stations (NPCA 2010c).

Table 9: Summarized Water Quality Data Monitored by the NPCA from 2002 to 2009

Station	Water Quality Index	BioMAP Rating	Factors Affecting Water Quality
Beaver Creek BV001	Poor	Impaired	• Exceedances of *E. coli* and total phosphorus • Algae observed during summer months
Coyle Creek CO001	Marginal	Impaired	• Exceedances of *E. coli*, total phosphorus and suspended solids • High sediment loading evident from upstream erosion and runoff • Evidence of nutrient enrichment • Site invaded by non-native Zebra Mussels • Adequate upstream forest and riparian buffer
Drapers Creek DR001	Poor	Impaired	• Exceedances of *E. coli* and total phosphorus • High sediment loading evident from upstream runoff • Site vulnerable to contaminants in runoff from urbanized sections of the watercourse and urban encroachment • Algae observed during summer months
Welland River WR007	Poor	Impaired	• Exceedances of nitrate and total phosphorus • Algae observed during summer months • Site is invaded by non-native Zebra Mussels
Welland River WR010	Marginal	n/a	• Exceedances of *E. coli* and total phosphorus • BioMAP assessment not completed due to access restrictions

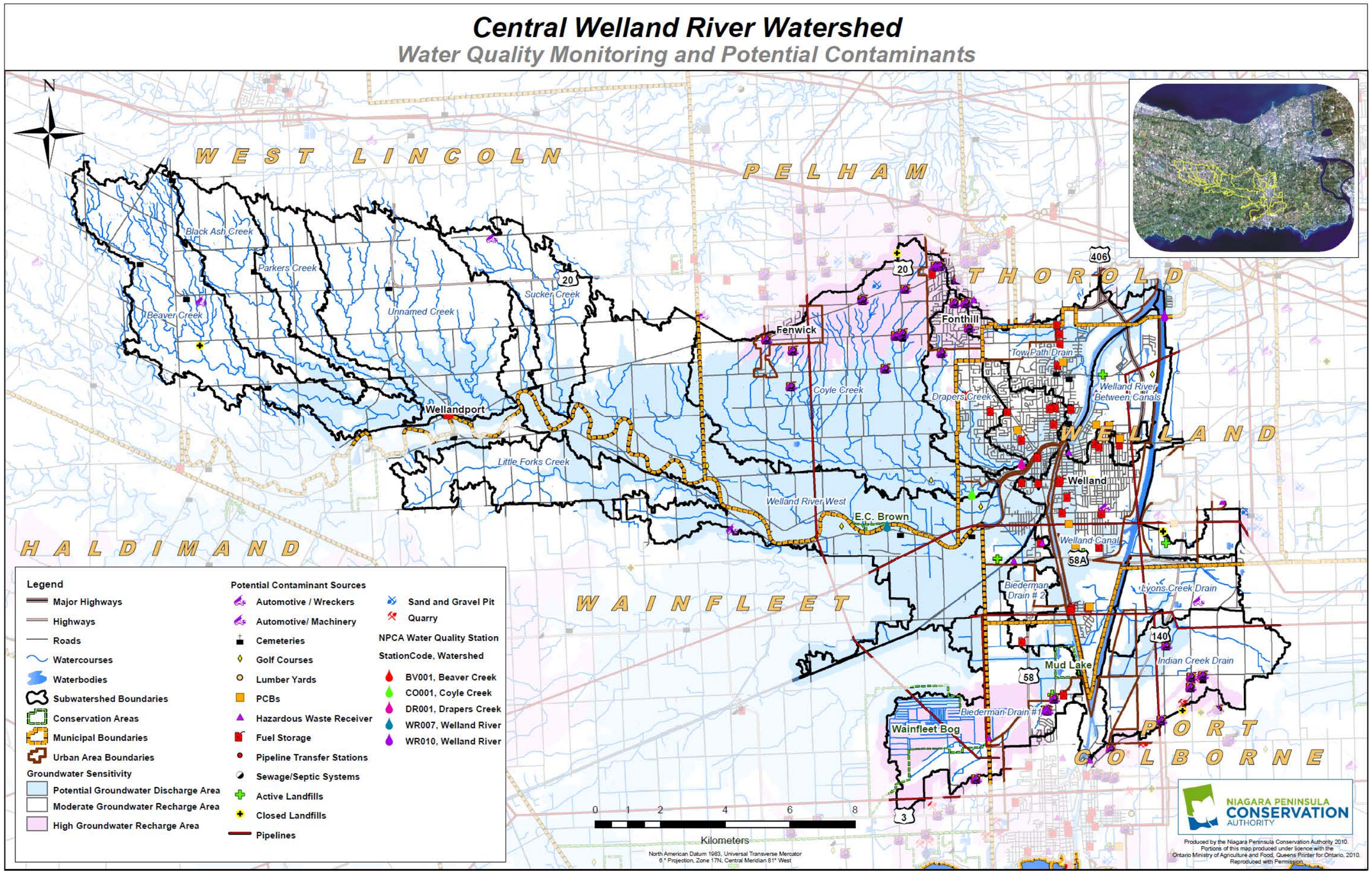

Figure 16: Water Quality and Potential Contaminants

Welland River Eutrophication Study

In 2008, the NPCA, MOE and EC initiated a 3 year study as part of the Niagara River Remedial Action Plan*; The Welland River Eutrophication Study* is slated for completion in March 2011. The study was initiated in response to the technical review of Beneficial Use Impairments and delisting criteria identified in the *Niagara River RAP Stage 2 Update Report.* The primary objectives of this study are to:

- Characterize the biological response of the Welland River to high phosphorus inputs including the type, frequency, location, and timing of algal blooms, and whether oxygen depletion is occurring in relation to aquatic plant or algae overgrowth;
- Characterize concentrations of plant-available phosphorus versus sediment-bound phosphorus along the length of the Welland River;
- Develop delisting criteria for the Welland River upstream of the Old Welland Canal;
- Develop phosphorus loading targets for different subwatersheds of the Welland River upstream of the Old Welland Canal to meet delisting criteria; and
- Monitor success in meeting ambient targets for the Welland River through alterations to the existing AOC Tributary Monitoring Program (NPCA 2010).

Monthly grab samples were collected by the NPCA at 23 monitoring stations throughout the Welland River watershed from April to November and sent to accredited labs for analysis. All grab samples were analyzed for nutrients, metals, bacteria, suspended solids, general chemistry, chlorophyll-a, and as a quality assurance/quality control measure additional samples were sent to the MOE lab for a phosphate analysis (NPCA 2010a).

In terms of total phosphorus (TP) and phosphate concentrations for samples collected during the 2008 and 2009 sampling seasons, *the Welland River Eutrophication Study Update Report: February 2010* reports a notable increase in both TP and phosphate in response to wet weather events. In regards to stations that fall within the Central Welland River Watershed Plan study area, the *Update Report* indicates that Drapers Creek (DR001) is observed to be the least responsive to wet weather events and Beaver Creek (BV001) was found to have the highest peak TP concentration observed during the August 2009 wet weather event (NPCA 2010a). In addition, "*phosphate concentrations are observed to increase sharply in the Welland River between WR004 and WR005* (upstream of CWR). *This increase in phosphate concentrations continues downstream and peaks at station WR007 before decreasing at station WR010 due to mixing with the Niagara River*" (NPCA 2010a).

Four dissolved oxygen (DO) sensors were also positioned within the study area to assess the diurnal DO variations in the Welland River and Oswego Creek. The *Update Report* reports that similar to the phosphorus data, there is an observed response in the DO data to the August 2009 rain event indicating that runoff contributed a high organic load resulting in DO depletion at these locations (NPCA 2010a). It was also noted that "the *observed decline in DO concentrations downstream of WR005 roughly coincides with the increased TP and phosphate concentrations"* (NPCA 2010a).

Groundwater Resources

In 2005, a *Groundwater Study* [Waterloo Hydrogeologic Inc. (WHI) 2005] was completed for the land area within the jurisdiction of the NPCA. This study was a key component for planning and implementing measures to protect the sources of water for use by the residents of the Niagara Peninsula.

The *Groundwater Study* provides baseline data that outlines threats, potential threats and impacts to the areas groundwater resources. The study includes a series of maps illustrating recharge/discharge areas, well locations, overburden thickness, bedrock types, groundwater use, contaminant sources, and groundwater susceptibility to contamination.

In addition, the identification of vulnerable areas that require protection from possible threats is also critical to protecting our drinking water; accordingly this mapping exercise was also conducted through the Source Water Protection program. The delineation of vulnerable areas produced through the Source Water Protection program is comparable to the mapping produced through the 2005 Groundwater Study for the Central Welland River watershed, aside from the addition of shallow bedrock vulnerability and transport pathways. Transport pathways that were considered to increase groundwater vulnerability include private water wells (including unused wells needing decommissioning), „unknown' status oil and gas wells, aggregate operations, and construction activities along the Welland Canal (NPCA 2010b)

Potential groundwater recharge and discharge areas are identified on Figure 16. 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 in the Central Welland River watershed have been identified in areas north of the Onondaga Escarpment and surrounding lowlands and the Welland River valley. The potential height of the water table ranges between 0 and 30 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 Central Welland River watershed, potential recharge areas are located along the Onondaga Escarpment and on the southern slopes of the Fonthill Kame-Delta Complex in Pelham on the northern cusp of the Central Welland River watershed study area. Water that infiltrates to the water table may carry contaminants with it. Therefore, these areas are considered groundwater sensitive.

Figure 17 illustrates areas with high, medium and low groundwater vulnerability. The Central Welland River watershed has been delineated as having a predominately low groundwater vulnerability due to the thick deposits of clay and silt of the Haldimand Clay Plain. Areas along the Onondaga Escarpment where there are bedrock outcrops have been delineated as having a high groundwater vulnerability due to the thin overburden and the porous limestone of the Onondaga Formation; openings in fractured bedrock allow for the direct passage of surface water and contaminants to groundwater resources. The Fonthill Kame-Delta Complex has also been delineated as having a high groundwater vulnerability due to the high permeability of the overburden.

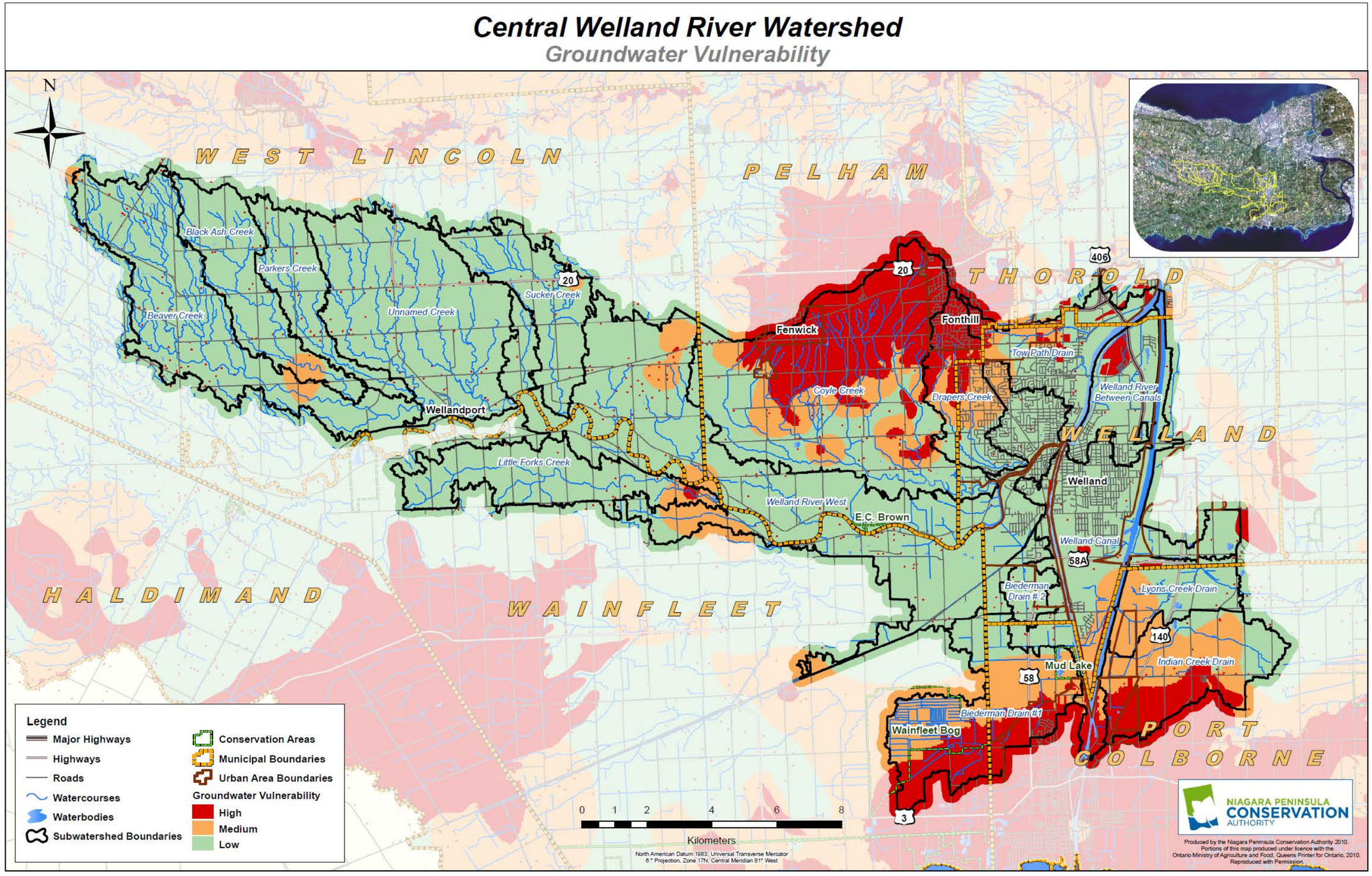

Figure 17: Groundwater Vulnerability

Areas of medium groundwater vulnerability are found north of the Onondaga Escarpment and south of the Fonthill Kame-Delta Complex where the overburden exceeds a thickness value of 50 meters above the bedrock. The red and orange areas illustrated on Figure 17 are considered vulnerable to groundwater contamination due to the presence of permeable soils and/or the shallow depth of the groundwater table. Under the *Clean Water Act*, (MOE 2006b), vulnerable groundwater areas that fall within an Intake Protection Zone will be protected under the *Source Protection Plan*.

Intake Protection Zone Study

All Ontarians have the right to clean water, not only for recreational purposes but also for bathing, drinking and cooking. In Ontario over 80 percent of the population receives their drinking water from municipal sources (O'Connor 2002). In Ontario, the provincial government launched a *Source Water Protection* program to address the need for better protection of water resources from contamination or overuse. A facet of source water protection was the passage of the *Clean Water Act* (CWA) in 2006 by the provincial government. The purpose of the *CWA* (MOE 2006b) is to protect existing and future sources of drinking water supplies.

Accordingly, the RMN has completed a *Surface Water Vulnerability Study* for each of its 6 municipal Water Treatment Plant (WTP) intakes; the Welland intake falls within the Central Welland River Watershed Plan study area. The Welland WTP is located in the area where the Welland River passes through a set of siphons under the Welland Recreational Canal. The Welland WTP obtains its source water from the Welland Recreational Canal, which in turn is supplied by water from Lake Erie via the present Welland Canal.

The main focus of the *Surface Water Vulnerability Study* was to characterize the aquatic and upland features of the area surrounding the WTP intake, delineate the Intake Protection Zone (IPZ) around the intake, and assess the vulnerability of this intake to drinking water threats that are located within the IPZ.

The *CWA (2006b)* required the Conservation Authorities across Ontario to establish source protection committees under the guidance of the provincial government with the Chairman of the committee being appointed directly by the province. There are 19 Source Protection Regions/Areas established in Ontario, each with a respective Source Protection Committee. The work of the committee includes mapping vulnerable areas around municipal drinking water sources, identifying and assessing risks to municipal drinking water, and ultimately developing and implementing plans for safeguarding rivers, creeks and other sources of surface and ground water for municipal drinking water supplies within their geographic jurisdictions. Therefore, all 6 *Surface Water Vulnerability Study[s]* are being used by the Niagara Peninsula Source Protection Committee (NPSPC) to prepare an *Assessment Report* (AR) and a *Source Protection Plan* (SPP) which are required under the *CWA* (MOE 2006b).

The purpose of the *AR* (NPCA 2010b) is to assess the quality and quantity of municipal drinking water supplies across the source protection area. The *AR* identifies significant threats including potential future threats that could impact our drinking water sources (NPCA 2010b). Based on the analysis for the Welland IPZ area, there are no significant threats in the IPZ zone immediate surrounding the intake. This intake does not have an IPZ-2 zone.

Upon approval of the *Proposed Assessment Report* by the MOE, the report will be used to prepare a *Source Protection Plan*. The purpose of the *SPP* is to eliminate or reduce significant threats to municipal drinking water sources that are identified in the *AR* (NPCA 2010b). The *SPP,* which should be completed by 2012, may require municipalities to restrict future land use activities within the area of the Intake Protection Zone, in order to protect the municipal drinking water source (Wright 2007). The *SPP* "*could use various types of policies ranging from outreach and education to incentive plans to risk management plans or even prohibition of certain activities"* (NPCA 2010b).

The *CWA* (MOE 2006b) also requires that decisions made under the *Planning Act* or the *Condominium Act* (MMAH 1990,1998) shall conform to the significant threat policies and designated Great Lakes policies set out in the SPP's; the *Source Protection Plan* „prevails' in the case of a conflict with official plans and zoning by-laws, although subject to "*the provision that provides the greatest protection to the quality and quantity of any water that is or may be used as a source of drinking water prevails"* (MOE 2006b, CWA Section 39). Therefore, while no policies are in place yet, once the *SPP* is approved, it could restrict future land use activities within the areas of the Intake Protection Zones.

Water Quantity

Water Budget

Under the *CWA* (MOE 2006b), one of requirements of the Assessment Report Technical Rules is that each Source Protection Region/Area must complete a Tier 1 Water Budget. The purpose of the Tier 1 Water Budget in Niagara Peninsula is to:

- Estimate the hydrologic stress of each watershed planning area in order to screen out areas that are unstressed with respect to water quantity
- Highlight areas where the reliability of water supplies is questionable
- Delineate significant groundwater recharge areas

The Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment (NPCA 2010e) contains an analysis of the water inflows and outflows within each watershed planning area, for example, the Central Welland River Watershed Plan study area. The inflows include precipitation, lateral groundwater inflows, surface water inflows from upstream catchments, and water diversions (such as those from Welland Canal). Outflows include evapotranspiration, surface water discharges (e.g. Beaver Creek into Welland River), water takings by industry, residences and agriculture, and lateral groundwater outflow.

A *Water Availability Study* (WAS) (AquaResource Inc 2009) was completed for each watershed planning area by analyzing the inflows and outflows using computer models. The purpose of the *WAS* was to determine the water available for surface water flow, groundwater recharge and evapotranspiration on a monthly basis for the time period 1991 to 2005. This time period was chosen to best suit available datasets and meet the minimum World Meteorological Organization climate normal criterion of fifteen years.

Once the *WAS* were completed, the Tier 1 Water Budget focused on anthropogenic water takings and water consumption, to determine if the watershed planning area is stressed hydrologically. *The Tier Water Budget and Water Quantity Stress Assessment* (NPCA 2010e) ties in the *Water Availability Study* and a Stress Assessment. The report

includes a watershed characterization (climate, topography, geology, physiology, land cover, soils, streamflow), watershed modelling (model set-up, calibration, verification, sensitivity, results, and uncertainty), water taking analysis and stress assessment, as well as conclusions and recommendations. The Stress Assessment was completed for both surface water systems and groundwater systems; these assessments were conducted separately. A system is considered moderately or significantly stressed if the demand exceeds a provincial benchmark threshold value Table 10 (NPCA 2010e).
The Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment (NPCA 2010e) identified the Central Welland River watershed as having a moderate surface water stress level based on provincial benchmark threshold values (Table 10). A moderate stress level is assigned to surface water systems where the maximum monthly water demand consists of 20% to 50% of the surface water supply. The Central Welland River was also identified as having a low groundwater stress level. A low stress level is assigned to groundwater systems where the demand for monthly maximum ranges between 0 to 25% or the average annual is between 0 to 10% of the groundwater supply.

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Table 10: Provincial Benchmark Threshold Values		
Potential for Surface Water Stress Thresholds		
Stress Level Assignment	**Maximum Monthly % Water Demand**	
Significant	> 50%	
Moderate	20% to 50%	
Low	< 20%	
Potential for Groundwater Stress Thresholds		
Stress Level Assignment	**Average Annual**	**Monthly Maximum**
Significant	> 25%	> 50%
Moderate	> 10%	> 25%
Low	0 to 10%	0 to 25%

Additional benefits that will result from the completion of the *Tier 1 Water Budget* include; this project will satisfy one of the Niagara Water Strategy objectives which is to prepare water budgets for watersheds within Niagara Region; and the project will aid the NPCA when commenting on Permit-To-Take-Water (PTTW) applications (Wright 2009).

In Ontario, water takings (both surface and ground) are governed under the *Ontario Water Resources Act* (MOE 1990) and the *Water Taking and Transfer Regulation*. Under the *Ontario Water Resources Act* "*a person shall not take more than 50,000 litres of water on any day by any means except in accordance with a permit issued by the Director"* (section 34.3). Currently in the Central Welland River Watershed Plan study area there are 26 PTTW.

Identification of Challenges in the Central Welland River Watershed

The *NWS* (RMN 2006a) summarized a list of key water protection issues in the Central Welland River watershed. Additional issues have been identified by residents living in the watershed via public open houses and workshops in the spring and fall of 2008. A *Land Management and Agricultural Best Management Practice* survey (NPCA 2006) (Appendix A) helped to identify land and water management issues in rural areas of the

watershed. A description of the challenges facing the Central Welland River watershed are reported here.

Landfill Sites

Three known closed dump/fill sites in the Central Welland River watershed were identified in the *Groundwater Study* (WHI 2005). Landfill sites labelled as "old dump/fill sites" are areas that were once used as a dump or landfill. The subwatersheds where these sites are located are as follows; one in Beaver Creek; one in Welland River Between Canals; and one in Welland Canal subwatershed. The *NWS* (RMN 2006a) has identified concern that potential leachate could be discharging from these old dump/fill sites. There are also 3 active landfills in the study area; Humberstone Landfill in Welland, former Atlas Steels landfill and one other located in Welland Canal subwatershed.

In 2004, a study conducted by the Conestoga-Rovers and Association detected polychlorinated biphenyl (PCB's) in the sediment of Brown Tap Drain adjacent to the Humberstone Landfill. The Brown Tap Drain runs between the Feeder Canal and the Welland River where it discharges.

The RMN retained the services of ASI Group to conduct a sediment quality and benthic macro invertebrate study to assess whether PCB's are negatively affecting the water quality, the sediment quality and the benthic invertebrate community in the Brown Tap Drain and the Welland River. The study design was reviewed and approved by the Ministry of the Environment and the study was implemented in the spring of 2006 (ASI Group Ltd. 2007). The results of the study indicate that the total PCB concentrations were below laboratory method detection in the water samples at all areas sampled along the Brown Tap Drain and Welland River (ASI Group Ltd. 2007). This is expected since PCB's are not readily dissolved in water; they are hydrophobic. The study also concluded that although PCB's are present in the sediment in low concentrations compared to provincial sediment criteria, the PCBs do not appear to be negatively affecting the water quality, sediment quality or the benthic communities in either Brown Tap Drain or Welland River (ASI Group Ltd. 2007).

The former Atlas Steels landfill adjacent to the Welland River on River Road in Welland was used to landfill steel-making residue between the 1930's and 2004. The owners of Atlas Steels abandoned the site in 2004 and subsequently abandoned the environmental controls that protected the surface and groundwater around the site. As a result, "*leachate began escaping from the landfill site contaminating shallow groundwater and the Welland River*" (XCG 2010). In 2006, the MOE ordered the City of Welland and the Region of Niagara to take over the operation and maintenance of environmental controls. In April 2009, Welland City Council voted in favour of a proposal that would provide the City with the necessary capital works to remediate the site and implement long term care and monitoring programs needed to bring the site into compliance with current environmental standards by allowing Integrate Municipal Services Inc. (an operating subsidiary of Walker Holdings Limited) to fill the site to its full approved capacity (XCG 2010). This arrangement will remediate this site in a timely fashion at no direct cost to the taxpayers of the City of Welland and Region of Niagara, while removing "*the stigma of having an abandoned industrial landfill in [the] community*,[and] *while creating „green' jobs associated with environmental remediation*" (XCG 2010).

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 concern by participants at a public open house and a workshop in the spring and fall of 2008 and by participants in the *Land Management Issues and Agricultural Best Management Practices* survey (NPCA 2006). 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.

Combined Sewer Overflows

Combined Sewer Overflows (CSO) have also been identified as a key issue in the Central Welland River watershed through the *NWS* (RMN 2006a). Twenty-three CSO's and 12 pumping stations have been identified in the study area. A combined sewer is designed to collect stormwater runoff and wastewater (sewage and used water) and transport it to the treatment plant. However, during heavy rain events or snow melts the wastewater in the sewer may reach capacity of the sewer system or possibly the treatment plant. When this occurs, the sewer system overflows and discharges the excess wastewater in to the nearby watercourse or waterbody. The overflows which contain sewage and stormwater are called Combined Sewer Overflows, and have been identified as a key issue in the Central Welland River watershed.

It is the intent of the City of Port Colborne to address this issue through the *Draft New Official Plan*(2010), which states "*Combined storm and sanitary sewers are not permitted and the City will endeavor to separate existing combined storm and sanitary sewers"* (Section 8.2d).

Likewise, it is also the intent of the City of Welland through the *Draft Official Plan* (2010) to prioritize the elimination of overflows due to the significant environmental impacts over flows have on water quality (Section 6.1.3.3.E). With the Region of Niagara, the City of Welland has already completed extensive sewer separation in the Oxford-Atlas-Wellington Roads area; the largest contributor of combined sewage overflows. *"It is estimated that the combined sewage reduction is 5 to 10%, increasing the estimated total wet weather flow capture rate to approximately 73%"* (City of Welland 2010)

Urban Storm Water Management

A lack of stormwater management facilities to treat urban runoff in Pelham, Welland and Port Colborne has been identified as a key issue in the *NWS* (RMN 2006a). Sixteen storm outfalls and 8 industrial outfalls have been identified in the Central Welland River watershed. 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 such as for example, storing excess water on or near the site, and releasing it slowly over a long period of time.

The NPCA and RMN have developed policies that provide for a long-term plan for the safe and effective management of runoff in urban and urbanizing areas, while sustaining the health of local rivers and stream (AECOM 2010). The report entitled *„Stormwater Management Policies and Guidelines'* provides a consist approach to stormwater management for all municipalities in Niagara Region. Examples of stormwater best management practices are listed in Appendix B.

The intent of the City of Port Colborne in the *Draft New Official Plan* (2010) is to manage stormwater on-site to reduce impacts on neighbouring properties or the drainage patterns of the surrounding area (Section 8.2a). The *Draft Official Plan* (2010) also specifies that development applications may require a stormwater management plan and a sediment and erosion control plan prepared by a qualified engineer (Section 8.2b) and that the storm water management plan "*demonstrates that the proposal will minimize vegetation removal, grading and soil compaction, erosion and sediments, and impervious services*" (Section 8.2.b) as well as meet the requirements of other policies with the *Official Plan (2010)*.

Similar to the City of Port Colborne, the *Draft Official Plan* for the City of Welland also outlines policies with regard to storm water management and sediment and erosion control. Like Port Colborne, development applications may also require a stormwater management plan and a sediment and erosion control plan prepared by a qualified engineer and the storm water management plan must "*demonstrate that the proposal will minimize vegetation removal, grading and soil compaction, erosion and sediments, and impervious services (*Section 6.1.3.3.G*).*

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 (EC 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 (EC 2004b).

In 2005, the RMN undertook a *Salt Vulnerability Study* (Ecoplans Ltd), which identified vulnerable areas from road salt for land use, surface water groundwater, and natural areas. For the Central Welland River study area, the *Salt Vulnerability Study* indicates the following*:*

Runoff vulnerability varies throughout the study area. The relatively flat topography and high number of roads in the eastern portion of the study area results in a high vulnerability; the Regional Road 20 corridor has also been ranked with a high vulnerability to road salt from runoff. The central portion of the study area has been ranked with a low vulnerability to runoff. Land use vulnerability in the built-up areas has been ranked as low and moderately low, while the remaining predominately agricultural study area has been ranked with a moderate to moderately high land use vulnerability to road salt. Groundwater vulnerability has been ranked as high around the Fonthill Kame-Delta Complex due to its high infiltration rate and the Wainfleet Bog due to the high water table; the remainder of the study area has a relatively low groundwater vulnerability to road salt. Surface water, wetland and fish habitat have been ranked as moderately high for the majority of the Central Welland River watershed. The Wainfleet Bog has been ranked as having a high vulnerability in all instances due to the inability of the bog to dilute the salt with surface water like a fluid body of water.

In 2009, Niagara Region initiated a pilot project whereby alternative winter maintenance practices were implemented in two areas identified as highly vulnerable areas in the Region's Salt Vulnerability Study. The pilot project included Niagara-on-the-Lake because of its tender fruit/agricultural areas, and the Wainfleet/West Lincoln area which is associated with the Welland River. The pilot project included the use of a sugar beet juice compound, an organic liquid de-icing product, and has been shown to reduce the amount of salt applied during winter operations by as much as 30 percent (RMN 2010).

The success of the pilot program is currently being finalized in a report by RMN staff; however staff reports that program resulted in a significant cost savings and a program expansion is planned for the 2010 winter maintenance season (Personal Communication 2010).

It is important to note that the Regional Niagara *Salt Vulnerability Study* only assessed risk for Regional roads and the Organic Anti-icing Agent Pilot Program was only conducted on regional roads within the 2 pilot areas, therefore Municipal roads should also be assessed to better identify salt vulnerable areas in the watershed and municipalities should also consider implementing a Organic Anti-icing Agent Program for their respective roadways.

Nutrient Management

Concern over proper nutrient management in the Central Welland River watershed was expressed by participants at a public open house and 2 public workshops in the spring and fall of 2008. Concerns over nutrient management were also identified in the *NWS* (RMN 2006a) and in the *Land Management and Agricultural Best Management Practices* (NPCA 2006) *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, in 2002 the Ontario government introduced the *Nutrient Management Act* (OMAFRA and OMOE). As of September 2003, new livestock farms that are over 5 Nutrient Units (NU) and existing livestock farms expanding to 300 NU or more are required to complete a nutrient management strategy (NMS) that includes information on its operation, how much nutrient is produced, how it will be stored, an analysis of its nutrient content, and where it will be used. In Niagara, only roughly a handful of farming operations currently have NMS in place.

A Nutrient Management Plan (NMP) must be completed for agricultural operations that apply nutrients to the land. The NMP includes information about the farm and its fields, an analysis of the nutrients to be applied, how much will be applied and at what rate, and how the nutrients will be stored (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination.

Groundwater Sensitivity

The *NWS* (RMN 2006a) and the *Groundwater Study* (WHI 2005) have identified areas in the Central Welland River study area as highly susceptible to groundwater contamination. The Onondaga Escarpment was an area identified as highly susceptible due to the thin overburden and bedrock outcrops. The thin overburden is unable to effectively provide the groundwater with sufficient protection from bacteria, sediment and other insoluble forms of contaminants that in a thick overburden would become trapped and filtered within the soil pores. In addition, the openings in the fractured bedrock as well as the porous limestone allow for the direct passage of surface water and contaminants to groundwater resources. The Fonthill Kame –Delta Complex was also identified as an area highly susceptible to groundwater contamination due to the high permeability of the overburden units with little or no low conductivity units.

The *PPS* in section 2.2.1(MMAH 2005a) requires planning authorities to protect, improve or restore vulnerable and sensitive surface and ground water features, and their hydrologic functions. Likewise, it is the intent of the *Regional Niagara Policy Plan* (RMN 2007) to protect, improve or restore the quantity and quality of ground and surface water resources[section 7(A.2.2)].

Under the *CWA*, vulnerable groundwater areas that fall within an Intake Protection Zone will be protected under the *SPP* and decisions made under the *Planning Act* must conform to the *SPP*.

Irrigation Water

Irrigation water shortages have been reported through the *Land Management and Agricultural Best Management Practices Survey* (NPCA 2006) that was distributed to Ontario Federation of Agriculture members and through the *Feasibility Study – Raw Water for Agricultural Irrigation Study* (Stantec 2007). The Regional feasibility study pertaining to taking raw water supplies for irrigation investigated 4 districts in Regional Niagara requiring additional irrigation water. One of these districts falls within the Central Welland River watershed.

The South District encompasses the Fonthill Kame-Delta Complex and a portion of the Erigan channel. The district extends from the top of the Niagara Escarpment southwards to the Welland River. It was concluded that it was not feasible to establish a well-based irrigation system for all parcels in the South District. The data indicated that the Erigan

bedrock channel was not a significant hydrogeological feature and that water on the Fonthill Kame-Delta Complex infiltrates to the deeper aquifer systems resulting in costly extraction of the groundwater due to the depth of the well. In addition, based on current groundwater demand, further study would be required to determine if additional irrigation demand would be sustainable (Stantec 2007).

Water Fluctuations in the Welland River

Concern regarding the reversal of flow and the fluctuations of the water level has been identified as a concern in the *NWS* (RMN 2006a). The lower Welland River has been severely modified for transportation and hydroelectric operations. The original outlet of the Welland River was the Niagara River; however the lower reaches are now diverted upstream from the Niagara River toward the Chippawa Power Canal. Regulated fluctuations occur in the flow of the Niagara River due to hydro operations, which in turn result in fluctuations in the lower Welland River. The diversion has created a pattern of regular diurnal fluctuations in water levels that extends upstream to Port Robinson, roughly 60 kilometres upstream of the diversion. Concerns regarding the affect of the flow reversals and fluctuations on the Welland River ecosystem have been expressed.

In 2004, Phillips Engineering completed the *Draft Welland River Water Fluctuation Study* for the NPCA and the Ontario Power Generation. The study objective was to "*comprehensively evaluate opportunities to either mitigate the impacts on the Welland River ecosystem, due to the water level fluctuations, and/or moderate the extent/significance of the water level fluctuations*".

The study identified a decrease in impact on the inshore habitat the further upstream from diversion travelled. The impacts appeared minor to the habitat between the two siphons and nearly insignificant upstream of the siphons. Therefore the affected portion of the Welland River does not fall within the Central Welland River watershed.

Lyons Creek West Contaminated Site

Historically the headwaters of Lyons Creek originated south of the City of Welland, but with the construction of the Welland Canal By-Pass in 1971, the headwaters were severed creating 2 separate watersheds; Lyons Creek West and Lyons Creek East. Lyons Creek West drains into the Welland Canal By-Pass while the flow of Lyons Creek East is augmented by water being pumped from Welland Canal By-Pass. In 1994 Lyons Creek West was rerouted, leaving a portion of the former channel to dry up and grass over (Dillon Consulting 2006).

In 2003, the Niagara River Contaminated Sediment Technical Advisory Group was established to evaluate contaminated sediment sites in the Niagara River Area of Concern. Lyons Creek West is one of the sites that is currently being addressed and the property owners of this site include Hydro One, City of Welland and Transport Canada with polychlorinated biphenyls (PCB's), arsenic and zinc being the potential chemicals of concern (Niagara River RAP 2009). In 2007, Hydro One removed arsenic contaminated sediment and soil from the site

eliminating the human health risk of the site; currently a management strategy is under development (Niagara River RAP 2009). The remaining area with PCB-contaminated sediment and soil is owned mostly by Transport Canada whom is the lead agency in developing a sediment management strategy; currently sediment management options are under investigation (Niagara River RAP 2009).

Urban Expansion and the Protected Countryside and Growth Plan for the Greater Golden Horseshoe

Future expansion of Welland and Port Colborne and the urban impacts from the smaller areas of Fonthill and Fenwick of Pelham have been identified as a concern in the *NWS* (RMN 2006a), in terms of affecting natural areas. In addition, this issue was also identified as a serious concern by participants of a public open house and a public workshop and by members of the agricultural community that participated in the *Land Management and Agricultural Best Management Practices* survey (NPCA 2006). Workshop and survey participants were very concerned about the loss of agricultural land and the loss of natural areas to urban development. However, it is the intent of the Town of Pelham, City of Welland and the City of Port Colborne to protect and support the rural and farm related operations by promoting intensification of future development within the urban area boundary as outlined in their respective Official Plans, and the provincial *Growth Plan for the Greater Golden Horseshoe* [(GGH) MPIR 2006] which has been prepared under the *Places to Grow Act* (MPIR 2005) as previously described.

As indicated earlier, the *GGH* promotes intensification of existing built-up areas and revitalization of urban growth centres while recognizing the vital economic and cultural importance of our rural communities. The *GGH* identifies the City of Welland and City of Port Colborne as a Gateway Economic Centre and the area surrounding the built-up areas adjacent to the Welland Canal in Port Colborne and Welland as designated greenfields areas, making them the focus area of future intensification with an overall minimum density target of 50 jobs and residents per hectare. The *GGH* also outlines policies regarding the expansion of a settlement area within a municipality. For instance, a settlement area boundary expansion may only occur as part of a municipal comprehensive review that has demonstrated numerous criteria, including for example, that opportunities to accommodate forecasted growth (through Schedule 3 of GGH) are not available; the expansion makes sufficient lands available for a time horizon not exceeding 20 years; and in prime agricultural areas the lands do not comprise specialty crop areas, and there are no reasonable alternatives that avoid these areas, and there are no reasonable alternatives on lower priority agricultural lands in the prime agricultural areas (Section 2.2.8.2.a,b,f).

It is also the intent of the Region of Niagara in the Sustainable Community Policies (Policy Plan Amendment 2-2009) to "*maximize the use of existing and planned infrastructure to support growth in a compact and efficient manner*" (Section 2.2) by outlining numerous policies and objectives in regards to for example, growth boundaries, intensification targets, designated intensification areas, and community structure.

In addition, Fenwick falls within the boundary of *Protected Countryside* under the *Provincial Greenbelt Plan* (MMAH 2005b). This Plan 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. The Protected Countryside lands are intended to enhance the spatial extent of agriculturally and

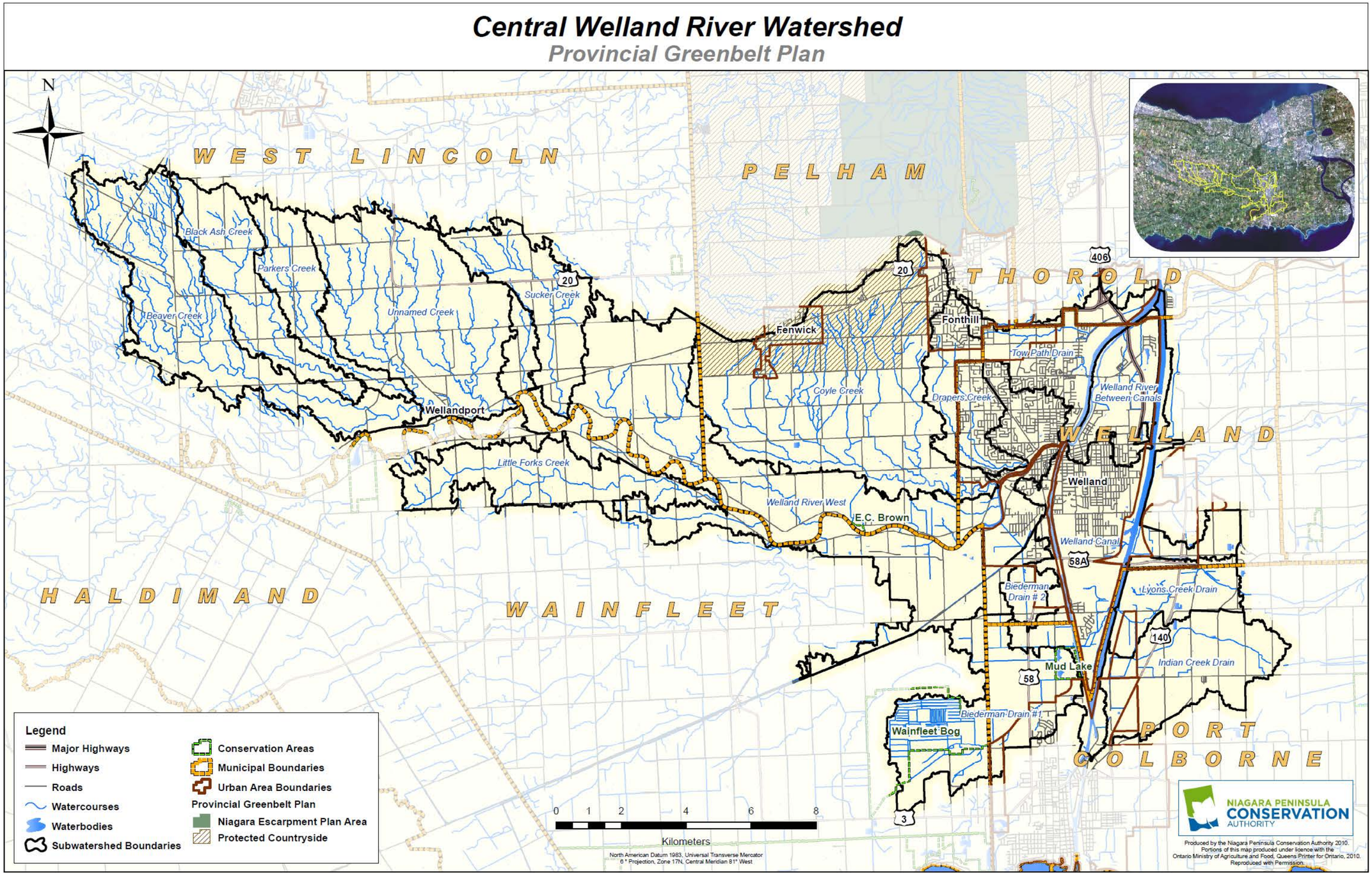

Figure 18: Provincial Greenbelt Plan

environmentally protected lands within the Niagara Escarpment Plan area as well as enhance linkages with surrounding major lake systems and watersheds. Only a small portion of the Protected Countryside lands fall within the Central Welland River watershed (Figure 18).

Municipal Drain Maintenance

In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains, especially through natural areas, is a recommendation that was made in the *NWS* (RMN 2006a) and by participants at a public open house and workshop in the spring and fall of 2008. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering the watercourse. Implementing Best Management Practices such as vegetating bare banks and maintaining a buffer strip; restricting cattle access; and allowing a slight meander to reduce bank erosion and flooding are a few measures that could potentially reduce the amount of sediment loading in the watercourse. In addition, when maintenance does occur several measures can be taken such as leaving the banks alone, working from one side of the drain and remove the vegetation at intervals. If a complete cleanout is necessary then ensure that the banks are not cut too steep as this will just make the banks more vulnerable to erosion. However, for a ditch or pipe to become a municipal drain there must be a by-law adopting an engineer's report. Once the municipal drain has been constructed under the by-law, it becomes part of the infrastructure of the respective municipality. The local municipality is therefore responsible for repairing and maintaining the drain. Therefore, in order to implement alternative maintenance practices, the engineers report for the respective drain will need to be re-visited. To review examples of current BMP mitigation measures, refer to Appendix I.

Over one hundred kilometres of watercourse in the Central Welland River watershed has been classified as municipal drain. In 2001, drain maintenance was conducted on Big Creek Drain in Coyle Creek subwatershed and Skelton Drain in Biederman Drain #1 subwatershed and Indian Creek Drain underwent maintenance in 2007.

Niagara to GTA Corridor

By 2031, the Greater Golden Horseshoe is expected grow by almost 4 million people (MTO 2010). From a transportation perspective, this level of growth poses significant challenges as during peak periods many of the transportation networks are already functioning at or near capacity, therefore unable to support the predicted level of growth associated with the increase in commuter, tourist and goods movement.

To address these issues the Ontario government initiated the Niagara to GTA Corridor Planning and Environmental Assessment Study. This study was initiated to "*explore all modes of transportation, including transit, freight rail, marine, air, freight inter-modal, and roads and highways*" (MTO 2010) and 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.

Since the initiation of Phase One in January 2007, several studies have been completed and released including: *Overview of Environmental Conditions and Constraints Report* and *Overview of Transportation and Socio-Economic Conditions* (MTO 2007a; 2007b);

Factors Influencing Transportation Demand in the NGTA Corridor: Discussion Paper and *Study Vision, Purpose, Goals and Objectives: Discussion Paper* (MTO 2008a; 2008b); *Draft Area Transportation System Problems and Opportunities Report* (MTO 2009); and *Area Transportation System Alternatives Report* (MTO 2010).
The latest report, *Area Transportation System Alternatives Report* (MTO 2010) serves as a "*critical stage in the study providing a foundation for further assessment, evaluation, and selection of Preliminary Planning Alternatives that will be incorporated in the ultimate Transportation Development Strategy for this phase of the NGTA Study*" (MTO 2010). One of the key findings of this study was that "*no single mode of transportation is capable of fully addressing all of the transportation problems and opportunities*". The report outlines four transportation group alternatives made up of a number of individual alternatives. Group #1 focuses on optimizing existing networks, Group #2 focuses on new/expanded non-road infrastructure and enhancements of Group #1, Group #3 focuses on widening and improving roads and improvements of Group #2, and Group #4 builds upon improvements provided in aforementioned 3 Groups plus new transportation corridors (MTO 2010).

Of the numerous transportation alternatives outlined in the four Groups, through Niagara widening of existing QEW is preferred and the monitoring of growth needs for the long term. The Central Welland River watershed is not affected by the preferred option.

Natural Heritage and Resources

Concern over the loss and lack of protection of natural areas was expressed by participants of a public open house and 2 public workshops in the spring and fall of 2008. 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 Central Welland River 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 upland extent and a lack of tributary buffers have been identified as issues in the watershed (RMN 2006a).

Wetland Habitat

Wetlands can provide benefits anywhere in a watershed, but particular wetland functions can be achieved by rehabilitating and/or establishing wetlands in key locations. For example, wetlands on floodplains are ideal for flood attenuation, headwater areas for groundwater recharge and discharge, and coastal areas for fish production. Special attention should be paid to historic locations and site and soil conditions (EC 2004).

Currently, the percent of wetland cover

(10%) in the Central Welland River watershed meets Environment Canada's *minimum* targets and should be maintained. However, Environment Canada recommendations state *10% or to historic value,* therefore, means to maintain and increase the numbers and /or size of wetlands 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

The area of land adjacent to a watercourse is the riparian or buffer zone. Environment Canada recommends that 75 percent of a streams length be naturally vegetated with a minimum of a 30 meter width naturally vegetated riparian zone on both sides of the watercourse. Headwater streams are highly dependent on vegetative cover for stream temperature moderation and the input of organic matter from adjacent vegetation for production.

Riparian cover in the watershed is very low with 43% of the watercourses having some vegetation along the watercourse. Therefore a means to improve the riparian habitat is addressed in the Restoration Strategy of the Central Welland River Watershed Plan. Riparian buffers, like wetlands, provide many benefits to a watershed, including improving water quality. The benefits of riparian buffers include the following:

- 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).

Upland Habitat: Woodland and Grasslands (Prairies and Meadows)

Environment Canada recommends that at least 30 percent of a watershed be in forest cover in order to support viable fish and wildlife populations. The forest habitat guidelines are designed to address habitat loss and fragmentation as two of the key factors in the decline of wildlife species, given that the amount of forest cover in a watershed determines its ability to support species diversity. The Central Welland River watershed is below adequate levels with 15 percent of the watershed in forest cover. However, forest cover not only directly results in habitat, but forest cover is beneficial because it:

- reduces flooding and high 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 Central Welland River watershed.

Percent of an Urbanizing Watershed that is Impervious

Environment Canada's *How Much Habitat is Enough?* (2004) outlines numerous studies that have been conducted in regards to stream health and the amount of imperviousness to runoff in a watershed. Although not every watershed will respond uniformly as a result of varying characteristics (e.g. soil type, slope, location and amount of built-up areas) "*the most commonly chosen threshold for impervious surface is 10 percent of the land cover within a watershed*" (EC 2004) to preserve the health of the aquatic systems. For urban watersheds that have exceeded the proposed 10 percent, a "*second threshold of 30 percent or less impervious surfaces*" in addition to "*implementing and defending stormwater best-management practices*". It was reported that the "*impairment of stream quality is first noted at 10 to 12 percent impervious cover and becomes severely impaired at 30 percent watershed imperviousness*" (EC 2004).

In the Central Welland River watershed Drapers Creek, Tow Path Drain, and Welland River Between Canals subwatersheds all have over 30 percent impervious land cover. Within urbanized and/or urbanizing watersheds as such, careful planning to mitigate the impacts of impervious surfaces is necessary, for example through storm water management practices. In addition, as land uses change in the watershed, efforts should be made to decrease the amount of impervious cover by changing the land use of given properties as parcels become available. For instance, is there opportunity to convert abandoned impervious lands into fallow pervious areas?

Fish and Aquatic Habitat

The need for protection and improvement of critical fish habitat was identified as a concern in the *NWS* (RMN 2006a). 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). In 2007, the MNR released a report on climate projections for Ontario and how Ontario's climate could change during the 21st century. Climate models predict the effect of higher greenhouse gases based on increasing amounts of heat trapped in the atmosphere. Each modelled scenario has a different set of assumptions about future social and economic conditions "*since the amount of greenhouse gas in the future depends on highly variable factors such as global population, human behaviour, technological development and the carbon sink/source behaviour of land and water ecosystems"* (MNR 2007b).

For the Niagara region and westward to Windsor and Sarnia, the modeled projections calculate an increase in summer (April to September) average temperatures of 5 to 6 degrees Celsius and a 10% decrease in precipitation by 2071 (MNR 2007b). The winter climate for most of southern Ontario is projected to increase 1 to 2 degrees Celsius between 2011 and 2040, and could increase by 3 to 4 degrees by mid-century. In addition, most of southern Ontario could receive 10% less precipitation during the cold season (MNR 2007b). Although the projections for Ontario's future climate are not certain, it is reported by the MNR in this study that the projections are likely "*closer to future reality than assuming that the future climate will be similar to that of the past 30, 60, or 100 years"* (2007b).

The report also outlines possible impacts that climate change could have on Ontario's ecosystems, societal values and infrastructure. For example, impacts to the agricultural sector could include a possible change in crops grown, longer growing season and a reduced productivity where an increase of temperature without a compensatory increase in precipitation occurs (MNR 2007b). Examples of potential impacts to the environment include changes in biodiversity of species and ecosystems, and new species becoming „at risk' because of disequilibrium with climate (MNR 2007b). For the complete list of examples of key possible impacts that climate change could have on Ontario's ecosystems, societal values and infrastructure taken from this report refer to Appendix C.

In *Mainstreaming Climate Change in Drinking Water Source Protection Planning In Ontario*, de Loë and Berg (2006) report some of the predicted impacts climate change could have on the hydrologic cycle and water resources in the Great Lakes Basin. The hydrologic cycle is sensitive to changes in temperature, precipitation and evaporation which accordingly could result in significant changes to streamflows, lake levels, water quality, groundwater infiltration, and patterns of groundwater recharge and discharge (de Loë and Berg 2006). The following are examples of potential impacts that the predicted changes to the hydrologic cycle could have on water resources in the Great Lakes Basin as reported by de Loë and Berg (2006):

- 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).

For the summary table of identified hydrological changes expected in the Great Lakes Basin identified in this report, refer to Appendix C.

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 Central Welland River 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 Appendix D. 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 and Incentive Programs

Policy tools addressing land use planning, significant natural heritage features and 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 and/or revitalization and intensification of developed areas, these tools ensure that issues pertaining to the protection, improvement, and enhancement of our natural resources are taken into consideration throughout the development process. Policy tools might include municipal policies, incentive-based tools as well as other water conservation related tools. Specific examples of these policy tools and incentives are presented here.

- **Stormwater Management Policies** require the control and treatment of stormwater discharges to prevent flooding, minimize downstream channel erosion, and protect water quality. As previously mentioned the NPCA and RMN have developed policies that provide for a long-term plan for the safe and effective management of runoff in urban and urbanizing areas, while sustaining the health of local rivers and streams; *Stormwater Management Policies and Guidelines(*AECOM 2010).Examples of stormwater best management practices are listed in Appendix B.
- **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 (EC 2004c).

- **Sustainable 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.
- **Incentive-based Tools** such as **Water Conservation Programs** aid in the protection of water quality, quantity and aquatic habitat by reducing the demand on water resources and maintaining instream flows. Thus, the natural hydrology of streams is protected during peak water demand.
- **Alternative Land Use Services** 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 Securement Programs:** securing land into public or private ownership can help to protect water quality and natural heritage features. For example, maintaining the natural condition of land around watercourses is an ideal approach to enhance water quality protection. Land securement programs help protect greenspace, conserve biodiversity and promote stewardship and community involvement, e.g. **NPCA, Niagara Land Trust**
- **Conservation Easements:** are agreements made between a landowner and a conservation groups whereby the landowner still owns the property but has agreed to restrict or prevent certain land uses in order to protect the natural features on the property.

In 2001, the province of Ontario passed new legislation entitled the *Brownfields Statute Law Amendment Act* to encourage the revitalization of contaminated land. Additionally, the *PPS* (2005) encourages the redevelopment of brownfields by stating that "*Planning authorities shall identify and promote opportunities for intensification and redevelopment where this can be accommodated taking into account existing building stock or areas, including brownfield sites*" (Section 1.1.3.3). Likewise, the Regional Municipality of Niagara has initiated numerous incentive programs, including a brownfields redevelopment initiative. These programs will involve partnerships with the local municipalities through their respective Community Improvement Plans. For example, the City of Welland adopted a *Brownfield Community Improvement Plan* (RCI Consulting) in 2007 to address the municipality's high number of brownfield areas. As indicated, The *CIP* provides incentive programs, strategies and actions that will promote brownfield remediation, rehabilitation and redevelopment in the City of Welland (RCI Consulting 2007). Currently it is estimated that over 200 hectares of brownfield sites exist along the canal and throughout the city (City of Welland 2007). The following are examples of incentive programs for local municipalities that are available at the provincial and regional level.

- **Brownfield Redevelopment Incentives** encourage the rehabilitation, remediation and redevelopment of abandoned, underused or idle industrial and commercial properties. There are several programs that can be implemented through the RMN and municipalities such as the **Brownfield Tax Grant Program, Brownfield Tax Assistance Program, Brownfield Tax Arrears Credit Program, Brownfield**

Development Charge Incentive Program, and **Municipal Brownfield Leadership Program** (RMN 2007b)

- **Brownfield Financial Tax Incentive Program:** is a provincial funding initiative to encourage the remediation and redevelopment of brownfield properties. The program matches provincial education property tax assistance to municipal property tax assistance for eligible brownfield property owners for the cleanup of the brownfield property.
- **Environmental Assessment Grant Program:** This program will assist developers of brownfield sites in acquiring the environmental information needed to determine the financial viability of developing these sites (RMN 2007b).
- **Downtown/Commercial Area Redevelopment Incentive Programs:** these programs are designed to provide financial incentives to encourage the redevelopment and rehabilitation of downtown properties and commercial areas in the Region of Niagara. These programs include the **Downtown Redevelopment Grant Program**, **Building and Façade Improvement Loan/Grant Program,** and **Downtown Development Charge Incentive Program** (RMN 2007b).
- **Heritage Properties Tax Reduction Program:** this program is designed to help property owners defer the higher maintenance and repair costs of heritage properties (RMN 2007b).
- **Heritage Restoration and Improvement Incentive Programs:** these programs are designed to provide financial incentives to encourage restoration and improvement of heritage properties in the Region of Niagara. These programs include the **Heritage Grant/Loan Program, Professional Design Study Grant Program,** and **Heritage Development Charge Incentive Program** (RMN 2007b).
- **Special Multi-Residential Tax Rate:** encourages the construction of new medium and high density rental housing by providing a special property tax rate (RMN 2007b).
- **Residential Conversion and Intensification Incentive Programs:** these programs are designed to provide financial incentives to encourage residential conversion and intensification. These programs **Residential Grant/Loan Program, Convert-to-Rent Grant Program,** and **Residential Development Charge Incentive Program** (RMN 2007b).

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. Examples of some of these programs follows:

Water Quality Improvement Program

The NPCA 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), offered by the MNR, was established by the province 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 MNR, and include: PSW's; provincially significant ANSI's; 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 and who are enrolled in 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), offered by the MNR, 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).

Species at Risk Farm Incentive Program

The Species at Risk Farm Incentive Program (SARFIP) was launched in 2008 by the MNR to encourage greater protection and conservation of species at risk and their habitats on privately owned agricultural lands across Ontario. The program provides "*enhanced cost share opportunities for farmers who take action on selected environmental Beneficial Management Practices that play a key role in contributing to a healthy and diverse environment as well as helping sustain production and profitability on the farm*" (MNR No Date-b). Ontario farmers may be eligible for up to 100 percent of the cost to establish a BMP project from the list of approved projects. Projects include, but are not limited to:

- riparian area management
- erosion control structures in riparian area
- improved pest management
- shelterbelt establishment, and
- enhancement of wildlife habitat and biodiversity.

Water Well Decommissioning Program

The NPCA has launched a water well decommissioning granting program for qualifying landowners with lands located within the NPCA jurisdiction. To qualify for 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 MOE as set out in Ontario Regulation 903;
- 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 for 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.

EcoAction Community Funding Program

Environment Canada's EcoAction Community Funding Program provides financial support to community groups for projects that have measureable, positive impacts on the environment. Funded projects promote the participation of local communities to address clean air, climate change, clean water, and nature to protect, rehabilitate or enhance the natural environment (EC No Data). A maximum of $100,000 is available per project and the project duration may be up to 3 years. The following is a list of those that can apply for funding through the EcoAction Community Funding Program:

- Non-profit non-government groups and organizations and community groups
- Environmental groups
- Aboriginal groups and First Nation Councils
- Service Clubs
- Associations, and
- Youth and Senior Organizations

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, *et. al.* 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 B.

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. Examples of Urban BMP's can be reviewed in Appendix B.

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. Measures for controlling storm water include at source and lot-level controls,

conveyance controls and end-of-pipe controls. Examples of Stormwater BMP's can be reviewed in Appendix B.

At Source and Lot-Level Quantity Controls:

Typically *At Source and Lot-Level* controls are the most effective in providing water quality protection because they prevent pollutants from entering the drainage system and provide for flow retention at source. Most practices can assist in addressing the four criteria; quantity, quality, stream erosion, and hydrologic cycle, but they are more often associated with quality and quantity control (National Guide to Sustainable Municipal Infrastructure 2003; AECOM 2010). At Source and Lot-Level controls consist of non-structural source controls, housekeeping practices, control of construction activities, and structural at-source controls (AECOM 2010).

Conveyance Controls

Conveyance controls provide quality and/or quality control within the conveyance system between the source and outlet, to help mitigate the impacts of urbanization. They transport runoff from developed areas through storm sewers, roadside ditches, or vegetated swales (AECOM 2010).

End-of-Pipe Controls

End-of-pipe controls allow for flow attenuation, major flow conveyance, and water quality enhancement of storm water before outletting to receiving body of water. Examples include wetlands, dry ponds and wet ponds. End-of-pipe controls allow for storm water quality and quantity mitigation at or near the downstream end of the conveyance control (AECOM 2010).

Managerial Best Management Practices

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. Examples of Managerial BMP's can be reviewed in Appendix B.

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 (RMN 2006). 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 B.

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 ensures bank stability and provides 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).

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 Central Welland River watershed strategy. A summary of the riparian, wetland and forest habitat restoration guidelines have been reproduced in Appendix G.

Watershed Restoration Guidelines

EC's (2004c) guidelines for wetland, riparian and forest habitat restoration identify targets for each habitat type in a watershed (Appendix G). 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 with a minimum 30m wide naturally vegetated adjacent-land on both sides, greater depending on site-specific conditions (e.g. urban areas)

As previously indicated, the guidelines are intended as minimum ecological requirements and are meant to provide guidance in setting local habitat restoration and protection targets.

The Central Welland River watershed currently contains approximately 10 percent wetland cover and approximately 15 percent forest cover. Based on the above guidelines, an additional 15 percent of forest cover is required to create minimum desirable habitat proportions in the Central Welland River 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 43 percent in the watershed. Based on this percentage approximately 32 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. In addition, whenever possible projects should benefit species which are designated federally under the *Species At Risk Act* or provincially under the *Endangered Species Act* (EC 2004c).

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 the following subwatersheds: Beaver Creek, Black Ash Creek, Parkers Creek, Unnamed Creek, Sucker Creek, Coyle Creek, Drapers Creek, Little Forks Creek, Welland River West, Tow Path Drain, and Indian Creek Drain.

Restoration priority areas have been identified using riparian, wetland and upland restoration suitability mapping produced by the NPCA (Figures 19 to 21); Carolinian Canada's „Big Picture' corridors; Regional Niagara's Core Natural Heritage System mapping, in conjunction with all natural heritage mapping layers including MNR's wetland mapping, wooded areas, NPCA ELC data, and ANSI's.

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. These layers and all subsequent layers were used in the analysis and identification of potential restoration areas in the Central Welland River Watershed.

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

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 H). 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 H, and the top three criteria for each restoration category are presented below.

Riparian Habitat Restoration Suitability

The criteria used to identify riparian habitat restoration 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.

Wetland Habitat Restoration Suitability

The criteria used to identify wetland habitat restoration 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

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; this area is known as the Critical Function Zone. The third 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 H. A series of habitat restoration suitability maps are provided (Figures 19 - 21)

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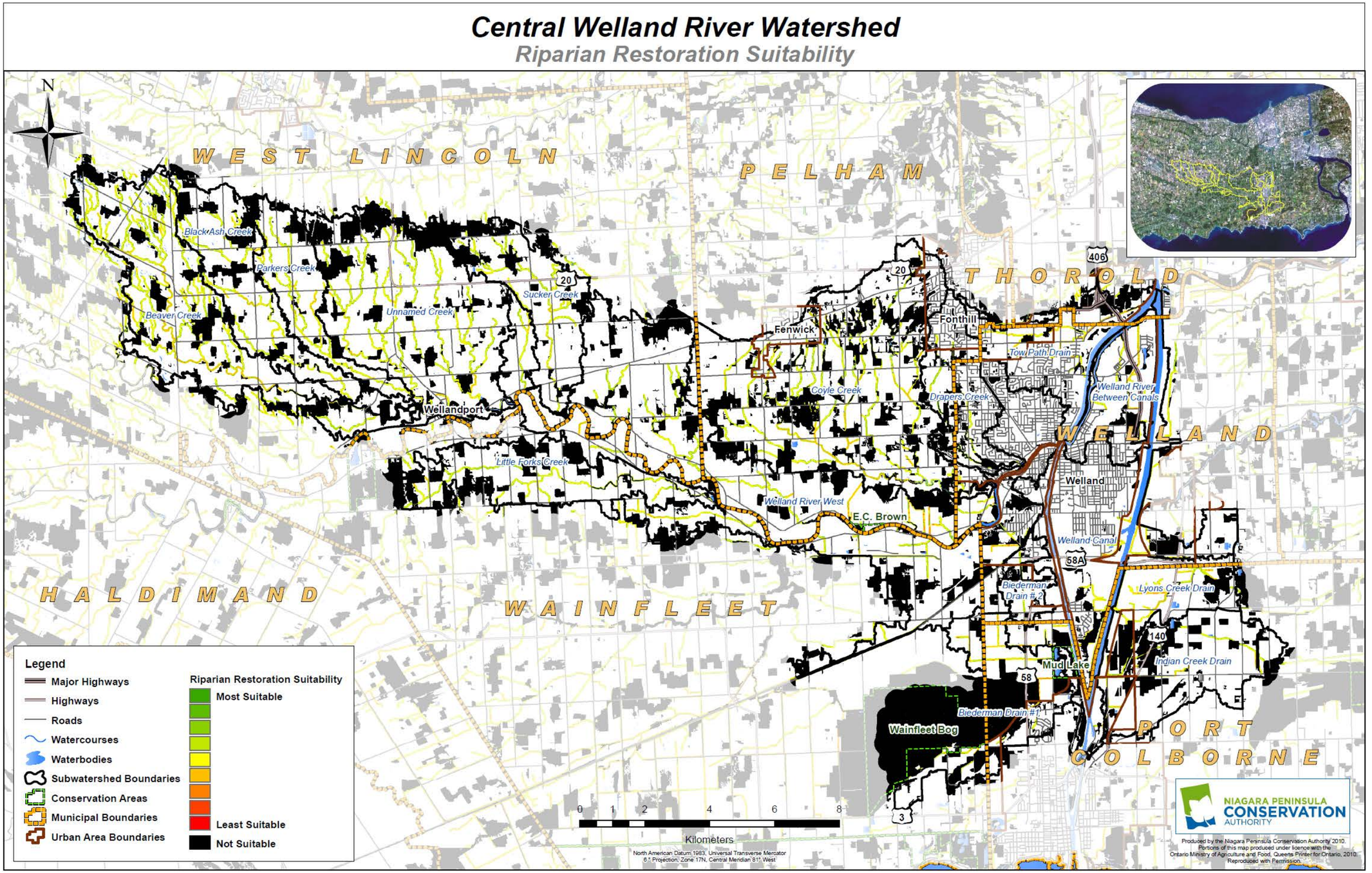

Figure 19: Riparian Restoration Suitability

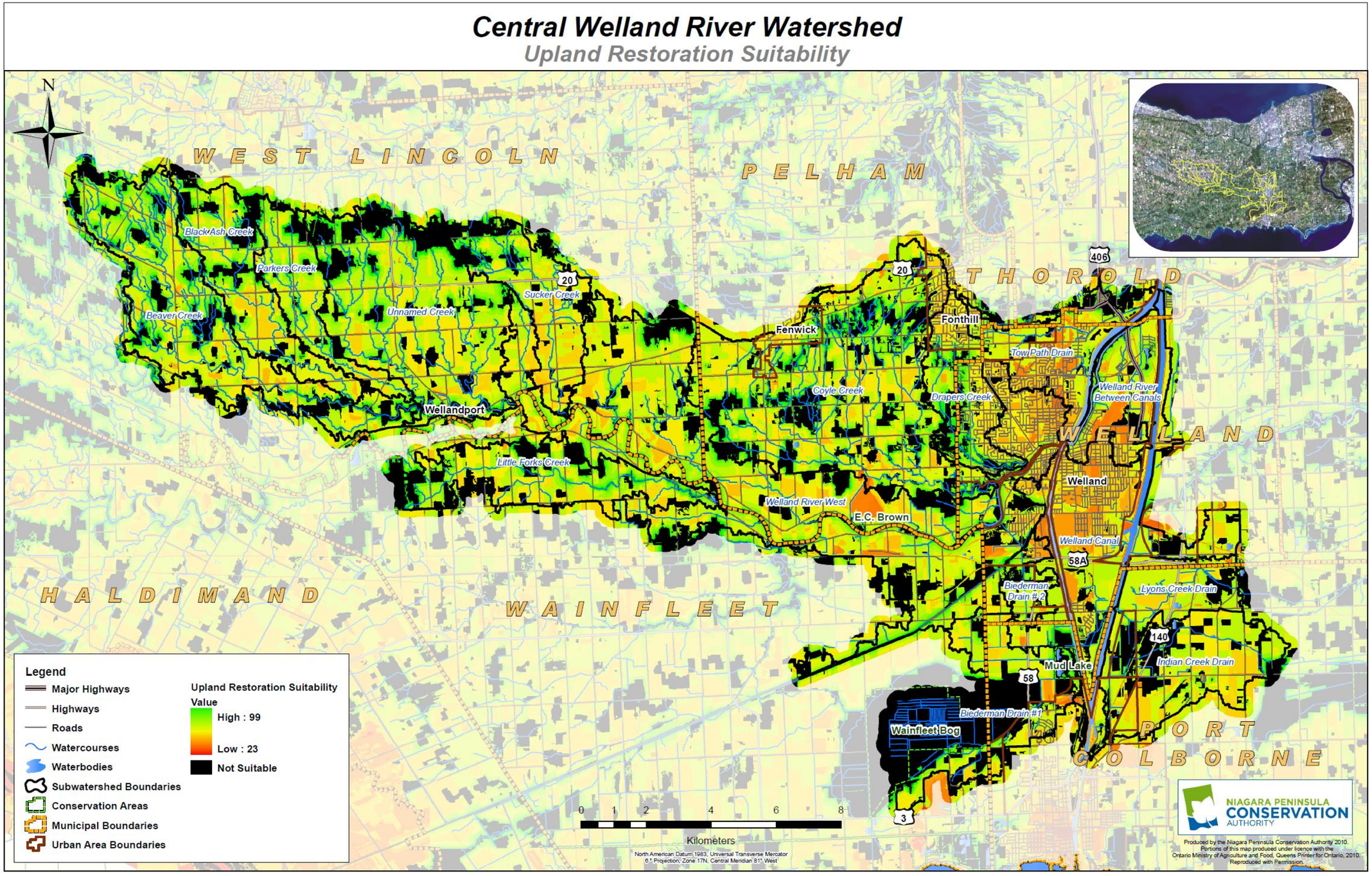

Figure 20: Upland Restoration Suitability

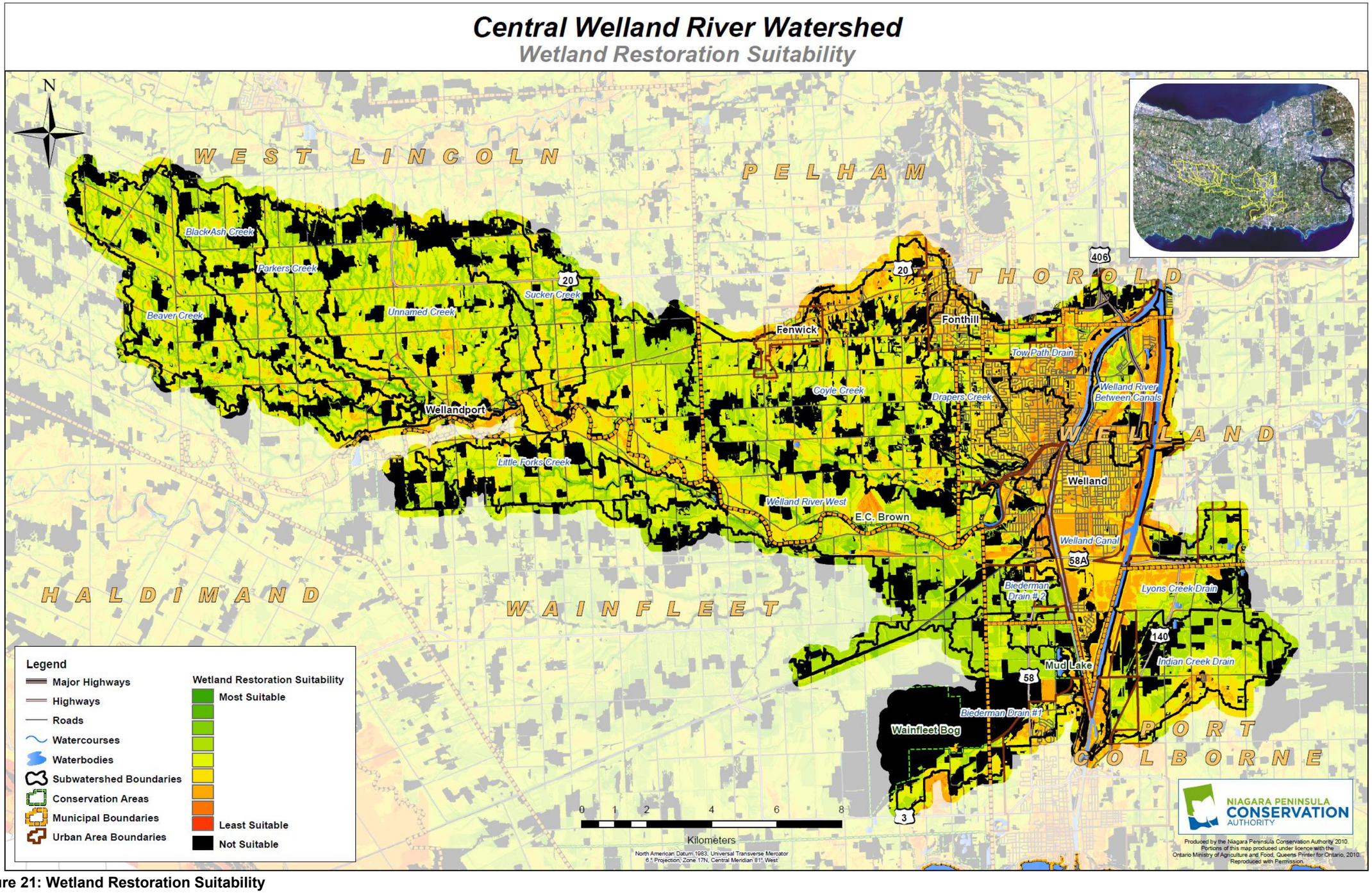

Figure 21: Wetland Restoration Suitability

Beaver Creek Subwatershed

Table 11:Beaver Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	25 sq km	
Land Use	primarily agricultural with one hamlet	rural residential cluster called Winslow
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	80 km	
Fish Habitat	Critical at outlet; important for majority of watercourses	Smaller headwater streams have not been evaluated
Municipal Drains	N/A	
Water Quality	Station:BV001 Water Quality Index: Poor BioMAP Rating: Impaired	Factors affecting water quality include exceedances of *E.coli* and total phosphorus. Of 68 NPCA surface water quality monitoring stations, the Beaver Creek station has the highest mean concentration of total phosphorus in 2009. Manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides are likely sources of total phosphorus (NPCA 2010). This station measures the cumulative impacts of Beaver Creek, Black Ash Creek, Parkers Creek and Unnamed Creek.
Groundwater Vulnerability	Low Groundwater Vulnerability; one small area has a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	26% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	7% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	15% is wetland habitat	EC recommends 10% to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date		
Clean Water Diversion	450L	1997: For laying hen barn storage
Reforestation	4 projects	2003, 2009: 15,175 trees planted, and aquatic plants for a 2.0 acre wetland
Riparian Enhancement	2 projects	1998, 2004: 3,800 trees/shrubs planted, installed 1750ft of streamside fencing, and retired 2 acres of riparian buffer
Fish Barrier Removal	N/A	

Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement		•currently amount of riparian habitat is low (26%). •water quality has been identified as an issue in the NPCA Water Quality Report. This site has the highest mean of total phosphorus of 68 Welland River sites. •large extents of watercourse evaluated as important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •potential opportunity to build on previous NPCA Water Quality Improvement project
Upland and Ecological Linkages		•currently amount of upland habitat is low (7%) •suitability mapping indicates very high suitability in upper watershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat		•currently level of wetland coverage (15%) exceeds EC minimum targets, however ample opportunity is present for filling in gaps between contiguous areas and enhancement of existing wetlands • high suitability for riparian-wetland restoration along watercourse which would provide linkages between wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
BvCMe	Riparian Enhancement	The middle portion of the watercourse at this field site is much wider than the upstream and downstream sections, suggesting that the channel has been altered. This wider section will act like an on-line pond. Bank instability is present in the form of bare soil extending up the bank. The lack of large woody vegetation in the buffer zone will impact habitat and cover over the channel. The presence of algae and turbid water was noted during a site visit in 2009. Recommendations for this site include further research to determine whether the wider section is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as provide cover and habitat for fish, insects, and invertebrate. Water quality should continue to be monitored in this watershed due to the presence of algae and turbid water.
BvCTa	Riparian Enhancement, Investigate impacts of online pond	The channel along this field site has been altered by the creation of an on-line pond. The presence of algae and turbid water was noted during a site visit in 2009, especially within the pond. Some bank instability is present in the form of bare soil extending up the bank. A number of small tributaries or possibly rills/gullies exist along the watercourse. The lack of large woody vegetation in the buffer zone will impact habitat and cover over the channel. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in

		the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as provide cover and habitat for fish, insects, and invertebrate. Water quality should continue to be monitored in this watershed due to the presence of algae and turbid water. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b).
NPCA Education and Incentive Programs		
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program		Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies		
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed		The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.

Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result*" (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Salt Vulnerability Study identified the Regional Road 20 corridor as having a high vulnerability to road salt from runoff. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of the surrounding surface water and natural heritage features and the adjacent agricultural lands to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Beaver Creek subwatershed 5 of these points were identified; 3 cemeteries, 1 automotive machinery, and 1 closed landfill. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

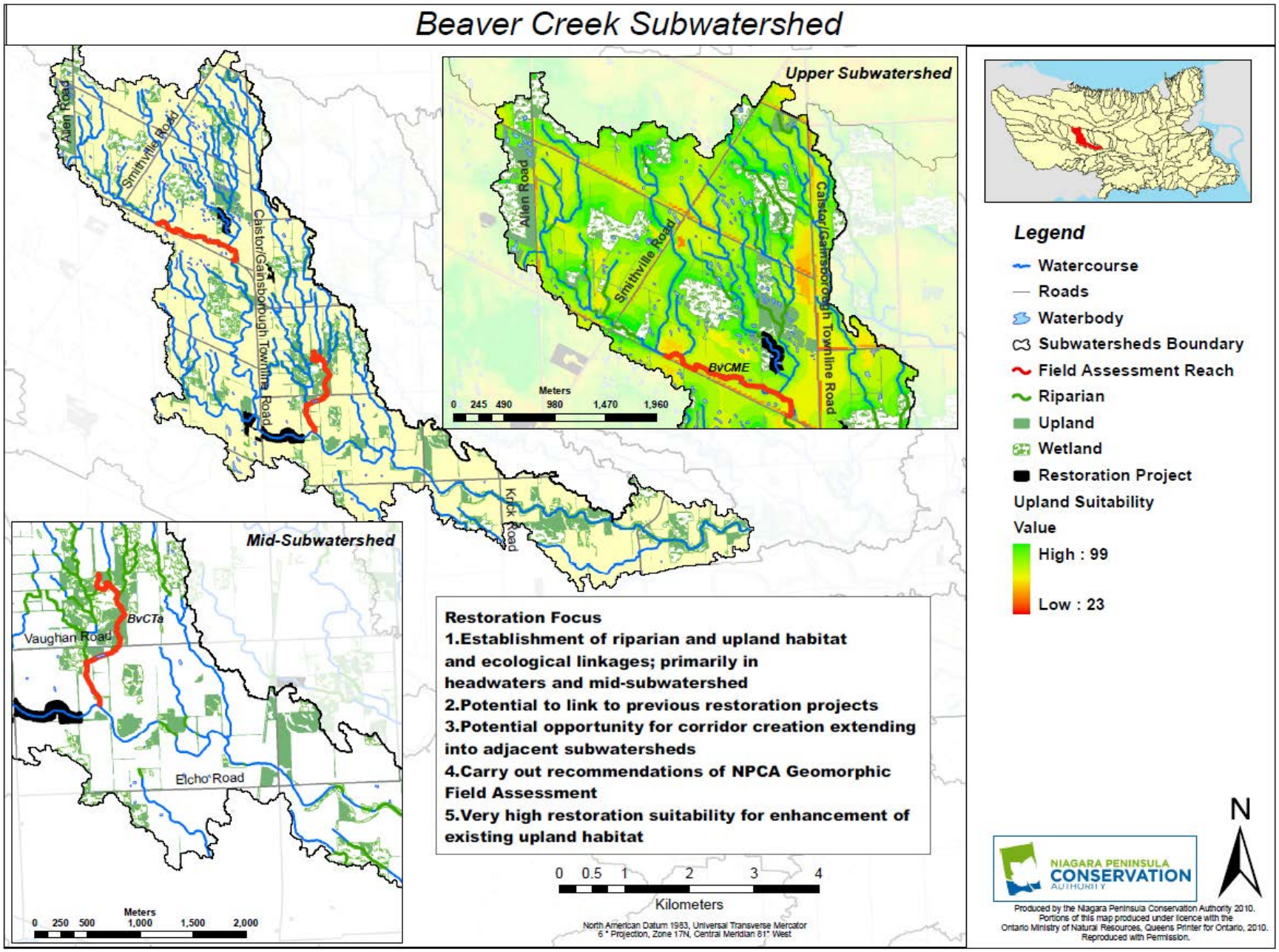

Figure 22: Beaver Creek Subwatershed

Black Ash Creek Subwatershed

Table 12:Black Ash Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	12 sq km	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	30 km	Outlets to Beaver Creek
Fish Habitat	Important	Smaller headwater streams have not been evaluated
Municipal Drains	Black Ash Creek Drain	Class E
Water Quality	Station:BV001 Water Quality Index: Poor BioMAP Rating: Impaired	Sampling is conducted downstream of the outlet of Beaver Creek subwatershed which captures the cumulative impacts of land use in both Beaver Creek, Black Ash Creek, Parkers Creek and Unnamed Creek subwatersheds. As indicated in Beaver Creek Strategy, factors affecting water quality include exceedances of *E.coli* and total phosphorus. Of 68 NPCA surface water quality monitoring stations, the Beaver Creek station has the highest mean concentration of total phosphorus in 2009. Manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides are likely sources of total phosphorus (NPCA 2010).
Groundwater Vulnerability	Low Groundwater Vulnerability; one small area has a medium vulnerability to groundwater contamination in southern portion of subwatershed. In addition pockets of high vulnerability are present.	Land use in medium vulnerability area is agriculture. Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	25% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	7% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	20% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed To Date		
Reforestation	1 project	2003: 4800 trees and shrubs planted
Manure Storage	1 project	2007
Fish Barrier Removal	2 minor barriers identified and removed	Low level crossing, and failed/perched/infilled culvert

Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement		•currently amount of riparian habitat is low (25%). •this subwatershed is contributing to the water quality sampling station that has been identified as having the highest mean of total phosphorus of 68 Welland River sites. •very little riparian is currently present in the area of medium groundwater vulnerability; establishment of a sufficient buffer should be implemented in this area •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •large extents of watercourses designated as important fish habitat flow through agricultural fields with little to no riparian buffer •potential opportunity to build on previous NPCA Water Quality Improvement project
Upland and Ecological Linkages		•currently amount of upland habitat is low (7%) •very little natural cover is currently present in the area of medium groundwater vulnerability •potential opportunity to build on previous NPCA Water Quality Improvement project •suitability mapping indicates very high suitability for enhancement surrounding existing uplands, for infilling pockets and corridor creation; initial focus should be directed towards areas of groundwater vulnerability • a larger natural block could support a larger diversity of flora and fauna and corridors would facilitate the movement of flora and fauna between natural areas
Wetland Habitat		•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps between contiguous areas and enhancement of existing wetlands; initial focus should be directed towards areas of groundwater vulnerability • high suitability for riparian-wetland restoration along watercourse which would provide linkages between wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary (e.g. nesting habitat)
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
BACMd	Riparian Enhancement, Monitor Sediment Accumulation	The riparian buffer along this reach basically consists of a manicured lawn and a few deciduous trees; therefore habitat and shading over the stream will be impacted. There is relatively deep unconsolidated sediment deposited along the channel bed and no distinct pools were identified along this field site. A Provincially Significant Wetland exists downstream of this field site. Recommendations for this site include not mowing the grass to the edge of the watercourse. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment

		sources.
NPCA Education and Incentive Programs		
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program		Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies		
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed		The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program		Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program		Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a*

	municipality, and may generate revenue as a result" (MMAH 2001).
Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix I.
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Salt Vulnerability Study identified the Regional Road 20 corridor as having a high vulnerability to road salt from runoff. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of the surrounding surface water and natural heritage features and the adjacent agricultural lands to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Black Ash Creek subwatershed 2 of these points were identified; both are cemeteries. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

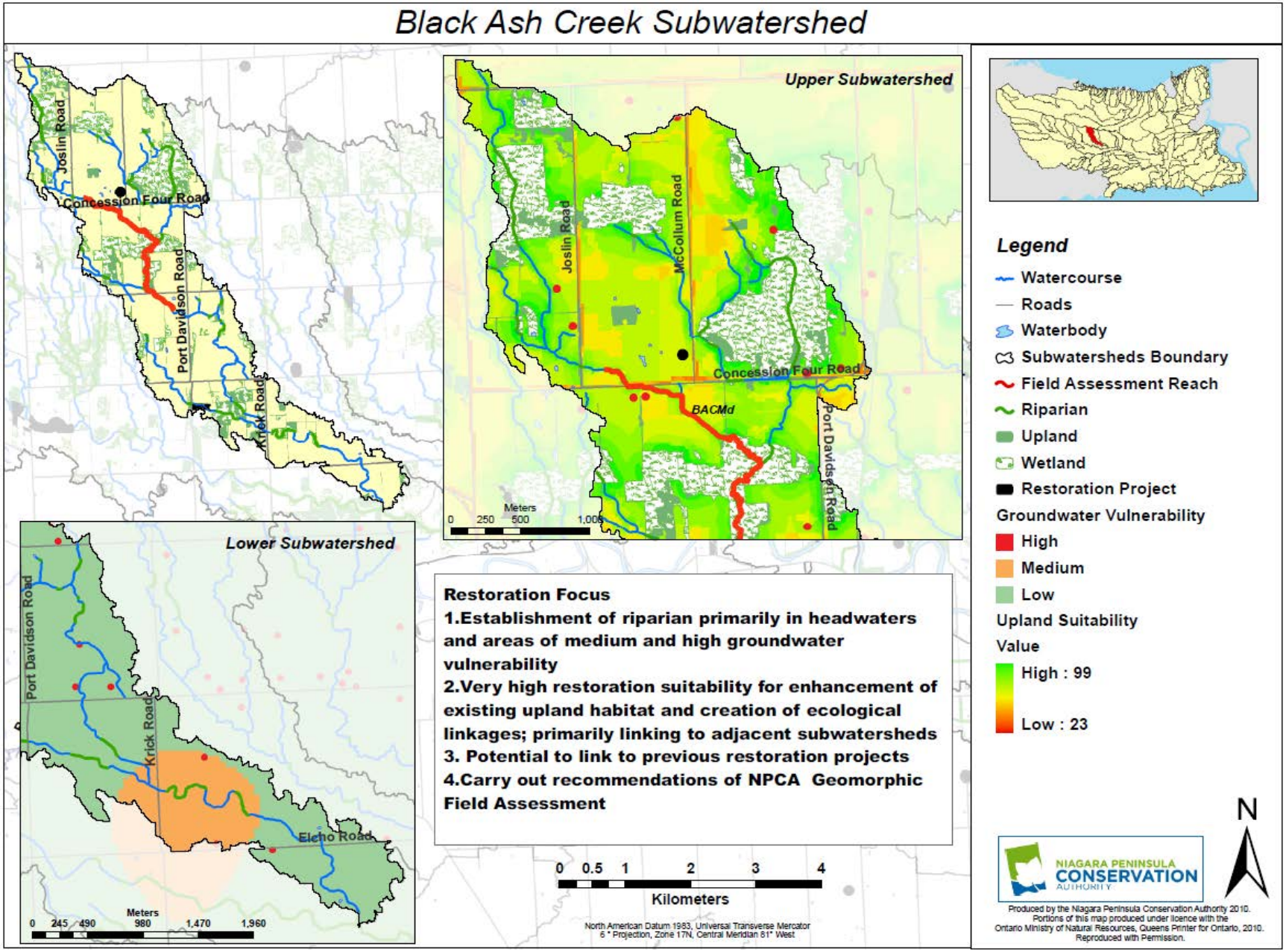

Figure 23: Black Ash Creek Subwatershed

Parkers Creek Subwatershed

Table 13:Parkers Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	8 sq km	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	22 km	Outlets to Unnamed Creek
Fish Habitat	Critical at outlet; important for majority of watercourses	A few smaller branches have not been evaluated in terms of importance for fish habitat
Municipal Drains	N/A	
Water Quality	Station:BV001 Water Quality Index: Poor BioMAP Rating: Impaired	Sampling is conducted downstream of the outlet of Beaver Creek subwatershed which captures the cumulative impacts of land use in Beaver Creek, Black Ash Creek, Parkers Creek and Unnamed Creek subwatersheds. As indicated, factors affecting water quality include exceedances of *E.coli* and total phosphorus. Of 68 NPCA surface water quality monitoring stations, the Beaver Creek station has the highest mean concentration of total phosphorus in 2009. Manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides are likely sources of total phosphorus (NPCA 2010).This section of the Welland River falls within zone of high phosphorus concentrations within the Welland River as identified in the Eutrophication Study
Groundwater Vulnerability	Low groundwater vulnerability with pockets of high vulnerability	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	15% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	7% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	15% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed To Date		
Non Point Source	2 projects	1997: Total Storage Capacity/m ³Year=4600
Fish Barrier Removal	N/A	
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (15%). •large extents of watercourse designated as important and critical fish habitat flow through agricultural fields with little to no riparian buffer; main channel has nearly no riparian buffer	

		•opportunity along west branch to connect natural heritage features by establishment of riparian •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.
Upland and Ecological Linkages		•currently amount of upland habitat is low (7%) •potential opportunity to establish and enhance ecological linkages facilitating in the movement of flora and fauna between natural areas and extending into adjacent subwatersheds; primarily in upper subwatershed •suitability mapping indicates very high suitability for enhancement surrounding existing uplands and infilling gaps between fragmented upland areas; filling in gaps of natural areas will reduce forest edge –interior ratio and create a larger natural area. A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat		•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps between contiguous areas and enhancement of existing wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary (e.g. nesting habitat)
NPCA Fluvial Geomorphology Study		
Reach	**Priority Action**	**Field Assessment and Recommendations**
PCMb	Riparian Enhancement, Monitor Sediment Accumulation	The buffer and in-channel vegetation at this field site basically consist of long grass (phalaris). There are areas where the buffer is absent or small between the channel and the agricultural field. Relatively deep, unconsolidated sediment was noted along the bed during this site visit. There is a crossing through the channel but no culvert is present. Channel boundaries are difficult to identify at this field site. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates. Planting a buffer where one is nonexistent will help to filter out sediment and pollutants that may enter the watercourse. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Vehicles crossing a channel with no culvert present contribute to bank instability therefore a culvert should be installed at this crossing. Respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation.
PCMb-2	Riparian Enhancement	Second field site along reach PCMb) The buffer zone is small and basically only consists of herbaceous vegetation. The long grass is providing the canopy cover over the watercourse. No pools were identified at this study site. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates along the watercourse.
NPCA Education and Incentive Programs		
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.

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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Salt Vulnerability Study identified the Regional Road 20 corridor as having a high vulnerability to road salt from runoff. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of the surrounding surface water and natural heritage features and the adjacent agricultural lands to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended

Program for sensitive areas	that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.

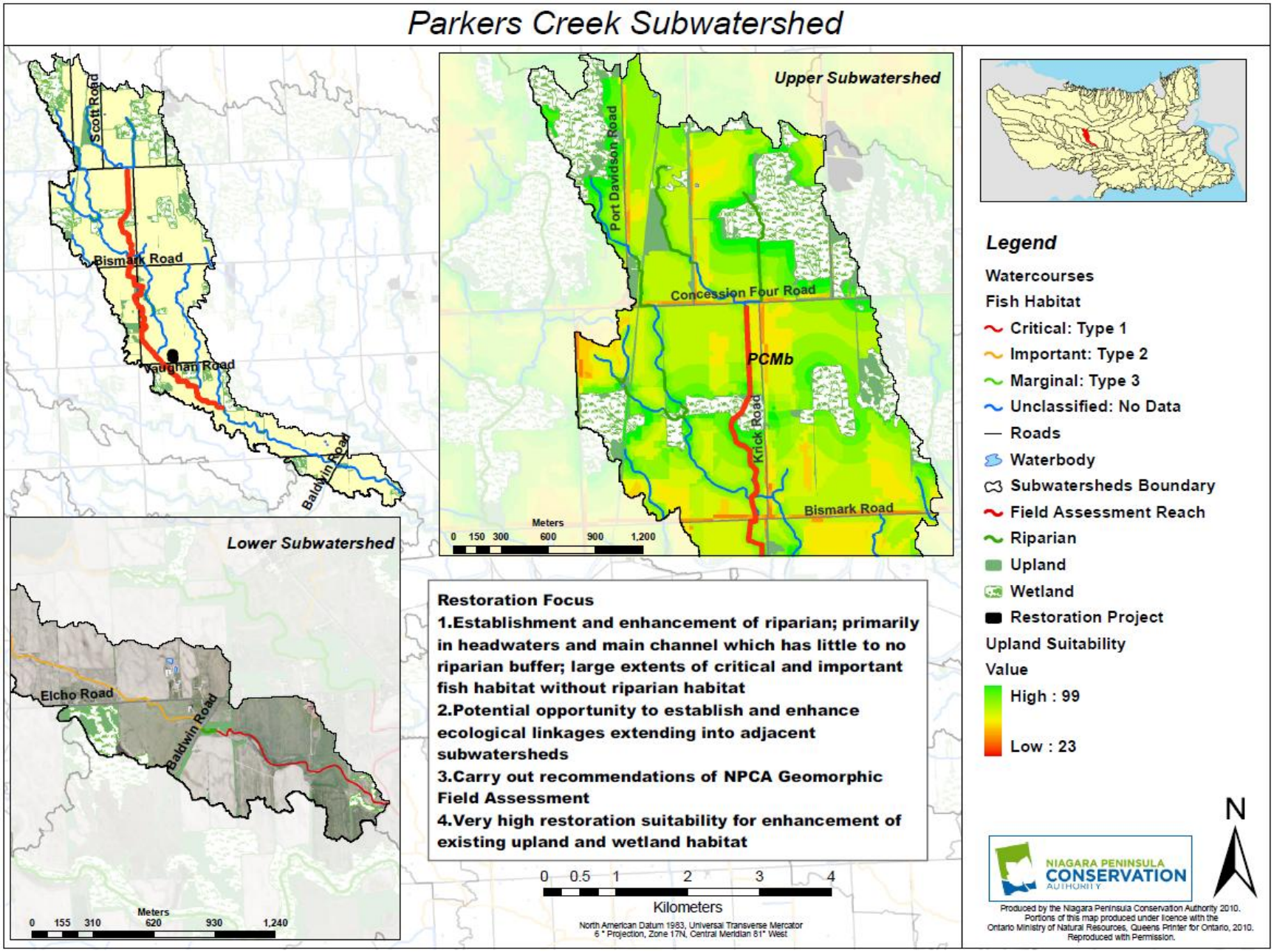

Figure 24: Parkers Creek Subwatershed

Unnamed Creek Subwatershed

Table 14:Unnamed Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	28 sq km	
Land Use	Primarily agriculture with a small rural cluster (Bismark) and rural hamlet community of Wellandport	
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	60 km	Outlets to Welland River
Fish Habitat	Critical at outlet; important for majority of watercourses	Smaller headwater streams have not been evaluated
Municipal Drains	N/A	
Water Quality	Station:BV001 Water Quality Index: Poor BioMAP Rating: Impaired	Sampling is conducted downstream of the outlet of Beaver Creek subwatershed which captures the cumulative impacts of land use in Beaver Creek, Black Ash Creek, Parkers Creek and Unnamed Creek subwatersheds. As indicated, factors affecting water quality include exceedances of *E.coli* and total phosphorus. Of 68 NPCA surface water quality monitoring stations, the Beaver Creek station has the highest mean concentration of total phosphorus in 2009. Manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides are likely sources of total phosphorus (NPCA 2010).This section of the Welland River falls within zone of high phosphorus concentrations within the Welland River as identified in the Eutrophication Study
Groundwater Vulnerability	Low Groundwater Vulnerability. Pockets of high groundwater vulnerability to contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program.
Natural Heritage Resources		
Riparian Cover	35% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	9% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	17% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	West Bismark Slough Forest, North Bismark Slough Forest, and South St. Anns Slough Forest	All 3 natural heritage areas are provincial Life Science ANSI's
Restoration Projects Completed To Date		
Non Point Source	2 projects	1996, 1999: Total Storage Capacity/m ³Year=1605
Reforestation	8 project	2002, 2005, 2006: Total planted was 23,695 trees, 26,155 seedlings, 130

		shrubs, 45.5kg seed, and 5.2kg herb seed
Riparian	4 projects	2003, 2004, 2006: Total 4165 trees and shrubs planted, erosion control, planted grass waterway
Fish Barrier Removal	N/A	
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (35%). •water quality has been identified as an issue in the NPCA Water Quality Report. This site has the highest mean of total phosphorus of 68 Welland River sampling sites. •large extents of watercourse evaluated as important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •riparian habitat also provides important linkages between fragmented natural areas providing cover for wildlife	
Upland and Ecological Linkages	•currently amount of upland habitat is low (9%) •potential opportunity to build on previous restoration projects; enhancement and infilling •suitability mapping indicates very high suitability in upper watershed for enhancement of existing upland areas and filling in gaps reducing forest edge –interior ratio creating a larger continuous natural area; primarily linking to ANSI's along northern edge of subwatershed. A larger natural block could support a larger diversity of flora and fauna •potential to create linkages between natural areas extending into adjacent subwatersheds. Corridors help to facilitate the movement of flora and fauna between natural heritage features.	
Wetland Habitat	•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps and enhancement of existing wetlands • very high suitability for riparian-wetland restoration along watercourse which would provide linkages between fragmented wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).	
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
UnCMa	Continue to monitor water quality	This site is located near the outlet and could be within the area of influence for the flow reversal of the Welland River. No visual indicators were identified that flow reversal was impacting this site. Turbid water and carp were noted during a site visit in 2009. No bank erosion was noted at this site so turbidity may be due to the presence of carp. This site is classified as a Provincially Significant Wetland. Continue to monitor water quality in this watershed is recommended due to turbid water.
UnCMa -2	Continue to monitor water quality	(Second field site along reach UnCMa) Algae, duckweed, dense macrophyte beds, and an orange algae-like substance were noted during a site visit in 2009. The channel lacked definition at this field site and is classified as a Provincially Significant Wetland. Continue to monitor water quality in this watershed is recommended due to the presence of algae, and dense macrophyte beds
UnCMa -3	Continue to monitor water quality	(Third field site along reach UnCMa) Algae, duckweed, and areas of dense macrophyte beds were noted during a site visit in 2009. The water was also turbid during this site visit and it is possible that carp were present. This site

		is classified as a Provincially Significant Wetland. Continue to monitor water quality in this watershed is recommended due to the presence of algae and areas of dense macrophyte beds.
UnCTa A	Monitor Sediment Accumulation; Remove Debris Jams; Continue to monitor water quality	Algae and areas of dense macrophyte beds were noted during field visit in 2009. There were also areas of relatively deep, unconsolidated sediment along the bed. Numerous vegetated debris jams were also noted. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Additional sediment may be entering the channel through bank erosion at the numerous debris jams present along this field site. If these debris jams are causing more sediment to enter the channel then they should be removed. Continue to monitor water quality in this watershed due to the presence of algae and dense macrophyte beds.
UnCTb	Riparian Enhancement; Monitor Sediment Accumulation; Culvert Installation; Continue to monitor water quality,	The channel is not defined in the upstream section of this study site, which may be due to the fact that the surrounding land is flat. There is little to no vegetation in the buffer zone which will impact cover and habitat adjacent to the watercourse. The long grass in the buffer zone is providing the canopy cover. A number of small tributaries or possibly rills/gullies exist along the watercourse. Areas with relatively deep unconsolidated sediment along the bed were identified. There is a crossing with no culvert present which could provide additional sediment into the channel due to the unprotected stream banks. There also seems to be an ATV trail across the channel. The presence of algae was noted during a site visit in 2009. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b). Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Vehicles crossing a channel with no culvert present contribute to bank instability therefore a culvert should be installed at this crossing. Respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation. Water quality should continue to be monitored in this watershed due to the presence of algae.
NPCA Education and Incentive Programs		
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.

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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Salt Vulnerability Study identified the Regional Road 20 corridor as having a high vulnerability to road salt from runoff. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of the surrounding surface water and natural heritage features and the adjacent agricultural lands to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended

Program for sensitive areas	that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Unnamed Creek subwatershed 2 of these points were identified; 1 cemetery and 1 fuel storage. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

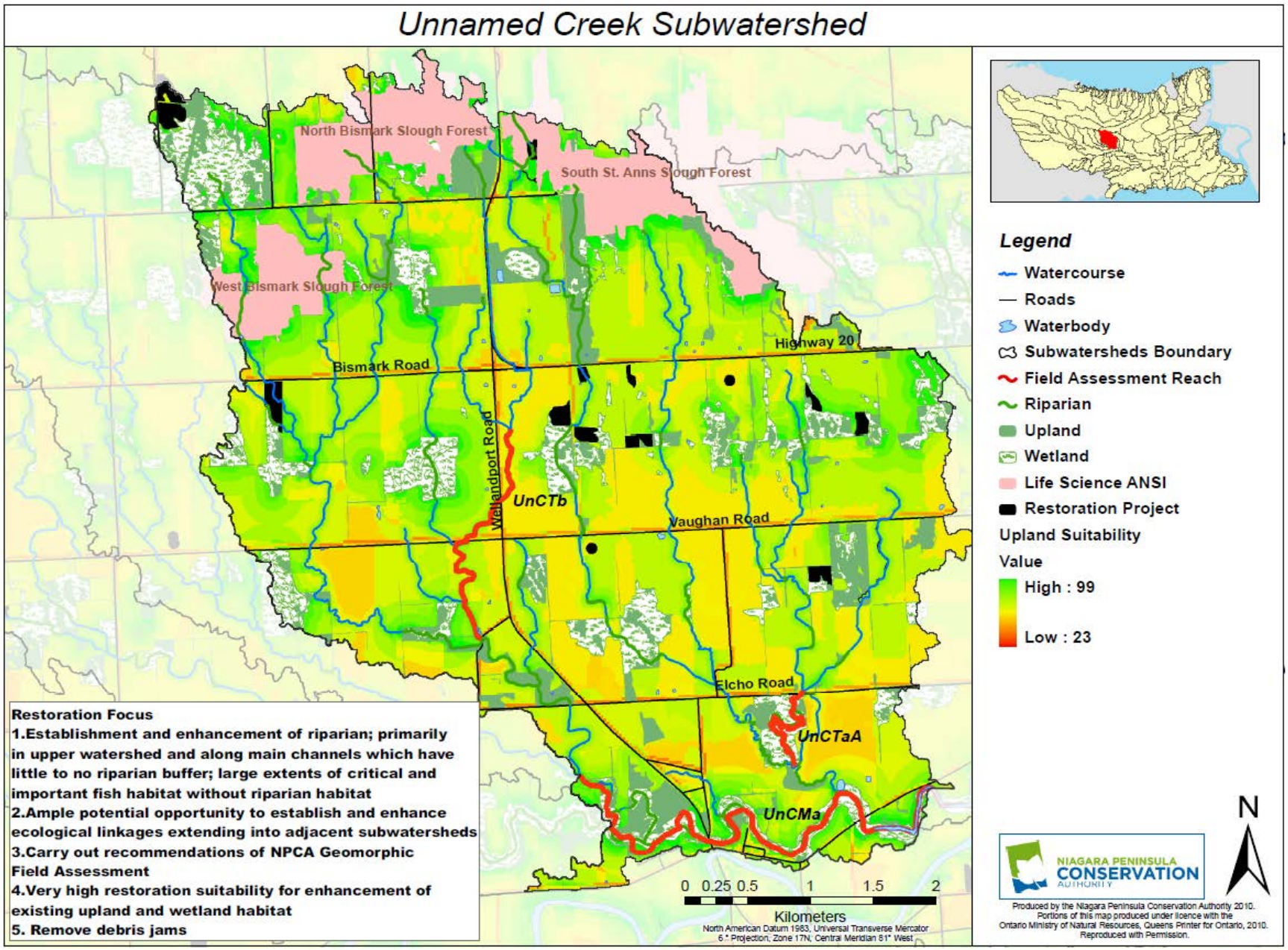

Figure 25: Unnamed Creek Subwatershed

Sucker Creek Subwatershed

Table 15:Sucker Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	11 sq km	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	22 km	Outlets to Welland River
Fish Habitat	Critical at outlet; important for majority of watercourses	Smaller headwater streams have not been evaluated
Municipal Drains	N/A	
Water Quality	N/A	The NPCA does not monitor water quality in this subwatershed, however, Sucker Creek outlets to the Welland River within the zone of high phosphorus concentrations within the Welland River as identified in the Eutrophication Study
Groundwater Vulnerability	Low Groundwater Vulnerability; one small area has a medium vulnerability to groundwater contamination. In addition pockets of high vulnerability are present.	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	41% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	9% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	21% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	South St. Anns Slough Forest	provincial Life Science ANSI
Restoration Projects Completed to date		
Non Point Source	2 projects	2001 Total Storage Capacity/m ³Year=4150
Riparian	2 projects	1997,2003: 2700m of stream fencing
Fish Barrier Removal	One major barrier identified and removed	Streambed altered/deformed
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (41%). •focus on establishment of riparian in mid-subwatershed reaches and areas of high groundwater vulnerability; currently little to no riparian habitat in these areas •potential opportunity to build on previous riparian restoration projects •large extents of watercourse evaluated as important fish habitat flow through agricultural fields with little to no riparian buffer	

		•riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •the establishment of riparian habitat is ideal for creating important linkages that will connect fragmented natural areas providing cover for wildlife
Upland and Ecological Linkages		•currently amount of upland habitat is low (9%) •suitability mapping indicates very high suitability for enhancement surrounding existing uplands; primarily in the headwater region south of St.Anns Slough Forest ANSI •ample opportunity for infilling pockets and creating a larger natural area while reducing forest edge –interior ratio. A larger natural block could support a larger diversity of flora and fauna •potential opportunity to establish and enhance ecological linkages facilitating in the movement of flora and fauna between natural areas and extending into adjacent subwatersheds; primarily in upper subwatershed
Wetland Habitat		•currently level of wetland coverage exceeds EC minimum target, however ample opportunity is present for filling in gaps between contiguous areas and enhancement of existing wetlands; primarily in headwater and floodplain regions • high suitability for riparian-wetland restoration along main channel of watercourse in upper and mid subwatershed •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitat)
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
SCMa	Monitor Water Quality	This site is located near the outlet and could be within the area of influence for the flow reversal of the Welland River. Very little water was present at this field site and no visual indicators were identified that flow reversal was impacting this site. No deep pools, boulders/cobbles, or riffles identified along the watercourse at this field site, therefore impacting fish cover. A sheen was identified on the water surface during a site visit in 2009. Water quality should be monitored in this watershed due to the sheen.
NPCA Education and Incentive Programs		
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Salt Vulnerability Study identified the Regional Road 20 corridor as having a high vulnerability to road salt from runoff. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of the surrounding surface water and natural heritage features and the adjacent agricultural lands to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.

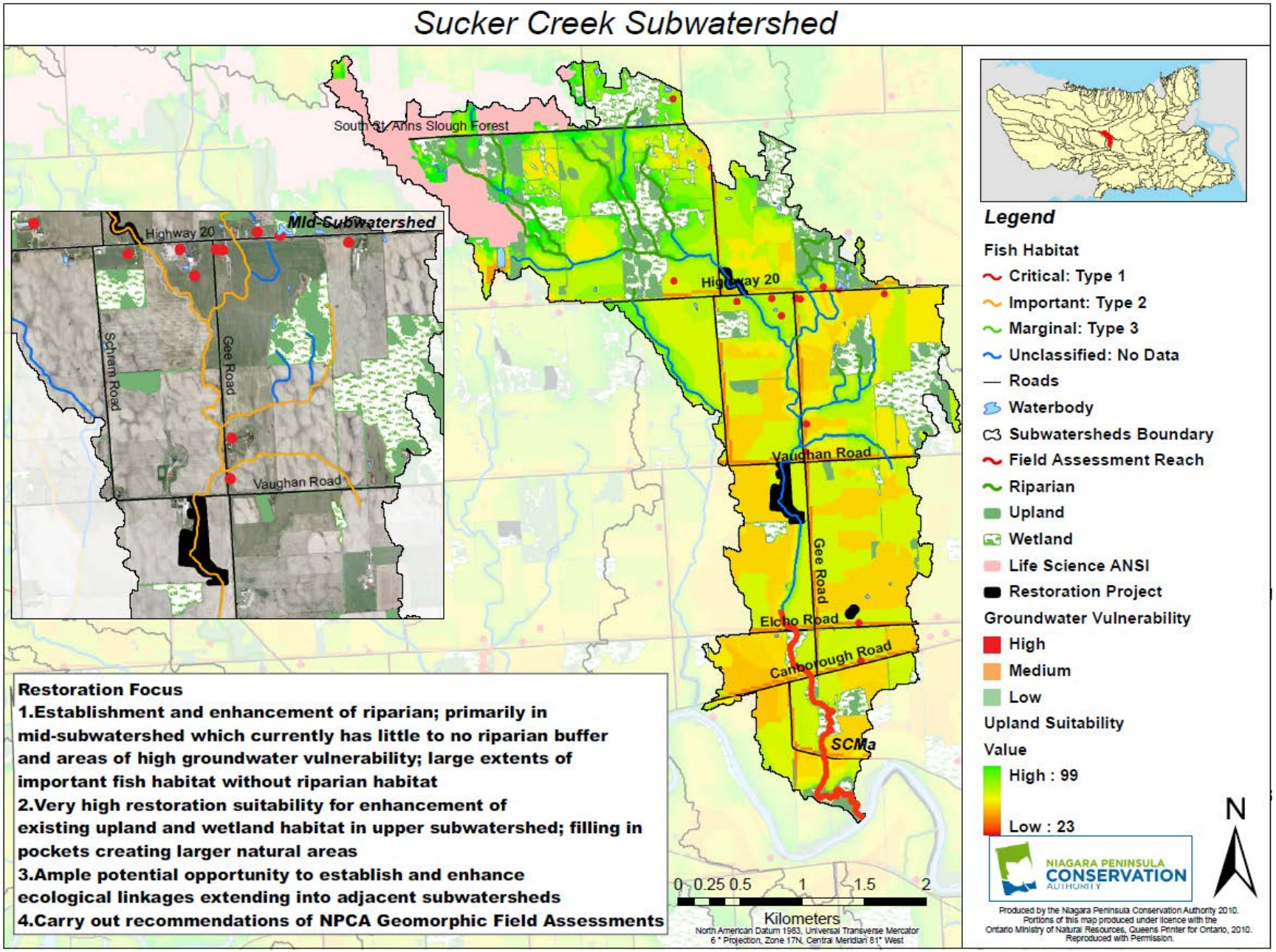

Figure 26: Sucker Creek Subwatershed

Coyle Creek Subwatershed

Table 16:Coyle Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	40 sq km	
Land Use	Agriculture with a mix of urban (Fenwick) and rural residential	• Fenwick urban area • Greenbelt Plan: Protected Countryside boundary in northern portion of subwatershed
Municipal Water and Sewer Services	Yes; partial	Within the urban areas of Fenwick and Fonthill One CSO and one CSO outfall in subwatershed
Recreation	golf courses	Pelham Hills Golf and Country Club
Aquatic Resources		
Length of Watercourse	88 km	40% of these are managed as municipal drains; outlets to Welland River
Fish Habitat	Important, and outlet is critical fish habitat	Some smaller headwater streams have not been evaluated
Municipal Drains	Swayze Drain, Nunn Drain, Big Creek Drain, Ridgeville Drain East, and Ridgeville Drain East	Drains classifications include Class C, E and F
Water Quality	Station:CO001 Water Quality Index: Marginal BioMAP Rating: Impaired	The NPCA has a water quality monitoring station near the outlet of Coyle Creek to capture the cumulative impacts of land use in the subwatershed. *The NPCA Water Quality Monitoring Program: 2009 Annual Report* (NPCA 2010) reports a Water Quality Rating of marginal with exceedances of *E.coli*, total phosphorus and suspended solids. The report also indicates that high sediment loading is evident from upstream erosion and runoff.
Groundwater Vulnerability	Predominantly high and medium vulnerability to groundwater contamination	Headwaters commence on Fonthill Kame-Delta Complex; a significant groundwater recharge area and an area of high groundwater vulnerability
Natural Heritage Resources		
Riparian Cover	52% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	23% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	13% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	Ridgeville Swamp Life Science ANSI, Fonthill Kame-Delta North Slope Earth Science ANSI	2 provincial ANSI's
Restoration Projects Completed to date		
Reforestation	4 projects	1999, 2004,2005,2008:17,010 trees planted
Riparian	2 projects	2004:300 trees and 150 shrubs hand planted
Trickle Irrigation/ Non Point Source	1 project	2006: for orchard; saves 24,610,365L/yr of water and covers a 30acre field

Fish Barrier Removal	10 barriers identified; 3 minor barriers identified and removed, 5 major removed, and 2 major status unknown	Failed dam, sediment filled pond with 30cm drop and rock dam: these need to be investigated to determine if barriers still exist and if can remediated.
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is 52%. •riparian establishment/enhancement should be implemented in headwaters; high groundwater recharge and highly vulnerable groundwater area. Some of the headwater watercourses are managed as municipal drains; work with drainage superintendant to find an ecologically compatible balance between drain maintenance and function • potential opportunity to build on previous riparian restoration projects •large extents of watercourse designated as important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.	
Upland and Ecological Linkages	•currently amount of upland habitat is low (23%) •potential opportunity to build on previous reforestation projects •ample opportunity for infilling gaps, and enhancing existing uplands throughout entire subwatershed creating larger natural areas; increasing interior size would increase the ability of the natural area to support a larger diversity of flora and fauna •opportunity for creation of corridor connections extending into adjacent subwatersheds primarily west of Church Street and extending into Sucker Creek subwatershed; connections facilitate the movement of flora and fauna between natural areas •suitability mapping indicates very high suitability for enhancement surrounding existing uplands	
Wetland Habitat	•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps between contiguous areas and enhancement of existing wetlands •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary (e.g. nesting habitat)	
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority action**	**Field Assessment and Recommendations**
CC Headwaters	Establishment of Riparian Habitat; Investigate potential fish barrier; Continue to monitor water quality;	The channel along this field site has been altered by the creation of two on-line ponds. Little to no buffer exists in the upstream section; therefore habitat and shading over the stream will be impacted. A submerged culvert was identified in the downstream section at the berm (old railway tracks). The presence of algae was noted in the watercourse during a site visit in 2009. A number of small tributaries or possibly rills/gullies exist along the watercourse. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habitat for fish, insects, and invertebrate. Further investigation into the size of the culvert at the berm is recommended. If an issue is identified then respective

		stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation. Water quality should continue to be monitored in this watershed due to the presence of algae. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b).
CCMa	Investigate potential mitigations for outfall; Continue to monitor water quality	This site is located near the outlet and could be within the area of influence for the flow reversal of the Welland River. No visual indicators were identified that flow reversal was impacting this site. Slow moving water was present within the channel but there were no distinct pools identified. Turbid water and algae were noted during a site visit in 2009. A downstream landowner did state some concerns about water quality and quantity at this study site. There is an outfall (possibly from the road) approximately 2 feet from the stream bed with concrete pieces below it. This could indicate that the water from the outfall is causing erosion at this location. Recommendations for this site include making sure the outfall is properly constructed to mitigate any problems to the watercourse, such as bed or bank erosion caused by flowing water falling from the outfall. A possible solution is to construct outfalls so they are flush to the bed of the channel. Respective stakeholders should be contacted prior to construction due to permit requirements. Water quality should continue to be monitored in this watershed due to the presence of turbid water and algae.
CCTaTa	Riparian Enhancement; Assess culverts along Chantler Road; Continue to monitor water quality; Bank Stabilization projects;	This channel is classified as a municipal drain named Ridgeville Drain East Branch. The channel along this field site has been altered by the creation of an on-line pond. The buffer is small or nonexistent in some areas along the watercourse. Bank erosion is present in the form of undercutting, bare soil extending up the bank, and exposed roots. Pieces of concrete have been placed along the bank probably to mitigate erosion issues. Algae and turbid/cloudy water were noted during a site visit in 2009. No distinct pools were identified at this field site. The landowner states that the channel floods over its banks typically in the fall and spring and that the ditches at Chantler Road also flood. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates. Flooding over the channel banks may be a natural process at this field site but further investigation into the size of the culverts within this site is recommended. If an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation. Water quality should continue to be monitored in this watershed. Proper bank stabilization methods should be installed to prevent erosion and should be discussed with the Drainage Superintendent. Options for erosion control and bank stabilization, such as planting bigger buffers, can be found in “The Drain Primer, Ontario Edition” (Evanitski, 2008).
CCTb	Erosion pins to monitor bank erosion	Slow moving water was present within the channel but there were no distinct pools identified. Some undercutting was identified along the steeper sections of bank. Bank erosion should be monitored at this field site to ensure the banks are adequately stabilized. Monitoring can be done by the use of erosion pins along the bank.
CCTb-2	Monitor Sediment Accumulation	(Second field site along reach CCTb) Slow moving water was present within the channel but there were no distinct pools identified. Pockets of relatively deep, unconsolidated sediment were identified along the bed. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments,

		increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources.
CCTb-3	Monitor Sediment Accumulation; Conduct Visual Assessments to determine sources of sediment; Rill remediation; Assess culvert	(Third field site along reach CCTb) Bank instability is present in the form of bare soil extending up the bank, slumping, and some undercutting. Areas of relatively deep unconsolidated sediment were identified along the bed. A number of small tributaries or possibly rills/gullies exist along the watercourse. It is possible that a culvert is undersized and submerged at a crossing at this site. The presence of bank slumping usually indicates that vegetative roots are too shallow to stabilize the banks or that the bank slopes are over steepened. Slumping is common in clay textured soil and over steepened slopes. Depending on the velocities and shear stresses within this area possible restoration choices include: brush layers, vegetated geogrids, or a hard engineering technique such as armourstone revetments. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b). Further investigation into the size of the culvert at the crossing is recommended. If an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation.
CCTb2	Riparian Enhancement	Although no distinct pools were identified at this field site there is an off-line pond adjacent to the channel. A section of the watercourse at this field site is basically a grass lined channel (phalaris). Recommendations for this field site include adding more native woody vegetation to the buffer zone.
CCTb2-2	Riparian Enhancement; Rill Remediation; Assess potential fish barrier; Continue to monitor water quality	(Second field site along Reach CCTb2) The riparian buffer along this section of the watercourse is poor due to the fact that some areas are mowed to the top of bank, as well as nonexistent in the agricultural area. This will impact habitat and cover for this field site. At least one rill was noted adjacent to the watercourse. The channel along this field site has been altered by the creation of an on-line pond. A weir was also identified at the downstream end of the pond. The presence of algae was noted during a site visit in 2009. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid

		excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b). Further research should also be conducted to determine whether the weir is causing problems with fish movement or flood issues. Changing the type of weir installed can be a solution for fish movement or if necessary, the weir can be removed. Water quality should continue to be monitored in this watershed due to the presence of algae.
CCTb2-3	Potential erosion	(Third field site along reach CCTb2) Although few pools were identified along this field site there are 3 off-line ponds adjacent to the channel. One of the ponds was taken off-line as part of a restoration project by the Niagara Restoration Council. The landowner did state some erosion problems with the berm between the watercourse and pond that was causing overflow. The Niagara Restoration Council was informed of the issue with the berm in 2009 and is being addressed.
CCTb2-4	Monitor Sediment Accumulation; Conduct Visual Assessments to determine sources of sediment	(Fourth field site along reach CCTb2) Relatively deep unconsolidated sediment was identified along this section of the watercourse. Riffle embeddedness is a measure of the depth to which objects are buried by sediment. Gravel particles tested at this location were approximated to be 40% buried by the sediment. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources.
CCTdTa	Rill Remediation; Continue to monitor water quality	This field site is within the designated municipal drain Disher Drain. This section of the watercourse has been channelized and has steep banks. Bank instability is present on both sides of the channel in the form of slumping. The riparian buffer along this section consists predominantly of herbaceous vegetation; therefore cover and habitat would be impacted. A number of small tributaries or possibly rills/gullies exist along the watercourse. The presence of algae was noted during a site visit in 2009. No distinct pools were identified during this site visit. Recommendations for this site include not grading the channel banks too steep during the dredging process so that deep rooted vegetation can become established along the banks and stabilize the soil. Alternatives to traditional drainage design, such as wetland creation, floodplain development, and increasing channel curvature should also be considered. Options for erosion control and bank stabilization, such as planting bigger buffers, can be found in "The Drain Primer, Ontario Edition" (Evanitski, 2008). All recommendations should be discussed with the Drainage Superintendent. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to avoid excessive amounts of sediment entering the watercourse. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b). Water quality should continue to be monitored within this watershed due to the presence of algae.
CCTdTa-2	Erosion pins to monitor bank erosion; Monitor sediment accumulation;	(Second field site along reach CCTdTa) Some bank instability was identified in the form of bare soil extending up the bank as well as undercutting. Relatively deep unconsolidated sediment was identified in some areas along this section of the watercourse. Recommendations for this site include monitoring bank erosion to ensure the banks are adequately stabilized. This can be done by the use of erosion pins inserted into the bank. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel

	Conduct Visual Assessments to determine sources of sediment	adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources.
CCTdTa-3	Erosion remediation works	(Third field site along reach CCTdTa) Bank instability is present in the form of slumping. There are some areas where the grass is mowed close to the edge of the channel. No distinct pools were identified along the channel but an off-line pond exists adjacent to the watercourse. The presence of bank slumping usually indicates that vegetative roots are too shallow to stabilize the banks or that the bank slopes are over steepened. Slumping is common in clay textured soil and over steepened slopes. Depending on the velocities and shear stresses within this area possible restoration options to limit the amount of sediment entering the watercourse include: brush layers, vegetated geogrids, or a hard engineering technique such as armourstone revetments. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Increase the variety and diversity of native plant species in the buffer zone.
CCTdTa-4	Investigate potential remediation of online pond; Riparian Enhancement; Assess potential fish barrier; Continue to monitor water quality	(Fourth field site along reach CCTdTa) The channel along this field site has been altered by the creation of an on-line pond. Algae, duckweed, and macrophytes were noted during a site visit in 2009. The buffer is small in areas and the landowner mows adjacent to the pond. A perched culvert in the downstream section may be considered a fish barrier. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Water quality should continue to be monitored in this watershed due to the presence of algae. Increasing the variety and diversity of native plant species within the buffer zone will provide cover and habitat for fish, insects, and invertebrates along the watercourse. Further investigation into the culvert that may be perched is recommended. If an issue is identified then the respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation.
NPCA Education and Incentive Programs		
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.
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 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.
Abandoned Well Decommissioning		Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater

Program	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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Combined Sewer Overflows and Extraneous Flow Reduction Program	Although combined sewers are no longer installed, existing infrastructure can have negative environmental impacts when during heavy rain events and snowmelts the combined sewer may reach capacity discharging excess wastewater in the watercourse. In an effort to help reduce the load on these sewer systems, a program similar to Port Colborne's Extraneous Flow Reduction Pilot Program is recommended. This program involves the "*inspection of private sanitary sewer services to assess their condition and the presence of any improper connections, followed by recommendations and City funded improvements to remove sources of rainwater from the sanitary sewer system"* (City of Port Colborne 2009).
Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the

	drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix I.
Environmentally Responsible Maintenance Practices for Golf Courses	By integrating golf course management practices with wildlife management, such as incorporating enhanced natural areas into the landscaping, golf courses have the potential to offer a wide range of habitat for wildlife. In addition, encouragement of environmentally responsible maintenance practices, if not already adopted, will be beneficial to water quality and the aquatic habitat. Investigation into the Audubon Cooperative Sanctuary Program for Golf Courses should be explored for golf courses if such a program has not already been adopted. In addition, environmentally friendly practices should be encouraged (e.g. chemical free practices).
Expansion of Niagara Region's Organic Deicing Material Program	In the upper portion of Coyle Creek subwatershed, Regional Road 20 traverses the Fonthill Kame-Delta Complex; an area of high groundwater vulnerability and a significant groundwater recharge area. Expansion of Niagara Region's Organic Deicing Material Program to include Regional Road 20 is recommended to reduce vulnerability of this area to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads. In this subwatershed, numerous municipal roads traverse areas of high and medium vulnerability as well as significant groundwater recharge areas. It is recommended that the initiation of an organic de-icing material program be implemented in these areas.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Coyle Creek subwatershed numerous points were identified; fuel storages, lumber yards, automotive wreckers, cemeteries, pipeline transfer stations, and potential PCB's. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

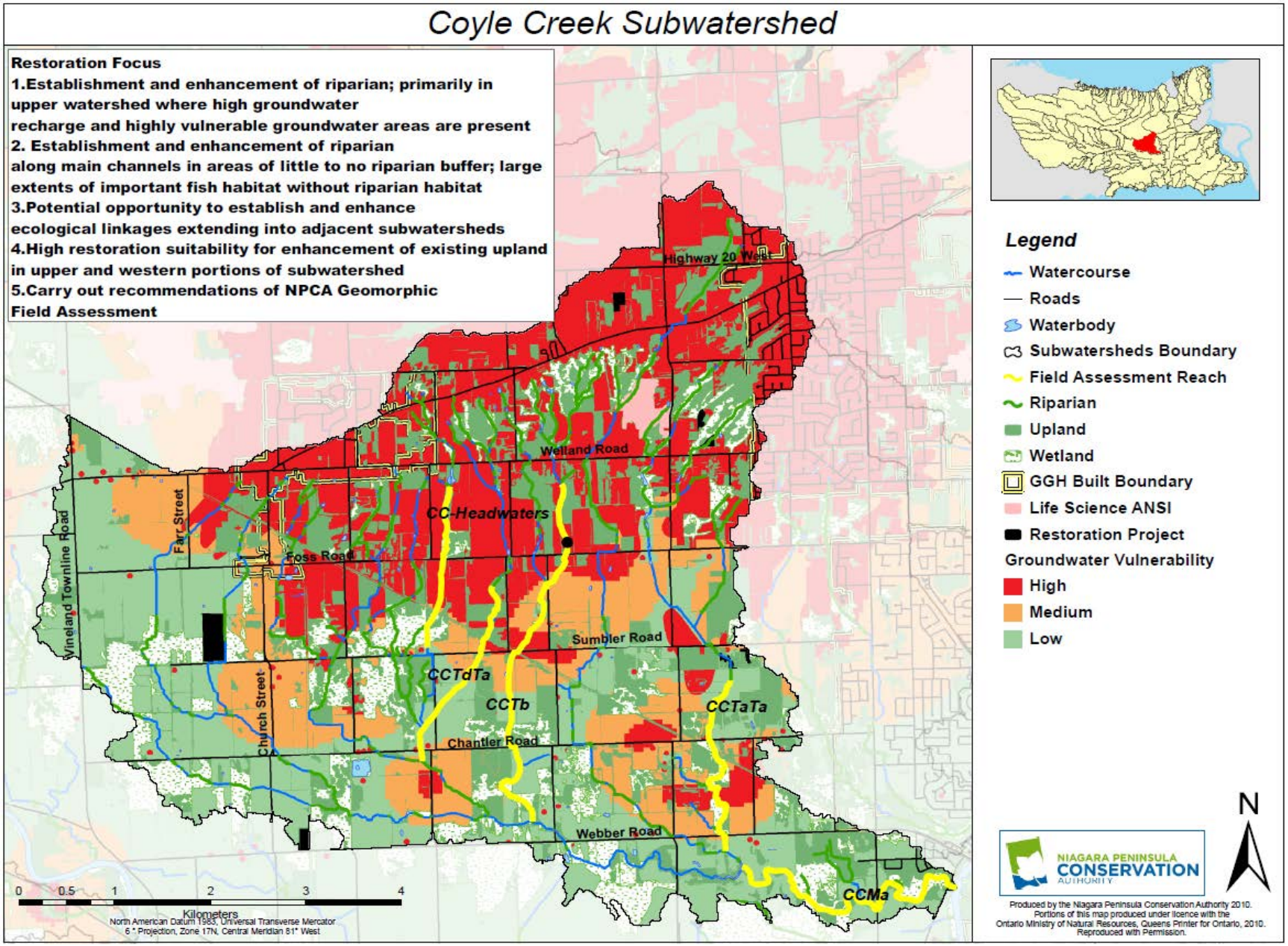

Figure 27: Coyle Creek Subwatershed

Drapers Creek Subwatershed

Table 17:Drapers Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	9 sq km	
Land Use	Predominantly urban as it encompasses parts of Fonthill and Welland. The remainder of the subwatershed is a mix of natural heritage areas and agriculture	
Municipal Water and Sewer Services	Small portion not serviced	Serviced areas include Fonthill and the City of Welland that falls within this subwatershed 2 CSO's and 3 CSO outfalls in subwatershed
Recreation	Recreational Trail	Fonthill Recreational Trail
Aquatic Resources		
Length of Watercourse	14 km	Outlets to Welland River
Fish Habitat	Important, and critical fish habitat	Eastern tributary which commences in Fonthill and flows through western Welland has been evaluated as important fish habitat and the main branch which also begins in Fonthill and flows through a series of agricultural fields and natural heritage features has been evaluated as critical fish habitat.
Municipal Drains	N/A	
Water Quality	Station:DR001 Water Quality Index: Poor BioMAP Rating: Impaired	The summarized water quality data from 2001 to 2009 indicates that *E.coli* concentrations frequently exceed the provincial objective. In addition, it was noted that high sediment loading was evident from upstream runoff and this site is vulnerable to contaminants in runoff from urbanized sections of the watercourse and urban encroachment (NPCA 2010).
Groundwater Vulnerability	Predominantly high and medium vulnerability to groundwater contamination	Headwaters commence on Fonthill Kame-Delta Complex; a significant groundwater recharge area and an area of high groundwater vulnerability
Natural Heritage Resources		
Riparian Cover	57% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	20% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	10% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date		
Reforestation	1 project	2007: 4410 trees planted
Riparian	2 project	2007, 2008: 38 upland trees, 200 lowland shrubs, 624 plugs
Fish Barrier Removal	8 identified; 5 minor removed, 2	Dam before bridge was identified as major barrier to fish; this area should

	major removed, one major: status unknown	be investigated to determine if barrier still exists and if it can remediated
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is 57%. •water quality index rating is poor as reported in the 2010 NPCA Water Quality Report. •large extent of watercourse evaluated as critical fish habitat flowing through agricultural fields with little to no riparian buffer between Foss and Sumbler Roads; this area has also been identified as having a medium groundwater vulnerability •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat	
Upland and Ecological Linkages	•currently amount of upland habitat is relatively low (20%) •opportunity for infilling gaps, and enhancing existing uplands creating larger natural areas in western subwatershed extending into adjacent Coyle Creek subwatershed, south of Chantler Road; increasing interior size would increase the ability of the natural area to support a larger diversity of flora and fauna •creation of corridor connections will facilitate in the movement of flora and fauna between natural areas	
Wetland Habitat	•currently level of wetland coverage is at EC recommended minimum target, however ample opportunity is present for filling in gaps and enhancement of existing wetlands in western subwatershed extending into adjacent Coyle Creek subwatershed, south of Chantler Road •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary (e.g. nesting habitat)	
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
DCMa	Continue to monitor water quality	This is the field site of Drapers Creek Stream Remediation Project completed by the Niagara Peninsula Conservation Authority, Ontario Power Generation, Environment Canada, Niagara Restoration Council, and the City of Welland. A perched culvert was removed and replaced, large stone block debris was removed, and a riparian buffer was planted. The culvert was replaced in 2007 and the rest of the work was completed in 2006. This project was implemented to alleviate the effects caused by the flow reversal of the Welland River. Turbid water, duckweed, and dense macrophyte beds were identified during a site visit in 2009. Recommendations for this site include continual monitoring of the remediation project to ensure all the components of the project are stable. Water quality monitoring in this watershed should continue due to the presence of turbid water and dense macrophyte beds.
DCMa-2	Monitor sediment accumulation; Conduct Visual Assessments to determine sources of sediment; Riparian Enhancement	(Second field site along Reach DCMa) This site is located near the outlet and could be within the area of influence for the flow reversal of the Welland River. No visual indicators were identified that flow reversal was impacting this site. Although no pools were identified along the bed there was stagnant water present throughout the field site. The left bank (determined looking downstream) of this channel is steep and has been altered by the use of large stones, riprap, and concrete. Relatively deep, unconsolidated sediment along the bed was noted during the site visit. Landowner commented about an increase in sediment and gravel along stream bed. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period

		of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as providing cover and habitat for fish, insects, and invertebrate.
DCMc	Bank stabilization; Riparian Enhancement	This straighter section of the watercourse at this field site has a steep right bank (determined looking downstream) with mostly herbaceous vegetation. There were no distinct pools identified but there was stagnant/low flow water present throughout. The canopy was open due to the lack of large woody vegetation on the right bank. Some slumping was identified along the right bank. Slumping is common in clay textured soil and over steepened slopes. Depending on the velocities and shear stresses within this area possible restoration options to limit slumping include: brush layers, vegetated geogrids, or a hard engineering technique such as armourstone revetments. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as provide cover and habitat for fish, insects, and invertebrate.
DCMc-2	Monitor sediment accumulation; Conduct Visual Assessments to determine sources of sediment; Bank stabilization	(Second field site along reach DCMc) There were no distinct pools identified but there was stagnant/low flow water present throughout the field site. There is an area where old riprap and cinder blocks are along the bank indicating that some erosion protection measures have been implemented by the landowner. The downstream section has relatively deep, unconsolidated sediment deposited along the channel bed. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Proper bank stabilization methods should be installed to ensure that the bank is protected. Depending on the velocities and shear stresses within these areas restoration can be a bioengineering technique or a hard engineering technique.
DCMd	Monitor bank erosion using erosion pins; Riparian Enhancement	This section of the watercourse seems to have been altered due to the straightness of the channel and the steep banks. Bank instability was present in the form of fallen vegetation, exposed roots, bare soil extending up the bank, and undercutting. Bank erosion on both sides of the channel could indicate that the channel may be widening. Riprap and logs are present along some bank areas. Although there is a good mixture of vegetation types in the buffer zone, the width is small. No distinct pools were identified at this field site. Bank erosion should be monitored at this field site to ensure the banks are adequately stabilized. Monitoring can be done by the use of erosion pins along the bank. Increasing the variety and diversity of native plant species in the buffer zone will provide additional cover and habit for fish, insects, and invertebrates.
NPCA Education and Incentive Programs		
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.

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 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.
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 hydrogeologically 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). 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.
Special Studies	
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Combined Sewer Overflows and Extraneous Flow Reduction Program	Although combined sewers are no longer installed, existing infrastructure can have negative environmental impacts when during heavy rain events and snowmelts the combined sewer may reach capacity discharging excess wastewater in the watercourse. In an effort to help reduce the load on these sewer systems, a program similar to Port Colborne's Extraneous Flow Reduction Pilot Program is recommended. This program involves the "*inspection of private sanitary sewer services to assess their condition and the presence of any improper connections, followed by recommendations and City funded improvements to remove sources of rainwater from the sanitary sewer system"* (City of Port Colborne 2009).
Expansion of Niagara Region's Organic Deicing Material Program	In Drapers Creek subwatershed South Pelham Road and Woodlawn Road (2 regional roads) traverse areas of medium groundwater vulnerability. Expansion of Niagara Region's Organic Deicing Material Program to include these regional roads is recommended to reduce vulnerability of these areas to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads. In this subwatershed, numerous municipal roads traverse areas of high and medium

	vulnerability as well as significant groundwater recharge areas. It is recommended that the initiation of an organic de-icing material program be implemented in these areas.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Drapers Creek subwatershed several of these points were identified; fuel storage, cemeteries, automotive wreckers, pipeline transfer station, and potentially PCB's. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

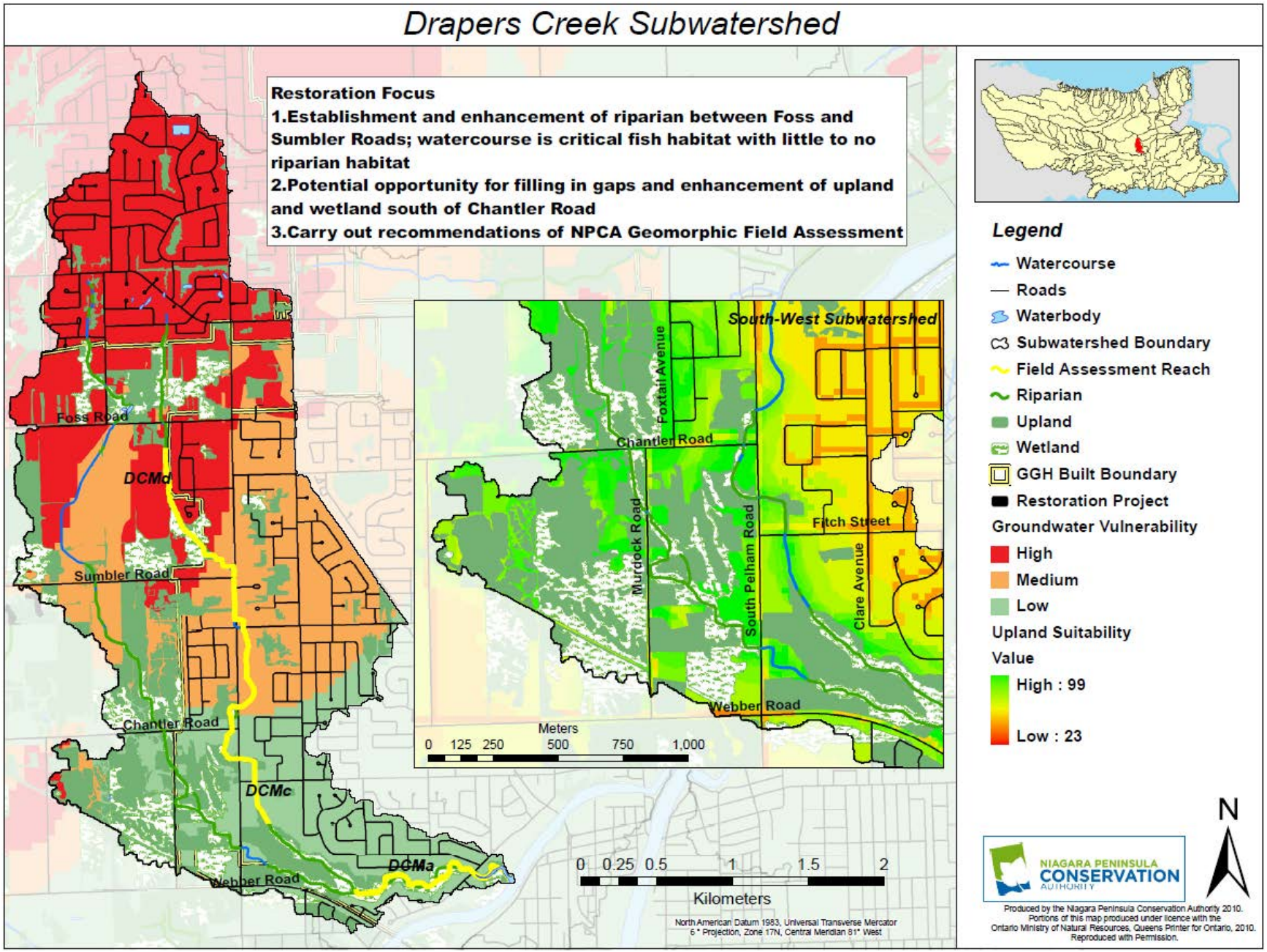

Figure 28: Drapers Creek Subwatershed

Little Forks Creek Subwatershed

Table 18:Little Forks Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	13 sq km	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	19 km	Outlets to Welland River
Fish Habitat	Main branch: critical Tributaries: important	
Municipal Drains	Little Forks Creek Drain	Lower half is Class B and the upper half is Class F
Water Quality	N/A	Although the NPCA does not monitor water quality in this subwatershed, Little Forks Creek does outlet into the mid reaches of the Welland River where it is most impacted by nutrient enrichment and elevated concentrations of suspended solids. Sources of nutrients and suspended solids include runoff from agricultural land use, soil erosion, sewage discharges, and animal waste (NPCA 2010). In addition, the *Eutrophication Study (2010)* reports that phosphate concentrations increase sharply between WR004 and WR005, increase downstream and peak at WR007.
Groundwater Vulnerability	Low Groundwater Vulnerability: one small area has a medium vulnerability to groundwater contamination, and one small areas has a high vulnerability	Land use in areas of medium and high vulnerability to groundwater contamination is agriculture
Natural Heritage Resources		
Riparian Cover	35% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	8% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	25% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed To Date		
Non Point Source	3 projects	1996, 1998: Manure Storage with Total Storage Capacity/m ³Year=4100, 1000 gallon pit w/transfer pipe to manure sump, 200ft eavestrough to divert water away from manure lagoon
Riparian	1 project	2004:755 trees machine planted, 380 shrubs, and another 315 trees in 2006
Fish Barrier Removal	3 minor barriers identified and removed	Instream debris, perched culvert, failed/infilled culvert
Restoration Opportunities: Recommended Actions for Public and Private Lands		

NPCA Water Quality Improvement Program	
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (35%). •headwater tributaries have little to no riparian buffer •large extents of critical and important fish habitat flow through agricultural lands with little to no riparian buffer •main channel is managed as a municipal drain, therefore work with local drainage superintendant to find an ecologically compatible balance between drain maintenance and function •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.
Upland and Ecological Linkages	•currently amount of upland habitat is low (8%) •suitability mapping indicates very high suitability for infilling gaps and enhancement surrounding existing upland habitat; primarily in upper portion of subwatershed. Increasing interior size would increase the ability of the natural area to support a larger diversity of flora and fauna •opportunity for the establishment/enhancement of corridor connections; connections facilitate the movement of flora and fauna between natural areas
Wetland Habitat	•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps and enhancement of existing wetlands •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitat)
NPCA Fluvial Geomorphology Study: N/A	
NPCA Education and Incentive Programs	
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist

	landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix I.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.

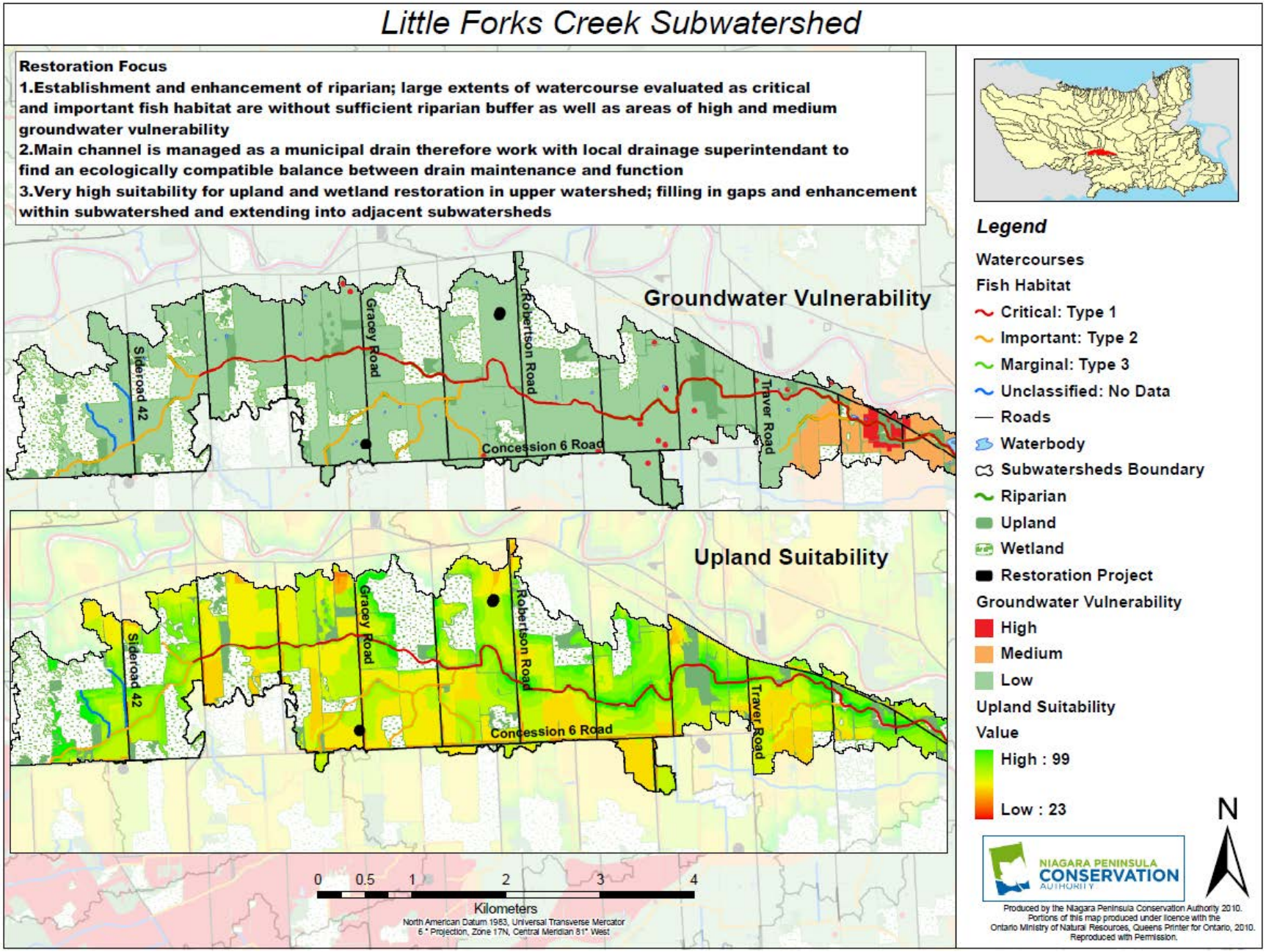

Figure 29: Little Forks Creek Subwatershed

Welland River West Subwatershed

Table 19:Welland River West Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	63 sq km of the Welland River watershed	
Land Use	Mix of agriculture, urban (City of Welland), rural, rural residential cluster (Boyle), industrial, and commercial	Also one small airport in this portion of the study area; Welland/Niagara Central Airport
Municipal Water and Sewer Services	Yes; partial	Urban and industrial portion of the City of Welland that fall within this subwatershed 11 CSO's and 13 CSO Outfalls in subwatershed
Recreation	3 golf courses Recreational Trail	Riverview Golf Course, Waterpark Golf and Country Club, and Sparrow Lakes Golf Club Steve Bauer Trail
Aquatic Resources		
Length of Watercourse	27 km of the Welland River; 90km total including tributaries in this portion of the study area	
Fish Habitat	Welland River: critical Tributaries: important	
Municipal Drains	Bridgewater Drain, Hilbing Drain	Both drains are Class F Drains.
Water Quality	Station: WR007 Water Quality Index: Poor BioMAP Rating: Impaired	*The NPCA Water Quality Monitoring Program: 2009 Annual Report* reports that water quality in the mid to lower reaches of the Welland River is most impacted by nutrient enrichment and elevated concentrations of suspended solids. Sources of nutrients and suspended solids include runoff from agricultural land use, soil erosion, sewage discharges, and animal waste (NPCA 2010). In addition, the *Eutrophication Study (2010)* reports that phosphate concentrations increase sharply between WR004 and WR005, increase downstream and peak at WR007.
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability; a few small areas have a medium vulnerability to groundwater contamination. In addition pockets of high vulnerability are present.	The areas identified as high groundwater vulnerability are transport pathways such as private wells (active and inactive), unknown status oil and gas wells and have been identified as posing a significant threat to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	32% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	12% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	18% is wetland habitat	EC recommends 10% or to historic value

ANSI, Conservation Areas	EC Brown Conservation Area	
Restoration Projects Completed to date		
Non Point Source	7 projects	1997, 1999, 2000, 2001: Manures Storage Total Storage Capacity/m³ Year=6578, transfer system, pad and runoff pit, earthen run-off pit
Reforestation	9 projects	2000, 2003, 2004, 2005, 2007, 2008: 52, 565 trees and 175 upland shrubs planted
Riparian	8 projects	1991, 2002, 2004, 2007: 847 trees, lowland shrubs and wildflowers planted
Fish Barrier Removal	1 major barrier identified	Crossing with culvert infilled with rock
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (32%). •water quality has been identified as an issue in the NPCA Water Quality Report and the Eutrophication Report. •area of highest total phosphorus within Welland River. •large extents of critical and important fish habitat have little to no riparian buffer •large number of tributaries in this portion of the Welland River flow through agricultural areas and have little to no riparian habitat •potential to build on previous riparian projects •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.	
Upland and Ecological Linkages	•currently amount of upland habitat is low (12%) •potential to build on previous reforestation projects •suitability mapping indicates very high suitability for infilling gaps and enhancement surrounding existing uplands; filling in gaps of natural areas reduces forest edge –interior ratio and creates a larger continuous natural; increasing interior size would increase the ability of the natural area to support a larger diversity of flora and fauna •focus should be in areas of high and medium groundwater vulnerability.	
Wetland Habitat	•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps creating larger natural area and enhancement of existing wetlands; primarily along floodplains and headwater region of tributaries •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitat)	
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
WRWTd	Riparian Enhancement; Monitor Sediment Accumulation; Rill Remediation;	This site is located near the outlet and could be within the area of influence for the flow reversal of the Welland River. Very little water was present at this field site and no visual indicators were identified that flow reversal was impacting this site. There is little to no vegetation in the buffer zone adjacent to the open field and a lack of woody vegetation in the buffer zone throughout this field site. This will impact cover and habitat adjacent to the watercourse. The long grass in the buffer zone is providing the canopy cover. Truck tracks adjacent and in the channel were noted during a site visit in 2009. At least one rill was identified during this site visit. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and

		invertebrates. Vehicles crossing a channel with no culvert present contribute to bank instability therefore a culvert should be installed at this crossing. Respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Projects to prevent and limit further development of rills adjacent to the watercourse should be implemented to also prevent additional sediment from entering the channel. Some examples include grassed waterways, chute spillways, tile drainage outlets, and proper tillage and cropping practices (OMAFRA, 1997a), (OMAFRA, 1997b).
WRWTf	Assess to determine if online pond is having negative impact; Monitor Sediment Accumulation; Conduct Visual Assessments to determine sources of sediment; Riparian Enhancement; Continue to Monitor Water Quality	This site is located along a small tributary near the outlet and could be within the area of influence for the flow reversal of the Welland River. Very little water was present at this field site and no visual indicators were identified that flow reversal was impacting this site. The channel along this field site has been altered by the creation of an on-line pond. Turbid water was noted in the pond during a site visit in 2009, as well as sediment deposition at the entrance to the pond. Bank instability is present in the form of bare soil extending up the bank, as well as undercutting. A manicured lawn exists adjacent to the watercourse which impacts cover and habitat for this field site. The presence of algae was noted during a site visit in 2009. Recommendations for this site include further research to determine whether the on-line pond is causing any issues to the watercourse. Examples of problems include thermal pollution (increases in water temperature in the pond area), reducing base flow, and channel alignment could be altered during creation of the pond. Temperature data loggers can be used to test thermal pollution, buffers can be planted to improve water quality, and if necessary on-line ponds can be taken off-line. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Monitoring the accumulation of sediment along the channel bed can be done by the creation of a permanent cross section at this field site. Re-surveying this cross section over a period of time will provide information on channel dimensions and will indicate if excessive sediment deposition is occurring (United States Environmental Protection Agency, 2010). Determining possible upstream sources of sediment would also be beneficial. Sources of additional sediment that may enter the watercourse include construction sites, large bank/slope erosion sites, and surface runoff from non-vegetated fields. Visual assessments of the watercourse can indicate potential sediment sources. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as providing cover and habitat for fish, insects, and invertebrate. Water quality should continue to be monitored in this watershed due to the presence of algae and turbid water.
NPCA Education and Incentive Programs		
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. *"Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Combined Sewer Overflows and Extraneous Flow Reduction Program	Although combined sewers are no longer installed, existing infrastructure can have negative environmental impacts when during heavy rain events and snowmelts the combined sewer may reach capacity discharging excess wastewater in the watercourse. In an effort to help reduce the load on these sewer systems, a program similar to Port Colborne's Extraneous Flow Reduction Pilot Program is recommended. This program involves the "*inspection of private sanitary sewer services to assess their condition and the presence of any improper connections, followed by recommendations and City funded improvements to remove sources of rainwater from the sanitary sewer system"* (City of Port Colborne 2009).
Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix I.
Environmentally Responsible Maintenance Practices for Golf Courses	By integrating golf course management practices with wildlife management, such as incorporating enhanced natural areas into the landscaping, golf courses have the potential to offer a wide range of habitat for wildlife. In addition, encouragement of environmentally responsible maintenance practices, if not already adopted, will be beneficial to water quality and the aquatic habitat. Investigation into the Audubon Cooperative Sanctuary Program for Golf Courses should be explored for golf courses if such a program has not already been adopted. In addition,

	environmentally friendly practices should be encouraged (e.g. chemical free practices).
Expansion of Niagara Region's Organic Deicing Material Program	In Drapers Creek subwatershed South Pelham Road and Woodlawn Road (2 regional roads) traverse areas of medium groundwater vulnerability. Expansion of Niagara Region's Organic Deicing Material Program to include these regional roads is recommended to reduce vulnerability of these areas to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads. In this subwatershed, numerous municipal roads traverse areas of high and medium vulnerability as well as significant groundwater recharge areas. It is recommended that the initiation of an organic de-icing material program be implemented in these areas.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Drapers Creek subwatershed several of these points were identified; fuel storage, cemeteries, automotive wreckers, pipeline transfer station, and potentially PCB's. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

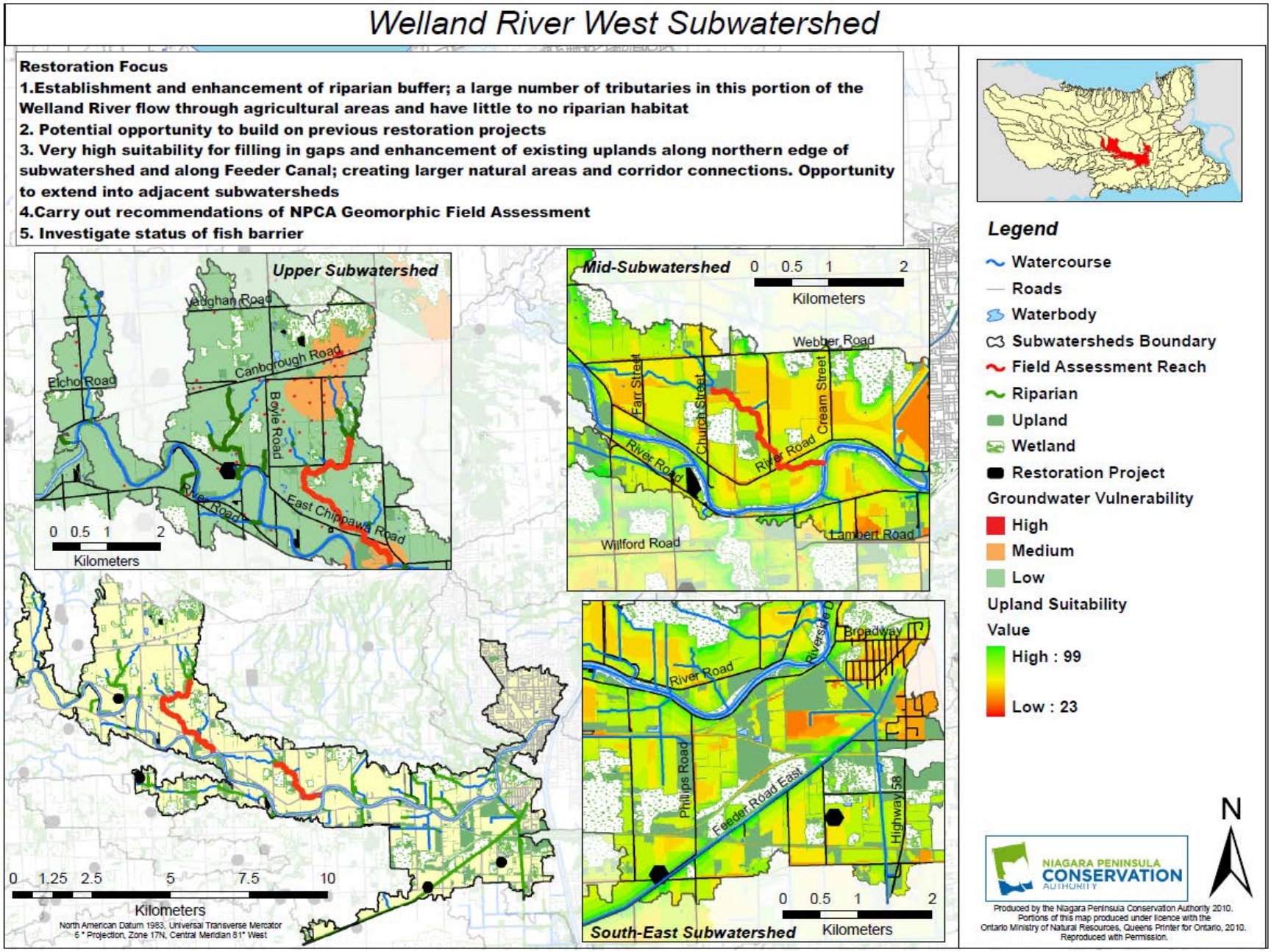

Figure 30: Welland River West Subwatershed

Tow Path Drain Subwatershed

Table 20:Tow Path Drain Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	17 sq km	
Land Use	Mix of urban, industrial, natural areas and agriculture	
Municipal Water and Sewer Services	Yes; partial	Northern portion of the subwatershed. Land use in this area is a mix of agriculture, rural and industrial. 3 CSO's and 2 CSO Outfalls in subwatershed
Recreation	Recreational Trails	Steve Bauer Trail, Welland Canal Trail
Aquatic Resources		
Length of Watercourse	25 km	Outlets to Welland Recreational Canal
Fish Habitat	Recreational Canal and one small tributary: important	The remaining watercourses in this catchment have not been evaluated
Municipal Drains	N/A	
Water Quality	N/A	
Groundwater Vulnerability	Predominantly Low with areas of Medium and High Groundwater Vulnerability	Headwaters commence on Fonthill Kame-Delta Complex; a significant groundwater recharge area and an area of high groundwater vulnerability. In addition, transport pathways such as private wells (active and inactive), unknown status oil and gas wells and have been identified as posing a significant threat to groundwater through the SWP Program
Natural Heritage Resources		
Riparian Cover	30% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	20% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	6% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date: N/A		
Fish Barrier Removal	N/A	
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (30%). •Welland Recreational Canal •large extents of watercourse flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat	
Upland and Ecological Linkages	•currently amount of upland habitat is adequate (20%) •suitability mapping indicates very high suitability for enhancement surrounding existing upland and wetland habitat in upper subwatershed north of Quaker Road •enhancement surrounding existing uplands; filling in gaps of natural areas reduces forest edge –interior ratio and	

		creates a larger continuous natural; increasing interior size would increase the ability of the natural area to support a larger diversity of flora and fauna
Wetland Habitat		•currently amount of wetland habitat is 6% •protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitat)
NPCA Fluvial Geomorphology Study: NPCA 2010		
Reach	**Priority Action**	**Field Assessment and Recommendations**
TPD-Headwaters	Riparian Enhancement; Garbage Removal	No pools were identified at this field site but this is probably due to the fact that surrounding land is flat and that the channel in the upstream section has little to no definition. There is a lack of large woody vegetation adjacent to the stream but cattails and long grass do provide canopy cover. Garbage and algae were noted in the channel during a site visit in 2009. Increase the variety and diversity of native plant species in the buffer zone. Remove garbage from the channel and monitor water quality in this watershed due to the presence of algae.
TPD-Headwaters-2	Riparian Enhancement; Implement Sediment Site Control Practices	(Second field site along reach TPD-Headwaters) No pools were identified at this field site but this is probably due to the fact that surrounding land is flat and that this site is within the headwaters. Instream culverts exist at this site and the water flows underground for a portion of the site length. The riparian vegetation consists of a manicured lawn with a lack of woody vegetation adjacent to the channel. This will impact habitat and cover at this field site. Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates.
TPD-Headwaters-3	Riparian Enhancement; Monitor Water Quality	(Third field site along reach TPD-Headwaters) Although there are some shrubs and deciduous trees in the buffer zone, the majority of vegetation in the buffer consists of a manicured lawn. Cover and habitat are low due to the fact that the bed has no pools, boulders/cobbles, or riffles and that the riparian buffer scored low. Comments from property owners include that their backyard is wetter than it used to be, bank erosion present, and oil is sometimes present. Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as providing cover and habitat for fish, insects, and invertebrate. Water quality testing should be monitored in this watercourse due to the possibility of oil in the stream.
TPDMb	Garbage Removal	Dense vegetation in the buffer zone made it difficult to identify channel characteristics. The channel seems to have been altered through this field site due to high stream banks and straightness of the channel. A dirt pile was identified adjacent to the watercourse in the parking lot. Garbage was noted in the channel during a site visit in 2009. Dirt should not be piled close to the channel so that additional sediment does not enter the watercourse. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Garbage should be removed from the channel to improve water quality.
TPDMb-2	Assess potential fish barrier; Monitor Water Quality; Debris and Garbage Removal	(Second field site along reach TPDMb) Algae, possible rot, and garbage were noted during a site visit in 2009. Quite a bit of in-channel vegetation was also noted during the site visit. The culvert at the downstream end of this field site seemed to be partially blocked and therefore could be a possible fish barrier. Water quality testing should be completed on this watercourse due to the presence of algae. Garbage should be removed from the channel. Debris should be removed from the culvert and it should be measured to ensure it is adequately sized. If an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation.

NPCA Education and Incentive Programs	
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Combined Sewer Overflows and Extraneous Flow Reduction Program	Although combined sewers are no longer installed, existing infrastructure can have negative environmental impacts when during heavy rain events and snowmelts the combined sewer may reach capacity discharging excess wastewater in the watercourse. In an effort to help reduce the load on these sewer systems, a program similar to Port Colborne's Extraneous Flow Reduction Pilot Program is recommended. This program involves the "*inspection of private sanitary sewer services to assess their condition and the presence of any improper connections, followed by recommendations and City funded improvements to remove sources of rainwater from the sanitary sewer system"* (City of Port Colborne 2009).

Expansion of Niagara Region's Organic Deicing Material Program	In Tow Path Drain subwatershed, 3 regional roads (Rice Road, Woodlawn Road and Niagara Street) traverse areas of medium groundwater vulnerability and significant groundwater recharge areas. Expansion of Niagara Region's Organic Deicing Material Program to include these regional roads is recommended to reduce vulnerability of these areas to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads. In this subwatershed, numerous municipal roads traverse areas of high and medium vulnerability as well as significant groundwater recharge areas. It is recommended that the initiation of an organic de-icing material program be implemented in these areas.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In Tow Path Drain subwatershed several of these points were identified; cemeteries, automotive/machinery, fuel storage, and potential PCB's. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

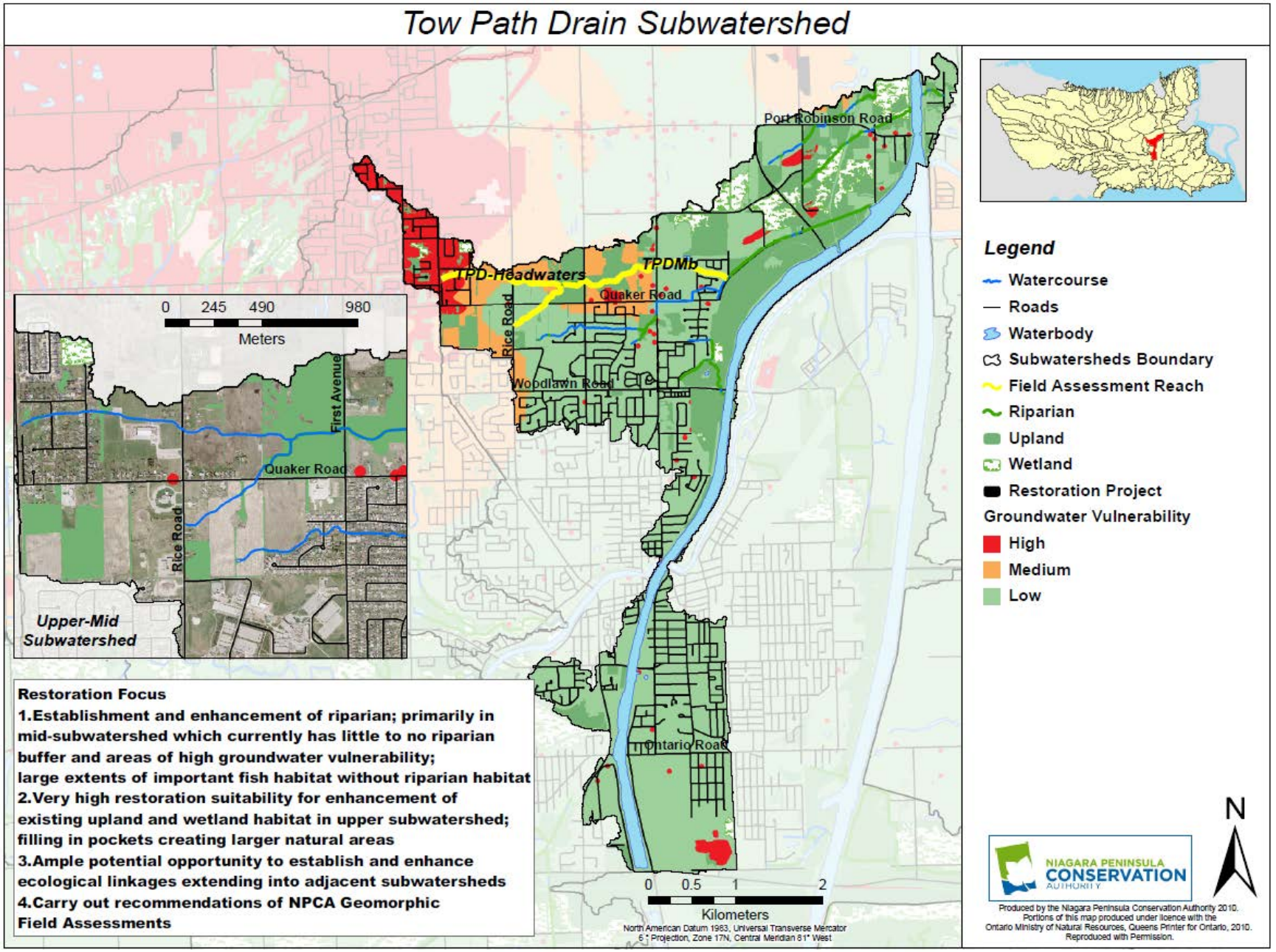

Figure 31: Tow Path Drain Subwatershed

Indian Creek Drain Subwatershed

Table 21:Indian Creek Drain Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	13 sq km	
Land Use	Agriculture with some industrial adjacent the Welland Canal	
Recreation	N/A	
Aquatic Resources		
Length of Watercourse	15 km	Outlets to Welland Canal
Fish Habitat	Main branch: important	Smaller watercourse has not been evaluated
Municipal Drains	Indian Creek Drain, Haun Drain, Ramay Drain	All Drains are Class F
Water Quality	N/A	
Groundwater Vulnerability	A mix of high, medium and low groundwater vulnerability	Land use in high and medium groundwater vulnerability areas is industrial and agriculture. Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	57% of watercourses have some riparian habitat	EC recommends 75% with 30m buffer
Upland Habitat	17% is upland habitat	EC recommends 30% to support viable wildlife population
Wetland Habitat	15% is wetland habitat	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date: N/A		
Fish Barrier Removal	N/A	
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is low (57%) •establish/enhance riparian habitat along main channel in areas where currently little to no buffer; large extents of watercourses designated as important fish habitat with little to no riparian buffer •main channel is managed as a municipal drain, therefore work with local drainage superintendant to find an ecologically compatible balance between drain maintenance and function •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.	
Upland and Ecological Linkages	•currently amount of upland habitat is low (17%) •suitability mapping indicates very high suitability for enhancement surrounding existing natural areas and for corridor connections within subwatershed and extending into adjacent subwatersheds •focus should be directed to areas of high groundwater vulnerability	

Wetland Habitat	•currently level of wetland coverage exceeds EC minimum targets, however ample opportunity is present for filling in gaps creating larger natural area and enhancement of existing wetlands •high suitability for riparian-wetland restoration along watercourse which would provide linkages between wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitat))
NPCA Fluvial Geomorphology Study: N/A	
NPCA Education and Incentive Programs	
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.
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 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.
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 hydrogeologically 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). 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.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).

Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix I.
Expansion of Niagara Region's Organic Deicing Material Program	In Indian Creek Drain subwatershed, 1 regional road (Miller Road) traverses areas of high and medium groundwater vulnerability. Expansion of Niagara Region's Organic Deicing Material Program to include this regional road is recommended to reduce vulnerability of these areas to the negative impacts of road salt during winter maintenance practices.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the majority of the Central Welland River watershed has been ranked as having a moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on local municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads. In this subwatershed, municipal roads traverse areas of high and medium vulnerability as well as significant groundwater recharge areas. It is recommended that the initiation of an organic de-icing material program be implemented in these areas.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Indian Creek subwatershed several of these points were identified; cemeteries, automotive/ wreckers, fuel storage, and potential PCB sites. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface water quality and aquatic habitat and whether or not a contaminant management plan is needed.

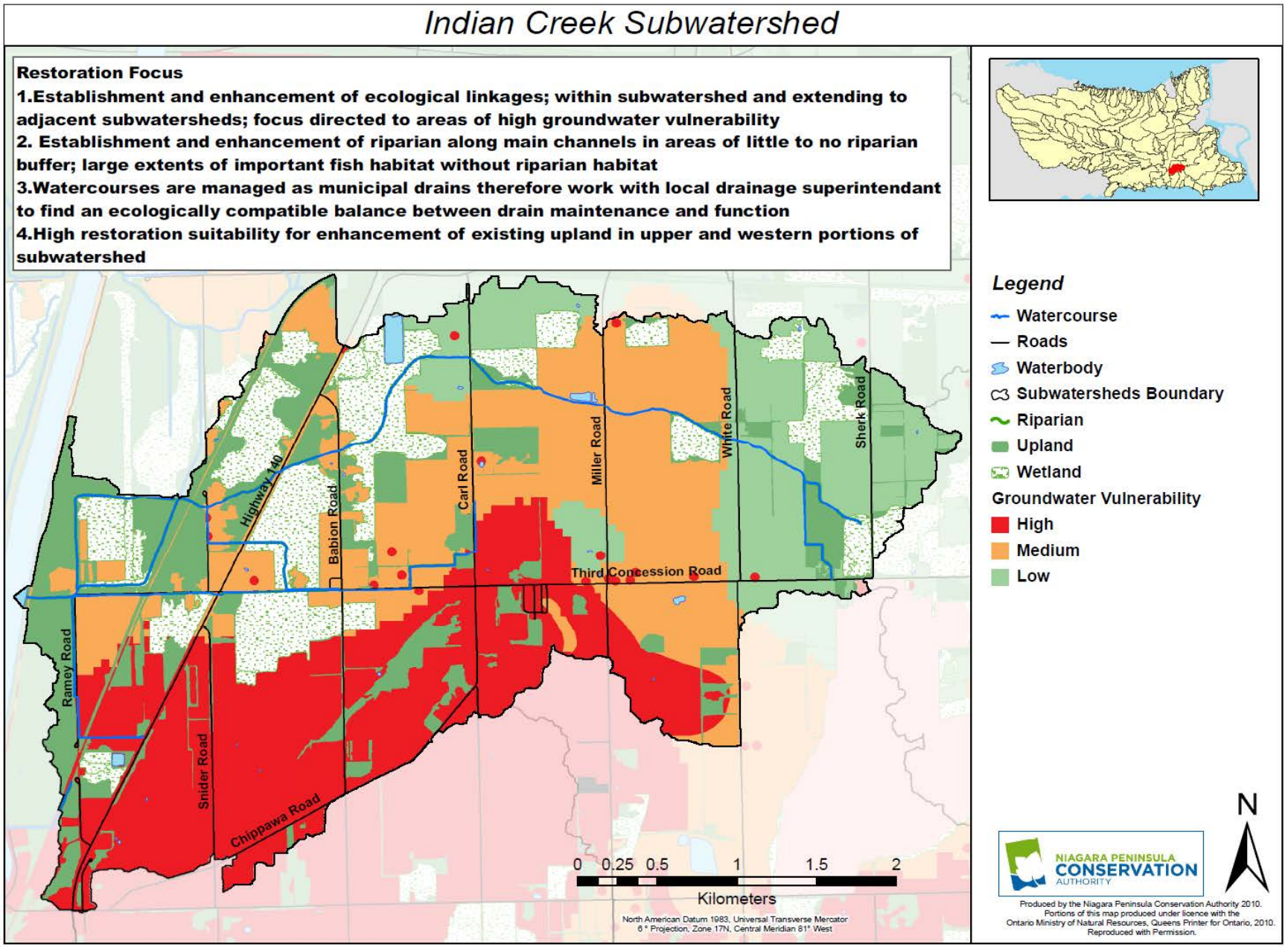

Figure 32: Indian Creek Subwatershed

Overview of Restoration Strategy

The Welland River watershed has been the focus of restoration for several decades due to its degraded water quality, and its restoration requires a collaboration of all stakeholders with a vested interest in the watershed. As indicated earlier, the IJC designated the Niagara River as one of 43 Areas of Concern in 1987. The Welland River is the largest tributary of the Niagara River and its drainage basin accounts for approximately 80 percent of the Canadian portion of the AOC.

Some have even described the Welland River as „*too thick to drink, and too thin to plow!*". One of the primary challenges in this watershed is nutrient management "*with elevated concentrations of total phosphorus being a widespread cause of water quality impairment*" (NPCA 2010c). Based on current data, 100% exceedance is observed at stations WR003 (upstream of CWR study area) through to WR007 (within CWR), with total phosphorus concentrations up to 20 times greater than the provincial objective (NPCA 2010c). In addition, of 68 NPCA surface water quality monitoring stations, the Beaver Creek station [again] has the highest mean concentration of total phosphorus in 2009. This station captures the cumulative impacts of land use in the Beaver Creek, Black Ash Creek, Parkers Creek and Unnamed Creek subwatersheds with "*manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides [being the] likely sources of total phosphorus in these tributaries"* (NPCA 2010c). Accordingly, upstream activities need to be managed in a sustainable manner as these actions affect not only the ecosystems in its direct and surrounding vicinity, but the Welland River and its related ecosystems.

As outlined in the Restoration Strategy, many of the watercourses in many of the subwatersheds do not have a sufficient riparian buffer (Table 22) and the establishment and/or enhancement of a number of riparian buffers has been recommended (e.g. riparian habitat, buffering land uses). It is important to note that the role of a buffer and its function is directly related to its location. For a list of objectives and functions for conservation buffers, please refer to the chart in Appendix G. This chart was taken directly from *Conservation Buffers; Design Guidelines for Buffers, Corridors, and Greenways* (Bentrup 2008) and can be a useful tool when planning such a restoration project.

The primary objective for the establishment of riparian buffers in this study area is to reduce erosion and runoff of sediments, nutrients and other potential pollutants. Buffers with the function of water quality enhancement will be more effective when combined with best management practices being implemented on land; together these strategies will work towards improving water quality issues.

As mentioned earlier and as identified through the NPCA Water Quality Monitoring Program and the *Welland River Eutrophication Study* (NPCA 2010a), total phosphorus is a major water quality issue in this watershed. Phosphorus in runoff either occurs as particulate phosphorus (sediment bound) or dissolved phosphorus. Sediment bound phosphorus can be moderately well trapped by deposition in buffers whereas dissolved phosphorus must infiltrate with runoff water and be trapped in the soil. Therefore key considerations when designing a buffer to help trap phosphorus are to a) avoid trapping in riparian zones which can be remobilizing by flood waters (upland buffer may be required); and b) unlike nitrogen (which can be released to the atmosphere through denitrification) phosphorus will accumulate in the buffer; once saturated it can then turn into a source of phosphorus (Bentrup 2008). However, "*buffers consisting of unfertilized crops or hayfields can trap and utilize phosphorus. Removing this vegetation through harvest may help export phosphorus, as well as nitrogen, out of the watershed*" (Bentrup 2008).

Restoration should initially be focused in the Beaver Creek, Black Ash Creek, Unnamed Creek and Parkers Creek subwatersheds. In most cases in these subwatersheds, the amount of riparian habitat present is roughly one-third of Environment Canada's recommendation of 75% of a streams length be

vegetated, as discussed earlier. Land use in all these subwatersheds is predominantly agriculture. It is recommended that the Agricultural Non-Point Source (AGNPS) model be executed for the Central Welland River Watershed Plan, starting in these subwatersheds, to assist the Implementation Committee in identifying „hot spots' in the watershed and therefore priority areas for remediation or restoration in an effort to improve water quality. In addition, the AGNPS model can be used to evaluate the success of restoration measures in subsequent years after the Watershed Plan has been implemented by re-evaluating pollutant loadings in the watershed.

Numerous projects have already been implemented in these subwatersheds through the NPCA Water Quality Improvement Program, including several non-point source pollution projects such as manure storages and a clean water diversion. Investigation into other potential non-point source pollution project opportunities should be undertaken, as well as inquiry into expanding upon existing reforestation and riparian projects that have already been successfully implemented.

The Restoration Strategy also identifies numerous potential opportunities for enhancement of existing natural areas; bulking them up to increase patch size. Larger patches tend to have a greater "*diversity of habitat niches and therefore are more likely to support a greater richness and/or diversity of wildlife species"* (EC 2004c). Currently, the percent of wetland cover is high and should be maintained. Accordingly, the Restoration Strategy identifies opportunities for the establishment of Critical Functions Zones. A Critical Function Zone "*describes non-wetland areas within which biophysical functions or attributes directly related to the wetland [of interest] occur*" (EC 2004c). These areas are functional extensions of the wetland into the upland area and provide a number of functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitats, foraging areas). These areas can also act as buffers, protecting the wetland and its functionality.

When the planning process is initiated to implement a restoration project in the study area, prairies and meadows should be given consideration and incorporated in habitat creation as they play an important role in creating habitat diversity and foraging areas for wildlife.

Opportunities for the establishment of corridor connections between fragmented areas are also identified. Such linkages not only provide shelter to facilitate in the movement of wildlife between natural areas, but they also promote seed dispersal and biodiversity in the watershed. The Restoration Strategy identifies core natural areas that should act as building blocks in which to connect and restore gaps in the surrounding landscape.

As indicated earlier, the Central Welland River watershed currently contains approximately 16 percent wetland cover, 15 percent forest cover, and approximately 43 percent of the watercourses in the watershed have riparian cover. Once again, Environment Canada recommends at least 30 percent of the watershed should be in forest cover, 10 percent wetland cover, and at least 75 percent of the watercourses should have a recommended 30 meter riparian buffer. The guidelines are intended as minimum ecological requirements and are meant to provide guidance in setting local habitat restoration and protection targets.

The following chart (Table 22) specifies the upland, wetland and riparian habitat percentages for each subwatershed in the study area generated from the NPCA Natural Areas Inventory data and the MNR

Ontario Wetland Evaluation Systems wetland layer (April 2010). The percent impervious data comes from the *Water Availability Study* (AquaResource Inc 2009) that was done through the Source Water Protection Program.
This chart should be used in conjunction with the Restoration Strategy and AGNPS model to prioritize the implementation of riparian, upland and wetland restoration projects. In addition, as earlier indicated, opportunity to enhance earlier projects that have been implemented through the NPCA Water Quality Improvement Program should be investigated.

Table 22:Subwatershed Natural Heritage/Habitat Statistics

Subwatershed Name	Area (sq.km)	% Upland	% Wetlands	% Riparian	% Impervious
Beaver Creek	24.6	7.6	15.3	25.8	2.4
Black Ash Creek	12.1	7.0	20.2	25.4	3.3
Parkers Creek	8.3	7.0	15.4	15.0	2.4
Unnamed Creek	27.5	9.0	17.5	34.5	3.2
Sucker Creek	11.1	9.0	21.8	41.2	3.6
Coyle Creek	40.6	23.2	13.2	52.1	11.8
Drapers Creek	8.8	19.7	10.8	57.4	49.4
Little Forks Creek	13.4	8.0	25.7	34.6	3.7
Welland River West	62.6	12.3	18.4	32.8	15.8
Tow Path Drain	17.4	20.3	5.7	30.6	32
Indian Creek Drain	13.8	17.7	15.2	57.0	5.8
Biederman Drain #1	10.2	8.1	84.1	95.9	0.9
Biederman Drain #2	7.9	15.1	19.3	23.9	6.3
Lyons Creek Drain	6.5	46.7	29.7	89.1	4.6
Welland River Between Canals	30.9	35.3	9.6	35.3	30.7

Estimating Ecosystem Services

Ecosystem services *„are the benefits that people obtain, either directly or indirectly, from our ecological systems. These services can be understood in ecological terms and they can also be translated into economic terms through valuation studies* (MNR 2009c)'. The MNR commissioned a study intended to understand the socio-economic value of our ecological systems and how this information could be used as a tool to support policy and planning decisions as well as to develop a defensible economic rationale for the conservation of southern Ontario's natural heritage systems. Although ecosystem services form the "*foundation of human well-being and they also represent a significant part of the total economic value of our landscape and economy" (*MNR 2009c), their value is often not considered.

The pilot study methodology was approached by assigning a value to each respective ecosystem category based on an average derived from research for similar research sites. This method is known as „value transfer' or „benefits transfer' and was used because it is not feasible to conduct valuation studies on the entire study area due to significant time and financial constraints. The project generated estimates for southern Ontario for the yearly value of ecosystem services. However, one of the key findings of the study was that due to the number of gaps in existing valuation study data, the results present a greatly under-estimated value of the natural systems. The science of Ecosystem Services Valuation is still relatively young and has not yet "*progressed to the point of matching changes in landscape configuration and ecosystem processes to levels of the provision and the values of the corresponding services. These processes affect ecological indicators like net primary productivity, biodiversity, soil quality, runoff, sedimentation rates, nutrient cycling, and natural disturbance processes, which in turn underlie the provision of most ecosystem services"* (MNR 2009c).

Although still a relatively new science, it is hopeful that as the science improves and data gaps are filled that Ecosystem Services will be considered in future provincial and local policy decision making. This tool would enhance the ability of decision makers to make informed decisions in areas such as cost-benefit analysis and to compare outcomes of various scenarios of different policy criteria (MNR 2009c).

Implementation Responsibilities and Recommended Management Actions

The Central Welland River Watershed Restoration Strategy is guided by an implementation framework (Table 23). The implementation framework 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 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 Central Welland River Watershed include planning and regulatory actions (e.g., septic system re-inspection program), project opportunities on private and public lands (e.g., riparian buffer planting, corridor creation), and areas requiring additional research and monitoring (e.g., salt studies, geomorphic assessments) in the watershed. The budget for NPCA restoration projects through the NPCA Water Quality Improvement Program 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.

Table 23: Implementation Framework

WATERSHED PLAN OBJECTIVE	RESPONSIBLE STAKEHOLDER											RECOMMENDED MANAGEMENT OPTION		
	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULTURAL COMMUNITY	PRIVATE LANDOWNERS	ENVIRONMENT CANADA	▲ Lead Stakeholder • Involved Stakeholder ● Short Term ● Medium Term ● Long Term	IMPLEMENTATION	COST ($)
Water Resources														
Improve, enhance, maintain or protect water quality and/or natural stream processes to support human uses and ecological functions in accordance with Provincial Water Quality Objectives		▲	▲									**1.** Include water quality protection in regional and municipal planning documents		Ongoing
	▲	•	•	•			•					**2.** Continue to restrict no new on-line pond construction		Ongoing
	▲			▲			▲			•		**3.** Where legislation permits, maintain stream flows by removing debris and sediment in watercourses		6,500/yr
	▲				•						•	**4.** Continue to monitor water quality to achieve Provincial Water Quality Objectives; theses stations are monitored through provincial initiatives		Existing Program
	•				▲						▲	**5**. Work with EC and MOE to implement recommendations from the Welland River Eutrophication Study once complete		Existing Program
Protect, improve or restore hydrologically sensitive areas (surface and groundwater features)	▲	•	•	•	▲							6. Develop and implement a specific Groundwater and Management Protection Strategy for high susceptibility areas identified as High Vulnerable Areas in the Assessment Report (NPCA 2010b)		Existing Program
	▲	•	•		•					•		**7.** Continue to implement the water well decommissioning program in the Central Welland River watershed through NPCA Decommissioning Program		Existing Program
	▲	•	▲		•							**8.** Continue to identify and map surface and groundwater "hot spots" to determine areas with poor water quality through Water Quality Program and Annual Report		Existing Program
	▲			▲								**9.** Mapping of shallow groundwater discharge areas		Need Program
	▲							•	•	•		**10.** Continue to promote the NPCA's Water Quality Improvement Program		160,000/yr*
	•	▲	▲		•							**11.** Incorporate surface and groundwater protection policies into regional and municipal planning documents		Ongoing
Find an ecologically compatible balance between drain maintenance and function	▲	•	•	▲			▲		▲	•		**12.** Best Management Practices for drain maintenance should be developed to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain		BMP Report in Progress
Ensure that storm water management practices minimize storm water volumes and contaminant loads,	▲	▲	▲									**13.** Continue to implement NPCA Stormwater Policies and BMPs into regional and municipal planning documents		Ongoing
		▲								▲		**14**. Implement/expand Extraneous Flow Reduction Program for urban areas		Ongoing
Recognize the role of natural features and pervious features in minimizing the impacts of flooding		▲	▲							▲		**15**.Continue to implement a rain barrel program for urban areas in watershed		Existing Program
	▲	•	•	•			•	•	•	•		**16.** Implement the recommended restoration actions outlined in Central Welland River Watershed Geomorphic Assessment (NPCA 2010)		10,000/yr
Manage and mitigate flooding risks to human life and property within acceptable limits	▲	•	•									**17.** Maintain NPCA flood warning system		Ongoing
	▲	•	•						•	•		**18.** Continue to implement regulations adopted under Section 28 of the Conservation Authorities Act		Ongoing
	▲	•	•						•	•		**19.** Continue to permit no new development in the 1 in 100 year floodplain		Ongoing
Fish and Aquatic Habitat														
Protect, enhance and restore populations of native species and their habitats in the watershed	▲	•	•	▲		•	▲	•	•	•		**20.** Identify and remove human created barriers to fish movement		Ongoing
	▲			▲						•		**21.** Identify and evaluate online ponds to determine value to fish habitat and function in watershed		Ongoing
	▲	▲	▲			•	•	•	•	•		**22.** Establish and/or enhance riparian buffer strips around watercourses, wetlands, and highly vulnerable groundwater areas		50,000/yr 5000/250m
Eliminate barriers to fish migration	▲			▲			▲					**23.** Develop recovery strategies for critical habitat (e.g. spawning areas)		Ongoing
	▲	•	•	▲		•	▲				▲	**24.** Review SAR management plans and work with partnering agencies to incorporate recommendations into restoration projects to benefit SAR where possible		Existing Program

WATERSHED PLAN OBJECTIVE	RESPONSIBLE STAKEHOLDER											RECOMMENDED MANAGEMENT OPTION		COST
	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULTURAL COMMUNITY	PRIVATE LANDOWNERS	ENVIRONMENT CANADA	▲ Lead Stakeholder • Involved Stakeholder Short Term Medium Term Long Term	IMPLEMENTATION	($)
Natural Heritage and Resources														
Protect, enhance and restore the health, diversity and integrity of the natural heritage systems in the watershed	▲							▲	▲	▲		**25.** Implement the upland reforestation program based on upland suitability mapping targeting interior forest expansion, and ecological linkage opportunities		28,500/yr (1500/acre)
	▲	•	•	▲				•		•		**26.** Continue comprehensive biological inventory and map of natural heritage areas including wetlands		45,000/yr ****
Create, maintain, protect and enhance corridors and linkages to natural heritage systems in adjoining watersheds	▲	▲	▲					•	•	•		**27**. Utilize conservation easements, land dedication and acquisition to secure critical linkages as desired lands become available for purchase		Existing Program
	▲	▲	▲	▲	▲	▲		▲	▲			**28.** Continue partnership building with public interest groups to access funding for reforestation programs (e.g., NRC)		Ongoing
Maintain, restore and improve the linkages among surface water features, groundwater features, hydrologic functions, and natural heritage features and areas, and their ecological functions	▲	▲	▲									**29.** Continue review of new developments and building permits; ensure compliance with PPS and NPCA Regulations		Ongoing
Reach goals set by Environment Canada's recommended habitat targets for riparian, wetland , and upland features	▲	•	•	▲			▲	•	•	•		**30.** Create new wetlands or enhance existing wetlands based on wetland suitability mapping		3,000/yr 10,000/project **
	▲			▲						▲		**31.** Review SAR management plans and work with partnering agencies to incorporate recommendations into restoration projects to benefit SAR where possible		Existing Program
Restore and protect habitat for all species	•	•	•	▲			•	•	•	•		**32.** Work with landowners and conservation groups to foster partnerships pertaining to Species at Risk and inform interested parties of funding programs such as Habitat Stewardship Fund, Species at Risk Farm Incentive Program		Existing Program
Communication, Education and Recreation														
	▲							•	•	•		**33**. Continue the NPCA's Water Quality Improvement Program whereby landowners are provided with incentives to carry out projects on their lands		110,000/yr***
Enhance and develop partnerships between and amongst agencies, interest groups and landowners	▲	•	•					•	•	•		**34.** Continue to recognize groups and individuals for their environmental efforts in the Central Welland River watershed		Ongoing
	▲	•	•									**35.** Present Watershed Plan findings and successes to regional and municipal government officials and policy makers		Ongoing
Foster educational programs and awareness pertaining to urban and rural best management practices (e.g. water conservation practices, alternate farming practices, septic maintenance, buffers, value of local resources)	▲	•	•	•	•	•	•	•	•	•	•	**36.** Assemble and meet with a Watershed Plan Implementation Committee made up of local representation (government agencies, organizations, landowners) to annually re-evaluate the CWR Watershed Plan's components, and provide input on new or revised restoration initiatives in the watershed		Ongoing
	•	•	▲		▲				•	•		**37.** Implement a septic system and Best Management Practices awareness and educational programs		15,000/yr**
Inform public of current incentive programs	▲									▲		**38**. Continue creating demonstration sites to educate landowners about the water quality benefits of riparian buffers, wetlands and upland restoration (if possible include map of demonstration sites on NPCA website)		Existing Program
	▲											**39.** Implement adaptive management and education projects for the Wainfleet Bog (bog trails, bog signs, wildlife viewing blinds)		7000/yr
	▲											**40**. Create and disseminate a Watershed Report Card to inform residents on the state of water resources and encourage public stewardship initiatives		Existing Program
	▲	▲	▲					▲				**41.** Seek partnerships with public interest groups to improve natural heritage features and recreational opportunities (e.g., conservation groups)		Ongoing
Development														
Incorporate best management practices into land use and zoning decisions (e.g. buffers)	•	▲	▲									**42.** Identify and incorporate significant natural areas and ecological linkages into planning documents and policies to ensure they are buffered from development		Ongoing
Promote environmentally-sound land use decisions for current and future urban development and rural/agricultural land use	▲	•	•									**43**. Continue to implement NPCA Policies, Procedures and Guidelines for the Administration of Ontario Regulation 155/06 and Land Use Planning Policy Document (NPCA 2010)		Ongoing
Encourage stormwater management within municipalities to address existing development and future growth capacity projections	▲	•	•									**44.** Continue to implement NPCA Stormwater Management Policies and Guidelines (NPCA 2010)		Ongoing
Encourage intensification of urban areas Incentive programs/packages for brownfield development		▲	▲									**45.** Discourage urban sprawl and focus new growth in existing urban areas through Official Plans and Brownfield Redevelopment Initiatives		Ongoing

Includes project costs, materials and salaries; ** Based on grant ceiling under NPCA's Water Quality Improvement Program for landowners ***Water Quality Improvement Program Annual Project Budget only; * Based on Student Wage**

Welland River Watershed Strategy Update

In 1998, the Welland River Restoration Committee was established to facilitate in the restoration of the Welland River watershed and its resources. As a result, in 1999 together with various stakeholders in the watershed, the *Welland River Watershed Strategy* (NPCA 1999) was initiated. The goal of the strategy was to "*restore the ecological health of the Welland River and its watershed"* (NPCA 1999). The strategy identified numerous management issues and options in the Welland River watershed and 10 year action plan listing the responsible agency for each project. Since the initiation of the *Welland River Watershed Strategy*, several of the project recommendations have been completed or addressed, including for example:

- Agricultural Stewardship and Monitoring Program: The NPCA continues to work with landowners through cost-sharing programs that demonstrate and encourage the use of Best Management Practices
- In addition to the restoration projects completed through the RAP program, over 200 projects have been completed in the Welland River since 1999 through the NPCA Water Quality Improvement Program; 65 of these fall within the Central Welland River watershed study area. Projects include, for example, reforestation, stream fencing, manure storage and buffer strips.
- Fish bypass channels have been constructed at the Port Davidson and Oswego Creek weirs to eliminate the barrier to fish migration
- The Regional Municipality of Niagara and the Niagara Peninsula Conservation Authority have developed policies that address sediment and stormwater management within Niagara Region.
- Water Quality Monitoring Program: The NPCA has established an extensive network of monitoring stations throughout the watershed to gather long term surface and ground water quality data. Included in this program is the area upstream and downstream of the Glanbrook landfill in addition to site specific targets such as the stormwater ponds.

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 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 Central Welland River Watershed Plan. The Plan will be reviewed by the NPCA Restoration Team and the Central Welland River Watershed Plan Implementation Committee (comprised of public interest groups, watershed municipalities, agency, and citizen 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 Central Welland River watershed. A complete review and necessary revisions is slated to occur every 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.

- 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.

Table 24: Watershed Monitoring Schedule

Time Frame	Action
Monthly during ice free season(April-November)	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 (BioMAP) sampling
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.

The overall objectives of the Central Welland River 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; and
- gauge the success of the restoration action plans in protecting and improving water quality and aquatic health.

Conclusion

The Central Welland River watershed is predominantly a rural watershed with nearly 65% of the land being agricultural and rural land uses. Albeit predominantly rich in agriculture, the Central Welland River watershed is also rich in cultural history and ecological diversity. The rich history of the Welland Canal has influenced and shaped the cultural and economic history of the area. The patterns of land use in the region are a result of the early construction of the Welland Canal. The strategic location of settlements and industries that took advantage of the accessibility to markets flourished throughout the last century and a half. In terms of ecological diversity, the watershed houses an abundance of provincially significant natural features such as ANSI's and PSW's, but the area is also home to 29 listed Species at Risk by COSEWIC, including the eastern massasauga rattlesnake; the only venomous snake in Ontario.

For the residents of the Central Welland River, they envision the watershed as one that will:

"support a balanced ecosystem with healthy watercourses, agricultural lands and natural areas while sustaining the needs of the community and providing habitat for a diversity of flora and fauna. The Central Welland River watershed will also support healthy communities with strong and sustainable economies that respect the natural environment and the cultural and traditional values of the communities served."

Through extensive public consultation during the watershed planning process, a wide-ranging set of watershed issues have been gathered resulting in a set of watershed objectives. The objectives have been divided under 5 main categories: water resources, fish and aquatic habitat, natural heritage and resources, urban development, and communication and education. These 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, education programs and tax incentive 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 and ecological linkages; 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 Central Welland River Watershed Plan can be updated and revised every 5 years.

The Niagara Peninsula Conservation Authority will oversee the implementation of the Central Welland River watershed strategy and recommendations made in this report with the assistance of the Central Welland River 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.

As indicated earlier, implementation of the Central Welland River Watershed Plan should be integrated into planning initiatives and roles of regulation by all levels of government. Land use changes in the Central Welland River watershed should also consider recommendations put forth by the Watershed Plan and supporting studies and documents where appropriate. The NPCA and the Central Welland River Implementation Committee will also work local stakeholders to identify restoration actions that are supportive of the Remedial Action Plan and help work towards delisting this area as an Area of Concern. Implementation of such actions will benefit both the watershed and the Niagara River.

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 Central Welland River watershed.

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Acronyms

ANSI: Area of Natural and Scientific Interest
AOC: Area of Concern
AR: Assessment Report
ARA: Aquatic Resource Area
BC MOE: British Columbia Ministry of Environment
BUI: Beneficial Use Impairments
BioMAP: Biological Monitoring and Assessment Program
BMP: Best Management Practice
CCME: Canadian Council for Ministers of the Environment
CIP: Community Improvement Plan
CLI: Canada Land Inventory Classification System
CLTIP: Conservation Land Tax Incentive Program
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
CSO: Combined Sewer Overflows
CWA: Clean Water Act
CWQG: Canadian Water Quality Guidelines
DFO: Department of Fisheries and Oceans
DO: Dissolved Oxygen
EC: Environment Canada
E. coli: Escherichia coli
ELC: Ecological Land Classification
GTA: Greater Toronto Area
GGH: Growth Plan for the Greater Golden Horseshoe
HADD: Harmful Alteration, Disruption or Destruction
IPZ: Intake Protection Zone
LMA: Local Management Area
LSW: Locally Significant Wetland
MFTIP: Managed Forest Tax Incentive Program
MMAH: Ontario Ministry of Municipal Affairs
MNR: Ministry of Natural Resources
MOE: Ministry of the Environment
MPIR: Ontario Ministry of Public Infrastructure Renewal
MTO: Ontario Ministry of Transportation
NAI: Natural Areas Inventory
NMP: Nutrient Management Plan
NMS: Nutrient Management Strategy
NPCA: Niagara Peninsula Conservation Authority
NPSPC: Niagara Peninsula Source Protection Committee
NU: Nutrient Unit
NWS: Niagara Water Strategy
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
OMNR: Ontario Ministry of Natural Resources
OMOE: Ontario Ministry of the Environment
OWES: Ontario Wetland Evaluation System
PCB's: Polychlorinated Biphenyl
PPS: Provincial Policy Statement
PSW: Provincially Significant Wetland
PTTW: Permit To Take Water
PWQO: Provincial Water Quality Objectives

RAP: Remedial Action Plan
RMN: Regional Municipality of Niagara
SAR: Species at Risk
SARFIP: Species at Risk Farm Incentive Program
SPP: Source Protection Plan
TP: Total Phosphorus
WAS: Water Availability Study
WHI: Waterloo Hydrogeologic Inc.
WTP: Water Treatment Plant
WQI: Water Quality Index

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

Biological Monitoring and Assessment Program: The use of benthic invertebrates as indicators of water quality.

Carolinian Life Zone: Also known as the Eastern Deciduous Forest Region, the Carolinian Life Zone stretches across southwestern Ontario from Toronto to Grand Bend. It is estimated that approximately one third of Canada's rare and endangered species are found within this zone.

Committee on the Status of Endangered Wildlife in Canada: Is an independent body responsible for identifying species that are considered to be at risk in Canada. Their findings are reported to the federal government who then determines which at-risk species qualify for protection under the Species At Risk Act (2003).

Committee on the Status of Species at Risk in Ontario: The provincial review body implemented by the Ontario Ministry of Natural Resources: also an independent body made up of non-OMNR members.

Critical Function Zone: A functional extension of the wetland into the upland area that provides a number of functions for wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitats, foraging areas).

Dentrification: The process in which anaerobic bacteria convert nitrate ions into nitrogen gas.

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).

Ecosystem services: The benefits that people obtain, either directly or indirectly, from our ecological systems. These services can be understood in ecological terms and they can also be translated into economic terms through valuation studies (MNR 2009c).

Endangered Species: A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act (MNR No Date)

Entrenched Channel: A channel that has eroded downward or was constructed such that it no longer has access to its original floodplain during moderate flow events.

Erigan Channel: A pre-glacial channel completely buried by glacial till and lacustrine deposits of Lake Warren. The pre-Niagara drainage channel runs from east of Lowbanks, northward to a point west of Fonthill.

Eutrophication: the process by which a lake becomes rich in dissolved nutrients and deficient in oxygen, occurring either as a natural stage in lake maturation or artificially induced by human activities such as the addition of fertilizers and organic wastes from runoff.

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.

Intake Protection Zone: Protected area (land and water) surrounding a surface water intake

Intrinsic Susceptibility: The vulnerability of the groundwater system to potential contamination from surface sources.

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.

Permeability: The measure of the ability of a material to transmit fluids through it.

Pervious: Allows the relatively free passage of liquid.

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: A Class I, II and III Wetland identified as provincially significant as defined in „*An Evaluation System for Wetlands of Southern Ontario, South of the Precambrian Shield, Third Ed*ition.'

Species of Special Concern: A species with characteristics that make it sensitive to human activities or natural events (MNR No Date).

Subwatershed: A subunit of a watershed; often defined as the drainage area of a tributary or watercourse (e.g. Wignell Drain).

Threatened Species: A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed (MNR No Date)

Topography: The relief of the land surface.

Watershed: An area of land from which surface runoff (water, sediments, nutrients and contaminants) drain into a common water body (e.g. Welland River).

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 (MOE and MNR 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 (PPS 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 (PPS 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 (PPS 2005).

Appendix A:
Land Management Issues and Agricultural Best Management Practices Survey

(Sample Survey Form)

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.

O Fort Erie O Niagara Falls O Niagara-on-the-Lake O Thorold O Welland O_____

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

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

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

- O Non-farm Landowner
- O Landowner / Farm Operator
- O Absentee Landowner
- O Tenant Farm Operator
- O Landowner / Farm Operator / Tenant Farm Operator
- O 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?

O Yes O 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?

O Yes O No O 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?

O Yes O 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	O	O	O	O	O
b. Nitrate, phosphate and bacteria levels in groundwater	O	O	O	O	O
c. Pesticide levels in streams, rivers and lakes	O	O	O	O	O
d. Pesticide levels in groundwater	O	O	O	O	O
e. Soil deposition in streams, rivers and lakes	O	O	O	O	O
f. Drinking water quality	O	O	O	O	O
g. Soil loss from agricultural fields	O	O	O	O	O
h. Rivers and streams with eroding banks	O	O	O	O	O
i. Smells, noise, or dust from livestock operations	O	O	O	O	O
j. Smells, noise, or dust from non-agricultural business	O	O	O	O	O
k. Seepage from septic tanks	O	O	O	O	O

Issue	Not a Problem	Slight Problem	Moderate Problem	Serious Problem	Do Not Know
l. Solid waste disposal	O	O	O	O	O
m. Frequency of flooding	O	O	O	O	O
n. Economic losses due to flooding	O	O	O	O	O
o. Economic costs of complying with land-use regulations	O	O	O	O	O
p. Loss of wetlands	O	O	O	O	O
q. Loss of forested or wooded areas	O	O	O	O	O
r. Loss of agricultural land to development	O	O	O	O	O
s. Loss of agricultural land to natural land	O	O	O	O	O
t. Loss of natural land to development	O	O	O	O	O
u. Loss of natural land to agricultural production	O	O	O	O	O
v. Wells drying up	O	O	O	O	O
w. Low surface water conditions (drought)	O	O	O	O	O
x. Other (please specify):_____	O	O	O	O	O

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.

O Tillage and seeding practices: _____

O Erosion control: _____

O Crop rotations: _____

O Residue management: _____

O Nutrient management: _____

O Pest management and pesticides: _____

O Irrigation: _____

O Other (please specify): _____

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

	Bad	Poor	Fair	Good	Excellent	Do Not Know
a. The availability of restoration/conservation funding programs	O	O	O	O	O	O
b. The availability of restoration/conservation technical assistance	O	O	O	O	O	O

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.

_____
_____
_____
_____

Communication

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

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

19. Please provide any additional comments:

_____
_____
_____
_____
_____
_____
_____

~ Thank you ~

Appendix B:
Best Management Practices

The following includes potential best management practices for the Central Welland River watershed derived in part from Niagara Region's and NPCA's policies regarding stormwater management; *Stormwater Management Policies and Guidelines, January 2010.* For detailed information regarding the policies please refer to directly to the document.

Management Alternative	Description
Stormwater Best Management Practices	
At Source and Lot-Level Quantity Controls	
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.
Lot Control	Ensure proper foundation drainage and type of soil and long-term behaviour as far as compaction should be considered. Reduced lot grading can be implemented for soil types with a minimum infiltration rate of 15mm/hr or greater.
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 Basin Restrictors	Detain storm water on parking lots or divert flows onto road surfaces, delaying the entry of storm water into the conveyance system.
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, and encourage permeable spillover parking.
Rain Gardens	Planted depressions designed to receive excess rainwater runoff from buildings and associated landscape. During a storm event the rain garden fills with water and slowly percolates into the ground rather than draining towards a storm drain.
Porous Paving for Low Traffic Roadways and Pathways	Parking areas, fire lanes, 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.
Conveyance Controls	
"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.
Pervious Pipe Systems	Convey runoff below ground level by allowing water to infiltrate through the pipe into adjacent soils, providing pollutant removal and reducing the amount of runoff in the storm sewer system
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.
End-of-Pipe Controls	
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, and assist in sedimentation control and pollutant removal.
Constructed Wetlands	Offer peak flow reduction, storage, filtration, sedimentation, biological uptake, and absorption. Beneficial from a water quality perspective as they have the ability to trap and hold contaminants and pollutants.
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.
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.
Screening	Generally installed upstream of storage facilities or overflow structures to remove floatable material before water discharges into the receiving waters. Screening requires maintenance and can be prone to clogging.
Oil/Grit Separators	Located in the place of conventional manhole below the ground in a storm drain system. Sediment in the runoff entering the separator is settled out and oil is removed through skimming and trapping. The separator implements the use of a permanent pool storage in the removal of hydrocarbons and sediment from storm water runoff before discharging into receiving waters or storm sewers.
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.
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; and 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 land use planning and management	Develop policies limiting pavement, preserving open space and define locations for more on-site storm water management facilities, and zone/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 and define locations for more on-site storm water management facilities, and zone/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.
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 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.
Use a website to host information	Develop a Central Welland River 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 C:
Examples of key Ontario ecological, infrastructure, and social values likely to be affected by climate change

The following chart lists examples of key Ontario ecological, infrastructure, and social values likely to be affected by climate change. This chart is taken directly from a report published by the Ontario Ministry of Natural Resources entitled *Climate Change Projections for Ontario: Practical Information for Policymakers and Planners (2007b)*

Area	Climate Change Impacts
Agriculture	• Reduced productivity where temperature rises without a compensatory increase in precipitation • Change in crops that can be grown • Less suitable climate to produce ice wine in southern Ontario • Longer growing season • Expansion of agriculture into new areas of northern Ontario where soils are productive
Environment	• Changes in the biodiversity of species and ecosystems • Increased difficulties for species currently at risk to survive or maintain their status • New species at risk because of disequilibrium with climate • Increased opportunity for natural migration of invasive species to Ontario • Loss of plants and animals for which some protected areas were established
Forestry	• Increased frequency and more area burned by forest fires, placing stress on firefighting infrastructure and increasing the number and length of shutdowns of bush operations • Regional changes in timber supply (some may increase while others decrease) • Less access for forestry operations due to late freeze-up and mid-winter thaws • Opportunities to plant faster-growing, less cold hardy tree species • Migration of mountain pine beetle from Alberta threatening old-growth pine forests
Human Health	• Fewer winter cold alerts but more summer heat alerts • More SMOG days • Appearance of new insect-borne diseases • Increased water quality issues due to less total precipitation but more extreme rainfall events
Northern Communities	• Threats to northern communities by forest fires will be more frequent • Soil instability and shifting of houses and other structures due to melting permafrost • Increased community isolation and higher cost of living due to shortened winter road season
Power Generation	• Higher maximum summer power requirements due to increased summer temperatures • Lower winter maximum power requirements due to warmer winters • Reduced hydroelectric power generation due to lower stream/river flow and lower lake levels • More risk to power transmission lines from ice storms
Tourism and Recreation	• Fewer winter outdoor recreation opportunities in southern Ontario (e.g., less reliable skiing, snowmobiling, ice fishing, and outdoor ice skating) • Longer warm weather outdoor recreation season (e.g., boating, camping, and golf)
Transportation	• Shorter road snow-clearing season • Greater risk of freezing rain and need for de-icing in southern Ontario • Longer Great Lakes shipping season • More shipping disruptions and channel/harbour dredging due to lower Great Lakes water levels

The following table summarizes commonly identified changes to the hydrological cycle that are expected in the Great Lakes Basin resulting from climate change. This chart is taken directly from *Mainstreaming Climate Change in Drinking Water Source Protection Planning (de Loe and Berg 2006).*

Hydrological Parameter	Expected Change in the 21st Century, Great Lakes Basin
Runoff	• Decreased annual runoff, but increased winter runoff • Earlier and lower spring freshet (the flow resulting from melting snow and ice) • Summer and fall flows are lower and last longer • Increased frequency of high flows due to extreme precipitation events
Lake Levels	• Lower net basin supplies and declining levels due to increased evaporation and timing of precipitation • Increased frequency of low water levels
Groundwater Recharge	• Decreased groundwater recharge, with shallow aquifers being especially sensitive
Groundwater Discharge	• Changes in amount and timing of baseflow to streams, lakes and wetlands
Ice Cover	• Ice cover season reduced, or eliminated completely
Snow Cover	• Reduced snow cover (depth, area, and duration)
Water Temperature	• Increased water temperature in surface and water bodies
Soil Moisture	• Soil moisture may increase by as much as 80% during winter in the basin, but decrease by as much as 30% in summer and autumn

Appendix D:
Summary of Legislation Governing Management in Ontario

The following is not an exhaustive list of legislation governing management in Ontario. The purpose of the following chart is to provide insight into some of the management tools used in the province of Ontario.

SUMMARY OF LEGISLATION GOVERNING MANAGEMENT IN ONTARIO		
MANAGEMENT TOOL	**DESCRIPTION**	**GOVERNMENT AGENCY**
FEDERAL LEGISLATION		
Fisheries Act	Established to manage and protect Canada's fisheries resources. It applies to all fishing zones, territorial seas and inland waters of Canada and is binding to federal, provincial and territorial governments	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	An Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. The Act is intended to protect the environment and human health from the risks posed by harmful pollutants and to prevent new ones from entering the Canadian environment.	Environment Canada
Canadian Environmental Assessment Act	Requires federal departments to conduct environmental assessments for prescribed projects and activities before providing federal approval or financial support.	Canadian Environmental Assessment Agency
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
Canadian-Ontario Agreement	Federal-provincial agreement that supports the restoration and protection of the Great Lakes Basin Ecosystem. The Agreement between the governments of Canada and Ontario outlines how the two governments will cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes basin ecosystem.	Environment Canada & Ministry of the Environment

Agricultural & Rural Development Act	An Act to provide for federal-provincial agreements for the rehabilitation and development of rural areas in Canada	Ministry of Industry, Science and Technology
Migratory Birds Convention Act, 1994	The Act ensures the conservation of migratory bird populations by regulating potentially harmful human activities. A permit must be issued for all activities affecting migratory birds, with some exceptions detailed in the Regulations.	Environment Canada
Canada Wildlife Act	The Act allows for the creation, management and protection of wildlife areas for wildlife research activities, or for conservation or interpretation of wildlife.	Environment Canada
Species at Risk Act	To prevent wildlife species in Canada from disappearing and to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened.	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 water. Sources of drinking water are to be mapped by municipalities and conservation authorities, especially vulnerable areas that require protections.	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
Sustainable Water and Sewage Systems Act	To ensure clean, safe drinking water for Ontario residents by making it mandatory for municipalities to assess the costs of providing water and sewage services and to recover the amount of money needed to operate, maintain, and replace them.	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
Endangered Species Act	The purpose of the Act is to Identify species at risk based on the best available scientific information, protect species that are at risk and their habitats, and promote the recovery of species that are at risk, and promote stewardship activities to assist in the protection and recovery of species that are at risk	Ministry of Natural Resources
Fish and Wildlife Conservation Act,1997	This Act enables the Ministry of Natural Resources to provide sound management of the province's fish and wildlife game	Ministry of Natural Resources
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
Beds of Navigable Waters Protection Act	Declares the beds of navigable waters as the Crown's responsibility.	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
Ontario Planning and Development Act	Authorizes Minister to establish development planning areas for promotion of the economic and environmental condition of areas	Ministry of Municipal Affairs and Housing
Development Charges Act	Empowers municipalities to impose development charges against land to be developed where the development will increase the need for municipal services.	Ministry of Municipal Affairs and Housing
Greenbelt Plan (Act)	Identifies where urbanization should not occur in order to provide permanent protection to the agricultural land base and the ecological features and functions occurring on this landscape.	Ministry of Municipal Affairs and Housing
Provincial Policy Statement	Issued under the Planning Act, it provides direction on matters of provincial interest related to land use planning and development, and promotes the provincial "policy-led" planning system.	Ministry of Municipal Affairs and Housing
Places to Grow Act	Ontario government's program to manage growth and development in Ontario in a way that supports economic prosperity, protects the environment and helps communities achieve a high quality of life	Ministry of Energy and Infrastructure
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
Building Code Act	The Building Code regulates standards for the construction and demolition of new buildings	Ministry of Municipal Affairs and Housing

UPPER AND LOWER TIER LEGISLATION		
Municipal Act	Provides for the structure of single, upper and lower tier municipalities, and sets out their basic powers including the ability to regulate (e.g. licensing), provision of services, finances and roads.	Ministry of Municipal Affairs and Housing
Regional Municipalities Act	This Act puts forth the structuring and governance of municipalities in support of the Municipal Act	Ministry of Municipal Affairs and Housing
Regional Municipality of Niagara Act	This Acts puts forth the structuring and governance of municipalities in support of the Municipal Act and Regional Municipalities Act.	Ministry of Municipal Affairs and Housing
Municipal Affairs Act	Give municipalities the power to be responsible and accountable governments with respect to matters within their jurisdiction and each municipality is given powers and duties under this Act and many other Acts for the purpose of providing good government with respect to those matters	Ministry of Municipal Affairs and Housing
Official Plans and Policy Plans	An official plan and/or policy plan describes your upper, lower or single–tier municipal council's policies on how land in your community should be used. It is prepared with input from you and others in your community and helps to ensure that future planning and development will meet the specific needs of your community	Regional or Municipal respective jurisdiction upon approval by the Ministry of Municipal Affairs and Housing
CONSERVATION AUTHORITIES		
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).	Ministry of Natural Resources
Ontario Regulation 155/06- Development, Interference with Wetlands and Alterations to Shorelines and Watercourses	This regulation and associated policies are used by Conservation Authorities to regulate all watercourses, floodplains, valley lands, hazardous lands, wetlands, shorelines, and lands adjacent to these features/functions within their respective jurisdictions.	Ministry of Natural Resources

Appendix E:
Central Welland River Watershed
Geomorphic Summary

Central Welland River Visual Assessment																			
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:	Salinity:	Riffle Embeddedness:	Marcroinvertebrates observed (optional):	Overall Score (Total divided by number scored):	Rank:	Suspected Causes of Observed Problems	Recommendations
BACMd	Black Ash Creek at Concession 4 Road	7	7	4	6	N/A	N/A	10	1	1	1	1	N/A	N/A	N/A	N/A	4.2	Poor	Buffer basically consists of manicured lawn and a few deciduous trees therefore habitat and shading over the stream will be impacted; Relatively deep unconsolidated sediment deposited along channel bed; No distinct pools were identified	Increase native vegetation types in buffer zone to provide habitat and shading; Don't mow to edge of watercourse; Monitor sediment accumulation along channel bed; Determine possible upstream sources of sediment to prevent too much sediment from entering channel
BvCMe	Beaver Creek at Bismark Road	5	6	3	5	4	4	10	4	6	3	1	N/A	N/A	N/A	N/A	4.6	Poor	Lack of large woody vegetation adjacent to watercourse impacting habitat & cover; Bare soil extending up the bank identified; Algae & turbid water noted; Wider section of the channel suggests channel has been altered (on-line pond)	Increase the size of the buffer zone, as well as the variety and diversity of native plants in it; Continue to monitor water quality in this watershed; Determine whether wider section is causing any issues to watercourse (could act like on-line pond)
BvCTa	Beaver Creek at Vaughan Road	5	6	3	6	2	2	10	3	5	2	1	N/A	N/A	N/A	N/A	4.1	Poor	Watercourse altered by creation of on-line pond; Algae & turbid water noted; Bare soil extending up the bank; Possible rills/gullies present; Lack of large woody vegetation in buffer zone	Determine whether on-line pond is causing any issues to watercourse; Increase variety & diversity of native plant species in buffer zone; Continue to monitor water quality; Projects to prevent & limit development of rills should be implemented
CC-Headwaters	Coyle Creek at Foss Road	5	8	5	7	7	7	10	8	5	7	10	N/A	N/A	N/A	N/A	7.2	Fair	Watercourse altered by creation of 2 on-line ponds; Little to no buffer in upstream section (habitat & cover impacted); Submerged culvert identified; Algae noted; Possible rills/gullies present	Determine whether on-line ponds causing any issues to watercourse; Increase variety & diversity of native plants in buffer; Measure culvert to ensure adequately sized (if an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation); Continue monitor water quality; Implement projects to prevent & limit development of rills
CCMa	Coyle Creek at South Pelham Road	8	7	9	7	3	5	10	5	5	8	10	N/A	N/A	N/A	N/A	7.0	Fair	Slow moving water present but no distinct pools identified; Turbid water and algae noted; Outfall approx. 2ft from bed with concrete pieces piled on bed; Landowner stated concerns about water quality and quantity at this site	Water quality should continue to be monitored in this watershed; Make sure the outfall is properly constructed to mitigate any problems to the watercourse (if an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements)
CCTaTa	Coyle Creek at Chantler Road	5	7	4	4	7	5	10	5	3	9	10	N/A	N/A	N/A	N/A	6.3	Fair	Municipal drain (Ridgeville Drain East Branch); Watercourse altered by creation of on-line pond; Buffer small or nonexistent in areas; Algae & turbid water noted; Bank erosion present & pieces of concrete have been placed to mitigate erosion in places	Determine whether on-line pond causing any issues to watercourse; Increase variety & diversity of native plant species in buffer zone; Proper bank stabilization methods should be installed; Continue to monitor water quality
CCTb	Coyle Creek at Poth Street	8	7	10	6	9	8	10	9	4	9	10	N/A	N/A	N/A	N/A	8.2	Good	Slow moving water was present within the channel but there were no distinct pools identified; Some undercutting was identified along the steeper sections of bank	Bank erosion should be monitored at this field site to ensure the banks are adequately stabilized - monitoring can be done by the use of erosion pins along the bank
CCTb-2	Coyle Creek at Webber Road	8	10	10	8	7	7	10	5	3	7	10	N/A	N/A	N/A	N/A	7.7	Good	Slow moving water was present within the channel but there were no distinct pools identified; Pockets of relatively deep, unconsolidated sediment were identified along the bed	Monitor sediment accumulation along the bed, determine possible upstream sources of sediment

Central Welland River Visual Assessment																			
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:	Salinity:	Riffle Embeddedness:	Marcroinvertebrates observed (optional):	Overall Score (Total divided by number scored):	Rank:	Suspected Causes of Observed Problems	Recommendations
CCTb-3	Coyle Creek at Sumbler Road	7	6	9	7	6	7	10	4	1	7	10	N/A	N/A	N/A	N/A	6.7	Fair	Bank instability present; Areas of relatively deep unconsolidated sediment identified; Possible rills/gullies present; Possible culvert undersized at crossing	Banks should be properly stabilized to ensure no excessive amounts of sediment enter the channel; Monitor sediment accumulation along the bed; Projects to prevent & limit the development of rills should be implemented; Culverts should be adequately sized (if an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation)
CCTb2	Coyle Creek at Poth Street	7	10	6	10	8	10	10	5	3	7	10	N/A	N/A	N/A	N/A	7.8	Good	No distinct pools were identified at this field site but there is an off-line pond adjacent to the channel; A section of the watercourse is basically a grass lined channel (phalaris)	Add more native woody vegetation to the buffer zone
CCTb2-2	Coyle Creek at Poth Street	7	8	3	7	6	3	5	3	3	3	7	N/A	N/A	N/A	N/A	5	Poor	Watercourse altered by creation of on-line pond; Some areas mowed to top of bank & buffer nonexistent in some areas impacting habitat & cover; At least 1 rill identified; A weir exists at this site; Algae noted	Increase variety & diversity of native plant species in buffer; Determine whether on-line ponds & weir causing issues to watercourse; Projects to prevent & limit the development of rills should be implemented; Continue to monitor water quality
CCTb2-3	Coyle Creek at Foss Road	10	9	10	10	9	8	10	8	3	7	10	N/A	N/A	N/A	N/A	8.5	Good	Few pools identified at this field site but 3 off-line ponds adjacent to channel, one was a project by the Niagara Restoration Council - landowner did state some erosion problems with the berm between the watercourse and pond that was causing overflow	The Niagara Restoration Council was informed of the issue with the berm in 2009 and it is being addressed
CCTb2-4	Coyle Creek at Welland Road	10	10	10	10	7	8	10	6	6	8	10	N/A	N/A	3	N/A	8.2	Good	Relatively deep unconsolidated sediment identified on the channel bed in some areas	Monitor sediment accumulation along the bed, determine possible upstream sources of sediment
CCTd	Coyle Creek at Chantler Road	4	4	4	2	6	7	10	2	3	3	1	N/A	N/A	N/A	N/A	4.2	Poor	Municipal Drain - Disher Drain; Slumping present; No distinct pools identified; Buffer mostly herbaceous impacting cover & habitat; Possible rills/gullies present; Algae noted	Channel banks should not be graded too steep; Projects to prevent & limit the development of rills should be implemented; Increase variety & diversity of native plants in buffer; Continue to monitor water quality in this watershed
CCTdTa-2	Coyle Creek at Sumbler Road	6	6	8	5	7	8	10	5	3	7	10	N/A	N/A	N/A	N/A	6.8	Fair	Some bank instability identified in the form of bare soil extending up the bank & undercutting; Relatively deep unconsolidated sediment was identified in some areas along this section of the watercourse	Monitor bank erosion to ensure adequate stabilization - can be done by use of erosion pins along the bank; Monitor the accumulation of sediment along the channel bed & determining possible upstream sources of sediment
CCTdTa-3	Coyle Creek at Centre Street	9	8	6	5	9	8	10	5	3	10	10	N/A	N/A	N/A	N/A	7.5	Good	Bank instability present in the form of slumping; Some areas where the grass is mowed close to the edge of the channel; No distinct pools identified along the channel but an off-line pond exists adjacent to the watercourse	Banks should be stabilized using proper stabilization measures to ensure no excessive amounts of sediment are entering the channel; Increase the variety and diversity of native plant species in the buffer zone
CCTdTa-4	Coyle Creek at Centre Street	7	8	7	10	5	3	5	3	2	3	10	N/A	N/A	N/A	N/A	5.7	Poor	Mows to edge of pond & sometimes to edge of stream; Possible perched culvert; Watercourse altered by creation of on-line pond; Long grass growing in the channel providing canopy; Algae, duckweed & macrophytes noted	Increase native plant species in buffer; Determine if culvert is creating fish barrier or problems with flow of water through watercourse (if an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation); Determine whether on-line pond is causing issues to watercourse; Continue to monitor water quality in this watershed

Central Welland River Visual Assessment																		
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:	Salinity:	Riffle Embeddedness:	Marcroinvertebrates observed (optional):	Overall Score (Total divided by number scored):	Rank:	Suspected Causes of Observed Problems	Recommendations
DCMa	Drapers Creek at Colbeck Drive	5	7	8	7	5	3	10	8	10	10	10	N/A	N/A	N/A	N/A	7.5	Good	Site of Drapers Creek Stream Remediation Project; A perched culvert was removed and replaced, large stone block debris was removed, and a riparian buffer was planted; Turbid water, duckweed, and dense macrophyte beds were identified	Continual monitoring of the remediation project to ensure all the components of the project are stable; Water quality monitoring in this watershed should continue
DCMa-2	Drapers Creek at Endicott Terrace	5	8	8	7	6	7	10	9	10	10	10	N/A	N/A	N/A	N/A	8.2	Good	Left bank of channel is steep and has been altered by the use of large stones, riprap, and concrete; Relatively deep, unconsolidated sediment along the bed noted; Landowner commented about an increase in sediment and gravel along stream bed	Monitoring the accumulation of sediment along the channel bed; Determine possible upstream sources of sediment; Increase the variety and diversity of native plant species in the buffer zone to help stabilize the banks
DCMc	Drapers Creek at South Pelham Road	5	5	5	6	7	8	10	5	2	10	1	N/A	N/A	N/A	N/A	5.8	Poor	This straighter section of the watercourse has a steep right bank with mostly herbaceous vegetation; Some slumping was identified along the right bank; The canopy was open due to the lack of large woody vegetation on the right bank	Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as provide cover and habitat for fish, insects, and invertebrate
DCMc-2	Drapers Creek at Fitch Street	5	8	8	7	6	8	10	8	5	9	10	N/A	N/A	N/A	N/A	7.6	Good	An area where old riprap and cinder blocks exists along the bank indicates some erosion protection measures implemented by landowner; Downstream section has relatively deep, unconsolidated sediment deposited along the channel bed	Monitor accumulation of sediment along channel bed; Determine possible upstream sources of sediment; Proper bank stabilization methods should be installed to ensure that the bank is protected
DCMd	Drapers Creek at South Pellham Road	4	5	4	2	6	8	10	5	1	10	10	N/A	N/A	N/A	N/A	5.9	Poor	Straight channel and steep banks; Bank instability present in the form of fallen vegetation, exposed roots, bare soil extending up the bank, and undercutting; Bank erosion on both sides of the channel; Buffer width is small	Bank erosion should be monitored at this field site to ensure the banks are adequately stabilized; Monitoring can be done by the use of erosion pins along the bank; Increase native plant species in the buffer zone
PCMb	Parkers Creek at Vaughan Road	8	10	8	10	6	7	10	3	1	3	10	N/A	N/A	N/A	N/A	6.9	Fair	Buffer & in-channel vegetation basically consist of long grass (phalaris); Areas where buffer is absent or small between channel & agricultural field; Relatively deep, unconsolidated sediment along the bed; Crossing but no culvert present	Increase variety & diversity of native plant species; Plant a buffer where one is nonexistent or too small; Monitor the accumulation of sediment along the channel bed; Determine possible upstream sources of sediment; Install a culvert at crossing (respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation)
PCMb-2	Parkers Creek at Krick Road	7	8	5	7	7	8	10	4	1	7	10	N/A	N/A	N/A	N/A	6.8	Fair	Buffer zone is small and basically only consists of herbaceous vegetation (long grass providing canopy over watercourse); No pools identified at study site	Increasing the variety and diversity of native plant species in the buffer zone will provide cover and habit for fish, insects, and invertebrates along the watercourse; Water quality should be monitored in this watershed
SCMa	Sucker Creek at Canborough Road	9	10	10	10	7	8	10	5	1	7	10	N/A	N/A	N/A	N/A	7.9	Good	No deep pools, boulders/cobbles, riffles (impacting the fish cover score)	Monitor water quality in this watershed

Central Welland River Visual Assessment																			
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:	Salinity:	Riffle Embeddedness:	Marcroinvertebrates observed (optional):	Overall Score (Total divided by number scored):	Rank:	Suspected Causes of Observed Problems	Recommendations
TPD-Headwaters	Towpath Drain at Rice Road	10	8	10	10	7	6	10	3	1	3	10	N/A	N/A	N/A	N/A	7.1	Fair	Surrounding land is flat & channel in upstream section has little to no definition; Lack of large woody vegetation adjacent to stream but cattails & long grass provide canopy cover; Garbage & algae were noted in the channel	Increase the variety and diversity of native plant species in the buffer zone; Remove garbage from the channel and monitor water quality in this watershed
TPD-Headwaters-2	Towpath Drain at Montgomery Road	4	7	1	7	8	7	10	1	1	1	1	N/A	N/A	N/A	N/A	4.4	Poor	Surrounding land is flat & site within headwaters; Instream culverts exist at site & water flows underground for portion of site length; Manicured lawn with lack of woody vegetation in buffer	Increase the variety and diversity of native plant species in the buffer zone
TPD-Headwaters-3	Towpath Drain at Crerar Avenue	5	7	2	7	8	7	8	3	1	3	10	N/A	N/A	N/A	N/A	5.5	Poor	Majority of vegetation in buffer consists of manicured lawn; Cover & habitat are low due to no pools, boulders/cobbles, or riffles; Comments from landowners include: backyard is wetter than it used to be, bank erosion present, oil is sometimes present	Increasing the variety and diversity of native plant species in the buffer zone could help to stabilize the banks, as well as providing cover and habitat for fish, insects, and invertebrate
TPDMb	Towpath Drain at Quaker Road	5	2	7	N/A	6	7	10	6	N/A	7	10	N/A	N/A	N/A	N/A	6.7	Fair	Dense vegetation in buffer made it difficult to identify channel characteristics; Channel seems to have been altered through this field site due to high stream banks & straightness of channel; Dirt pile adjacent to channel; Garbage in channel	Dirt should not be piled so close to the channel so that additional sediment does not enter the watercourse; Garbage should be removed from the channel to improve water quality
TPDMb-2	Towpath Drain at Niagara Street (upstream)	5	8	6	8	2	3	4	5	3	7	10	N/A	N/A	N/A	N/A	5.5	Poor	Algae, possible rot, and garbage; Quite a bit of in-channel vegetation was also noted; Culvert at downstream end of this field site seemed to be partially blocked and therefore could be a possible fish barrier	Water quality testing should be completed on this watercourse and garbage should be removed from the channel; Debris should be removed from the culvert and it should be measured to ensure it is adequately sized (if an issue is identified then respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation)
UnCMa	Unnamed Creek at Canborough Road	10	10	8	10	5	8	10	7	7	7	N/A	N/A	N/A	N/A	N/A	8.2	Good	Turbid water and carp were noted during site visit; No bank erosion was noted at this site so turbidity may be due to the presence of carp	Continue to monitor water quality in this watershed
UnCMa-2	Unnamed Creek at Canborough Road	10	10	9	10	5	4	10	6	3	7	10	N/A	N/A	N/A	N/A	7.6	Good	Algae, duckweed, dense macrophyte beds, and an orange algae-like substance were noted during a site visit in 2009; The channel lacked definition at this field site and looked more like a wetland then a watercourse	Continue to monitor water quality in this watershed
UnCMa-3	Unnamed Creek at Beavercreek Crescent	10	10	9	10	5	6	10	8	7	7	10	N/A	N/A	N/A	N/A	8.4	Good	Algae, duckweed, and areas of dense macrophyte beds were noted; The water was also turbid during this site visit and it is possible that carp were present	Continue to monitor water quality in this watershed
UnCTaA	Unnamed Creek at Elcho Road	10	10	10	7	5	3	10	8	6	10	10	N/A	N/A	N/A	N/A	8.1	Good	Algae and areas of dense macrophyte beds were noted; There were also areas of relatively deep, unconsolidated sediment along the bed; Numerous debris jams were also noted	Monitor sediment accumulation along channel bed & determine possible upstream sources of sediment; Numerous debris jams present along this field site; Continue to monitor water quality in this watershed
UnCTb	Unnamed	7	10	3	7	4	3	10	3	1	1	10	N/A	N/A	N/A	N/A	5.4	Poor	Channel not defined upstream; Little to no vegetation in	Increase variety & diversity of native plants in buffer; Projects to prevent & limit further

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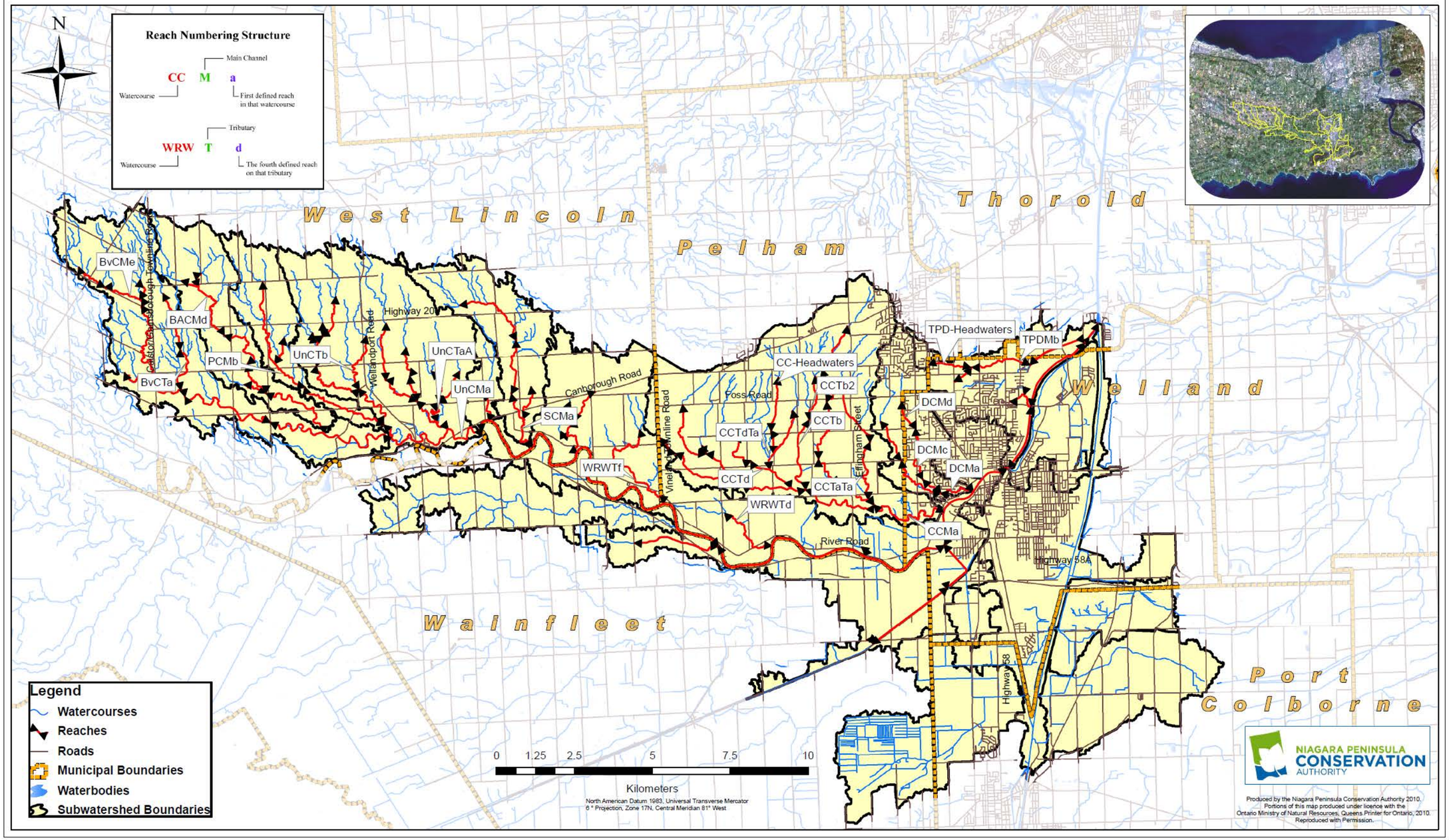
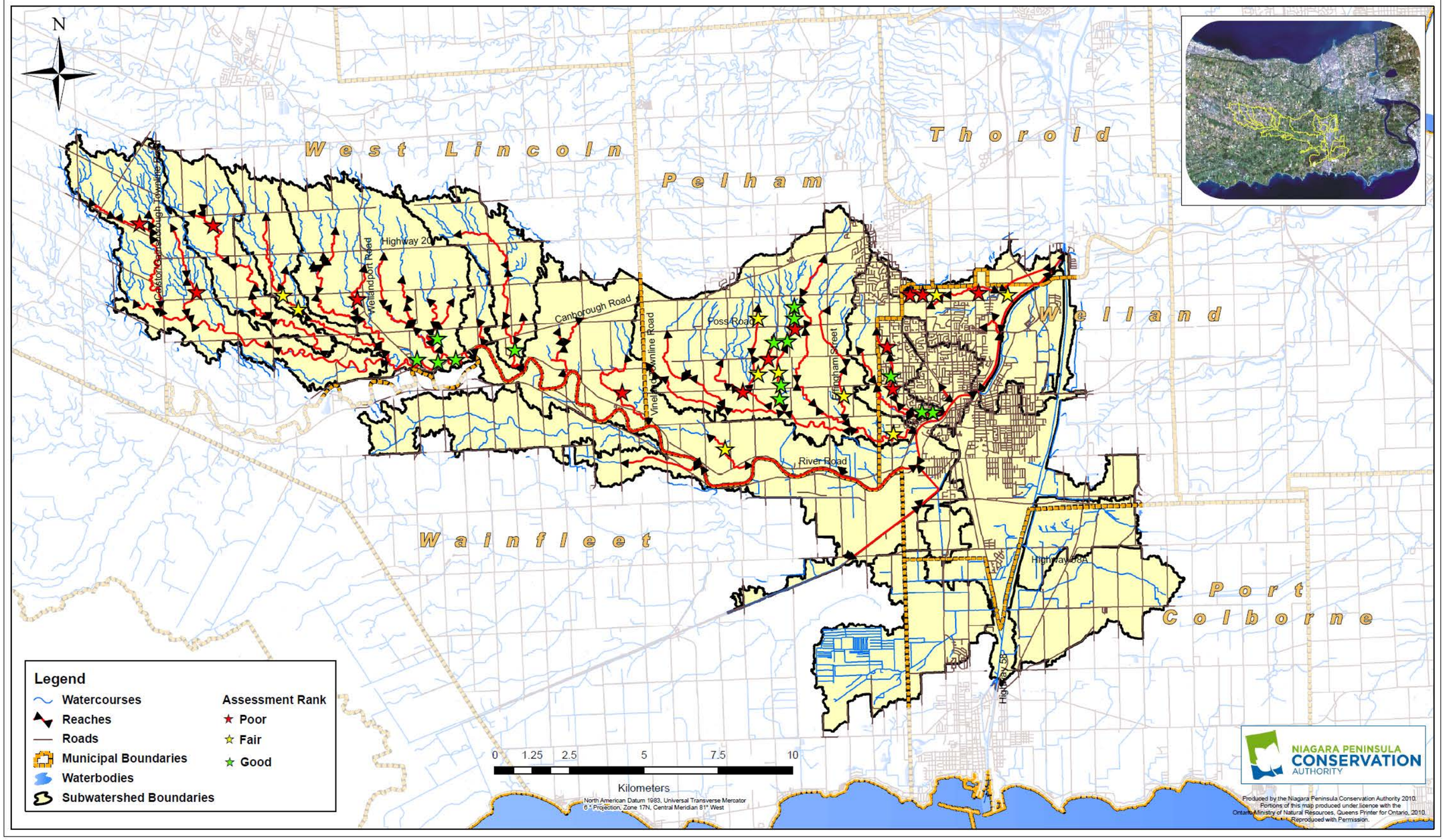
	Creek at Baldwin Road																		buffer; Number of small tributaries or possibly rills/gullies exist; Areas with relatively deep unconsolidated sediment along bed; Crossing with no culvert; Algae noted	development of rills; Monitor sediment accumulation & determine possible upstream sources; Culvert should be installed (respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation); Monitor water quality
WRWTd	Welland River West at Church Street	7	10	6	10	6	7	10	1	4	1	10	N/A	N/A	N/A	N/A	6.5	Fair	Little to no vegetation in buffer adjacent to open field & a lack of woody vegetation in buffer throughout field site; Long grass in buffer is providing canopy cover; Truck tracks adjacent & in the channel were noted; At least one rill was identified	Increase variety & diversity of native plant in buffer; Proper crossings with culverts should be installed at all locations where vehicles are crossing the watercourse (respective stakeholders should be contacted prior to construction due to permit requirements for any new culvert installation); Projects to prevent & limit further development of rills should be implemented
WRWTf	Welland River West at East Chippawa Road	5	8	2	5	4	7	10	5	6	5	1	N/A	N/A	N/A	N/A	5.3	Poor	Channel altered by creation of on-line pond; Turbid water noted in pond & deposition at entrance to pond; Bank instability present -bare soil extending up & undercutting; Manicured lawn adjacent to channel; Algae noted	Determine whether on-line pond is causing any issues to watercourse; Monitor sediment accumulation & determine possible upstream sources; Increase variety & diversity of native plant species in buffer; Water quality should continue to be monitored

Central Welland River Watershed
Reach Locations

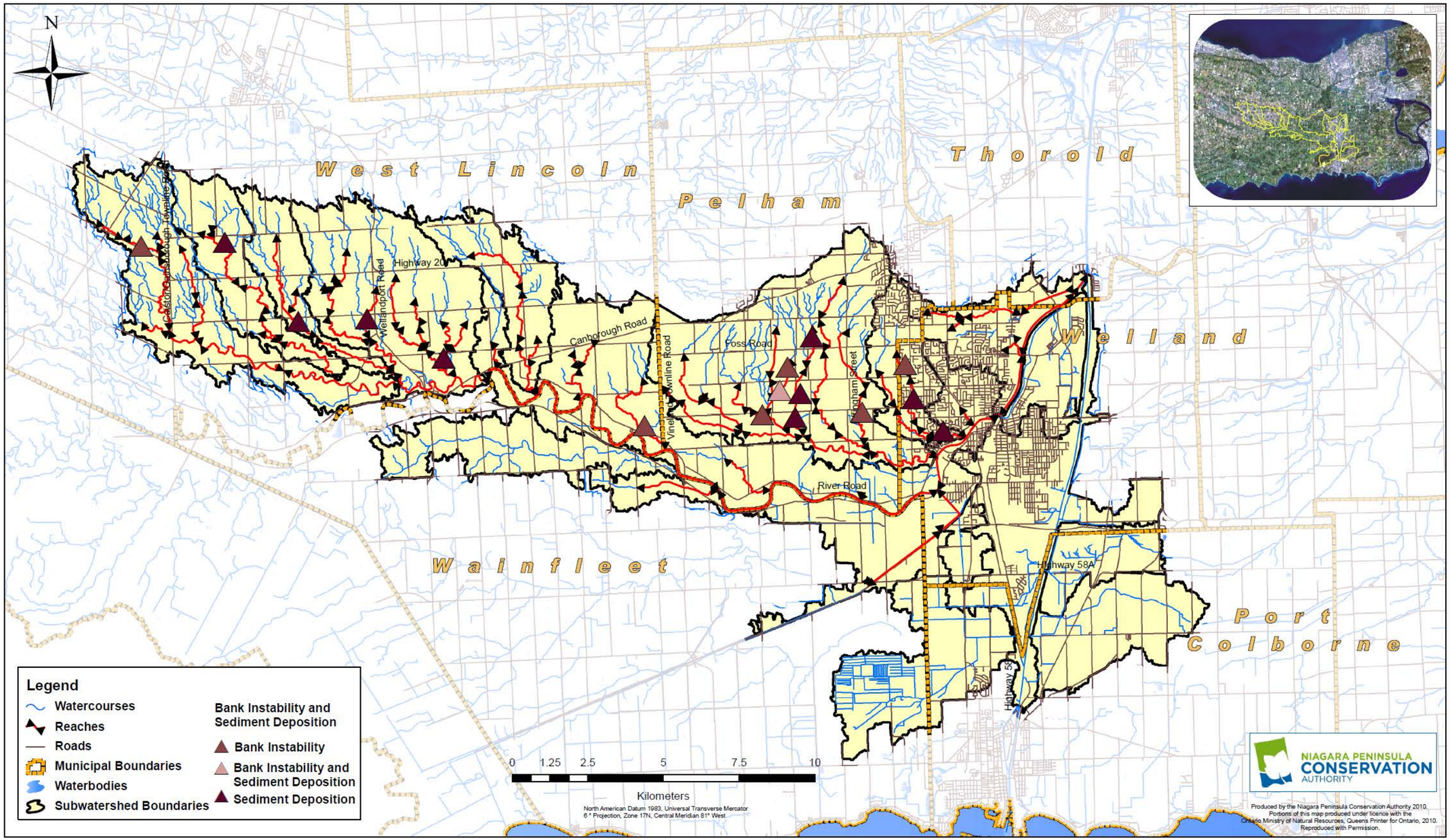


Central Welland River Watershed
Visual Assessment of Field Work Sites



Central Welland River Watershed

Identified Bank Instability and Sedimentation Sites



Appendix F:
Natural Heritage Species Reference List

Common Name	***Scientific Name***
Alpine Rush	*Juncus alpinoarticulatus*
American Beech	*Fagus grandifolia*
American Elm	*Ulmus americana*
Asters	*Aster sp*
Austrian Pine	*Pinus nigra*
Avens	*Geum sp*
Basswood	*Tilia americana*
Bebb's Willow	*Salix bebbiana*
Beechdrops	*pifagus virginiana*
Beggarstick's	*Bidens frondosa*
Bent Grass	*Agrostis sp.*
Birch	*Betula*
Bird Cherry	*Prunus padus*
Bitternut Hickory	*Carya cordiformis*
Bittersweet Nightshade	*Solanum dulcamara*
Black Cherry	*Prunus serotina*
Black Chokeberry	*Aronia melanocarpa*
Black Gum	*Nyssa sylvatica*
Black Maple	*Acer nigrum*
Black Walnut	*Juglans nigra*
Bladder Sedge	*Carex intumescens*
Bladderwort sp.	*Utricularia sp.*
Blueberry	*Vaccinium sp.*
Blue Beech	*Carpinus caroliniana*
Blue Cohosh	*Caulophyllum thalictroides*
Broad-leaved Cattails	*Typha latifolia*
Brown-eyed Susan	*Rudbeckia hirta*
Buckthorn	*Rhamnus cathartica*
Bulrush	*Scirpus sp.*
Burdock	*Arctium minus*
Bur Oak	*Quercus macrocarpa*
Bur-reed	*Sparganium sp*
Buttonbush	*Cephalanthus occidentalis*
Canada Enchanter's Nightshade	*Circaea lutetiana ssp. canadensis*
Canada Mayflower	*Maianthemum canadense*
Cattail	*Typha sp*
Choke Cherry	*Prunus virginiana ssp. virginiana*
Cinnamon Fern	*Osmunda. cinnomomea*
Climbing Poison Ivy	*Rhus radicans ssp. negundo*
Clubmoss	*Lycopodium sp*
Curly Pondweed	*Potamogeton crispus*
Cut-leaved Grape Fern	*Botrychium dissectum*
Common Apple	*Malus pumila*
Common Blackberry	*Rubus alleghanensis*
Common Bladderwort	*Utricularia vulgaris*
Common Buckthorn	*Rhamnus cathartica*
Common Cinquefoil	*Potentilla simplex*
Common Clearweed	*Pilea pumila*
Common Elderberry	*Sambucus canadensis*
Common Speedwell	*Veronica officinalis*
Common Strawberry	*Fragaria virginiana ssp. virginiana*
Crack Willow	*Salix fragilis*

Creeping Bent Grass	*Agrostis stolonifera*
Crested Sedge	*Carex cristatella*
Dame's Rocket	*Hesperous matronalis*
Downy Serviceberry	*Amelanchier arborea*
Duckweed	*Lemna sp.*
Early Goldenrod	*Solidago juncea*
Eastern Bracken Fern	*Pteridium aquilinum var. latiusculum*
Eastern Cottonwood	*Populus deltoids ssp. deltoids*
Eastern Hemlock	*Tsugacanadensis*
Eastern White Pine	*Pinus strobus*
European Birch	*Betula pendula*
False Nettle	*Boehmeria cylindrica*
False Solomon's Seal	*Maianthemum racemosum*
Fern	*Osmunda sp.*
Field Strawberry	*Fragaria virginiana ssp. virginiana*
Flat Sedge sp.	*Cyperus*
Flat-topped White Aster	*Aster umbellatus var. umbellatus*
Fowl Manna Grass	*Glyceria striata*
Foxglove Beard-tongue	*Penstemon digitalis*
Fox Sedge	*Carex vulpinoidea*
Freeman's Maple	*Acer fremanii*
Garlic Mustard	*Allaria petiolata*
Glossy Buckthorn	*Rhamnus frangula*
Goldenrod	*Solidago sp*
Grasses	*Poa sp*
Grass-leaved Goldenrod	*Euthamia graminea*
Gray Dogwood	*Cornus foemina ssp. racemosa*
Gray Goldenrod	*Solidago nemoralis*
Greater Duckweed	*Spirodela polyhiza*
Green Ash	*Fraxinus pennsylvanica*
Hairy Solomon's Seal	*Polygonatum pubescens*
Hawkweed	*Hieracium sp.*
Hawthorn	*Crataegus sp*
Herb Robert	*Geranium robertianum*
Highbush Blueberry	*Vaccinum corymbosum*
Highbush Cranberry	*Vaccinium corymbosom*
Hop Hornbeam	*Ostrya verginiana*
Horned Pondweed	*Zannichellia palustris*
Jack-in-the-pulpit	*Arisaema triphyllum ssp. triphyllum*
Jumpseed	*Polygonum virginianum*
Kentucky Blue Grass	*Poa pratensis*
Lakebank Sedge	*Carex lacustris*
Large-leaved Aster	*Aster macrophyllus*
Largetooth Aspen	*Populus grandidentata*
Lesser Duckweed	*Lemna minor*
Lichens	*Lichen sp*
Lily species	*Lilium sp.*
Little Bluestem Grass	*Schizachyrium scoparium*
Liverwort	*Riccia fluitans*
Maple-leaved Viburnum	*Viburnum acerifolium*
Mayapple	*Podophyllum peltatum*
Moneywort	*Lysimachia nummularia*
Mosses	*Moss sp.*

Narrow-leaved Cattail	*Typha angustifolia*
Narrow-leaved Meadowsweet	*Spirea alba*
Norway Spruce	*Picea abies*
New England Aster	*Aster novae-anglais*
New York Fern	*Thelypteris noveboracensis*
Nodding Beggar-ticks	*Bidens cernua*
Northern Blue Flag	*Iris versicolor*
Northern Lady Fern	*Athyrium filix-femina var. angustum*
One-sided Aster	*Aster lateriflorus var. lateriflorus*
Panicled Aster	*Aster lanceolatus ssp. lanceolatus*
Partridge Berry	*Mitchella repens*
Pennsylvania Sedge	*Carex pennsylvanica*
Pin Oak	*Quercus palustris*
Poison Sumac	*Rhus vernix*
Pondweed	*Potomageton sp.*
Poplar	*Populus sp*
Porcupine Sedge	*Carex hystercina*
Poverty Oat Grass	*Danthonia spicata*
Prickly-Ash	*Zanthoxylum americanum*
Purple Loosestrife	*Lythrum salicaria*
Raspberry species	*Rubus sp*
Red Cedars	*Juniperus virginiana*
Red Elm	*Ulmus rubra*
Red Maple	*Acer rubrum*
Red Oak	*Quercus rubra*
Red Osier Dogwood	*Cornus stolonifera*
Reed Canary Grass	*Phalaris arundinacea*
Rice Cut Grass	*Leersia oryzoides*
Riverbank Grape	*Vitis riparia*
Rough Avens	*Geum laciniatum*
Rough Goldenrod	*Solidago rugosa ssp. rugosa*
Royal Fern	*Osmunda regalis*
Running Strawberry	*Euonymus obovata*
Rushes	*Juncus sp*
Sedges	*Carex sp.*
Sensitive Fern	*Onoclea sensibilis*
Serviceberry	*Amelanchier sp*
Sessile-leaved Bellwort	*Uvularia sessilifolia*
Shagbark Hickory	*Carya ovata*
Silky Dogwood	*Cornus amomum ssp. obliqua*
Silver Maple	*Acer saccharinum*
Slender Stinging Nettle	*Urtica dioica ssp. gracilis*
Small White Water-lily	*Nymphaea odorata ssp. odorata*
Smartweed	*Polygonum sp.*
Snakeroot	*Sanicula*
Soft Rush	*Juncus effusus ssp. solutus*
Southern Arrow-wood	*Viburnum recognitum*
Spicebush	*Lindera benzoin*
Spotted Crane's-bill	*Geranium maculatum*
Spotted Touch-me-not	*Impatiens capensis*
Staghorn Sumac	*Rhus typhina*
Star Duckweed	*Lemna trisulca*
Starflower	*Trientalis borealis*

Sugar Maple	*Acer saccharum ssp. saccharum*
Swamp Dewberry	*Rubus hispidus*
Swamp Maple	*Acer fremanii*
Swamp White Oak	*Quercus bicolor*
Tall Buttercup	*Ranunculus acris*
Tall Goldenrod	*Solidago altissima var. altissima*
Tartarian Honeysuckle	*Lonicera tatarica*
Thicket Creeper	*Parthenocissus inserta*
Three-lobed Beggar-ticks	*Bidens tripartita*
Trembling Aspen	*Populus tremuloides*
Tulip Tree	*Liriodendron tulipifera*
Virginia Spring Beauty	*Claytonia virginica*
Water Meal	Wolfia columbiana, Wolfia borealis
Water-milfoil species	*Myriophyllum sp.*
Western Poison-ivy	*Rhus radicans ssp. rydbergii*
White Ash	*Fraxinus Americana*
White Avens	*Geum canadense*
White Cedar	*Thuja occidentalis*
White Elm	*Ulmus americana*
White Oak	*Quercus alba*
White Wood Aster	*Eurybia divaricata*
Wild Carrot	*Daucus carota*
Wild Leek	*Allium tricoccum*
Wild Red Raspberry	*Rubus idaeus ssp. melanolasius*
Wild Sarsaparilla	*Aralia nudicaulis*
Wild Yamroot	*Dioscorea quaternata*
Willow	*Salix sp*
Winterberry	*Ilex verticillata*
Wintergreen	*Galtheria procumbens*
Witch-hazel	*Hamamelis virginiana*
Wood Nettle	*Laportea canadensis*
Woodrush species	*Cinna sp*
Yellow Birch	*Betula alleghaniensis*

Appendix G:
Riparian, Wetland and Upland Habitat Restoration Guidelines

Restoration guidelines for riparian, wetland and forest habitat as recommended by Environment Canada (2005) in its *„How Much Habitat is Enough?'* document. This framework was used as a guideline in the Central Welland River 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	Steams 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 steam 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.

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 wetlands 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	Wetlands of a variety of sizes, types, and hydroperiods should be maintained across a landscape. Swamps and marshes 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.

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 of 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.

The following chart is taken directly from *Conservation Buffers; Design Guidelines for Buffers, Corridors, and Greenways* (Bentrup 2008).

Issue and Objectives	Buffer Functions
Water Quality	
Reduce erosion and runoff of sediment, nutrients, and other potential pollutants Remove pollutants from water runoff and wind	Slow water runoff and enhance infiltration Trap pollutants in surface runoff Trap pollutants in subsurface flow Stabilize soil Reduce bank erosion
Biodiversity	
Enhance terrestrial habitat Enhance aquatic habitat	Increase habitat area Protect sensitive habitats Restore connectivity Increase access to resources Shade stream to maintain temperature
Productive Soils	
Reduce soil erosion Increase soil productivity	Reduce water runoff energy Reduce wind energy Stabilize soil Improve soil quality Remove soil pollutants
Economic Opportunities	
Provide income sources Increase economic diversity Increase economic value	Produce marketable products Reduce energy consumption Increase property values Provide alternative energy sources Provide ecosystem services
Protection and Safety	
Protect from wind or snow Increase biological control of pests Protect from flood waters Create a safe enviroment	Reduce wind energy Modify microclimate Enhance habitat for predators of pests Reduce flood water levels and erosion Reduce hazards
Aesthetics and Visual Quality	
Enhance visual quality Control noise levels Control air pollutants and odor	Enhance visual interest Screen undesirable views Screen undesirable noise Filter air pollutants and odors Separate human activities
Outdoor Recreation	
Promote nature-based recreation Use buffers as recreational trails	Increase natural area Protect natural areas Protect soil and plant resources Provide a corridor for movement Enhance recreational experience

Appendix H:
Restoration Suitability Criteria and Weighting Scheme

RESTORATION SUITABILITY CRITERIA : RIPARIAN HABITAT			
HABITAT: RIPARIAN	**RATIONALE**	**METHODOLOGY**	**REFERENCE**
CRITERIA: Proximity to Watercourse/Waterbody			
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*	Niagara River AOC RAP
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*	Riparian Habitat Guidelines
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*	
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*	
CRITERIA: Land Use Type			
(lurwood)	*In terms of potential conflict, existing land use type is scaled in terms of*	*Generate Land Use surface on Land Use Type value. Reclassify*	Niagara Peninsula Conservation
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*suitability to restoration. Areas classified as scrub, low intensity*	*Land Use values where low conflict land use types have higher*	Authority
2 Recreational, Residential, High Intensity Agriculture	*agriculture, or natural area are much more suitable to restoration*	*suitability values than high conflict land use types.*	
1 Industrial, Built Up Urban	*than areas classified as industrial or built-up urban.*		
CRITERIA: Slope			
(slopedr)	*Considers the presence of vegetation in terms of hydrological and*	*Generate slope surface from DEM. Reclassify surface where*	Niagara Peninsula Conservation
3 ≥ 10 degrees	*mechanical contribution to bank stability and erosion control.*	*higher slope values have higher suitability values.*	Authority
2 < 10 degrees	*As slope increases, restoration suitability increases.*		
1 0 degrees			
CRITERIA: Fish Habitat Classification of Catchment			
(catchfhr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*	Niagara Peninsula Conservation
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*	Authority
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*	
1 Marginal			
CRITERIA: Stream Order of Catchment			
(catchsor)	*Catchments which drain to watercourses in headwater streams*	*Generate surface from catchment polygons on stream order*	Niagara River AOC RAP
3 intermittent flow (1st & 2nd order)	*are considered more suitable for restoration than those that drain to*	*value. Reclassify values according to restoration suitability.*	Riparian Habitat Guidelines
2 intermittent / permanent flow (3rd order)	*higher ordered streams in terms of water quality improvement.*		
1 permanent flow (> 3rd order)			
CRITERIA: Forest Cover			
(coverwor)	*It is more suitable to restore habitat where vegetation does not*	*Generate surface from natural vegetation polygons based on*	Niagara River AOC RAP
3 woodland not present	*presently exist, or where infilling may be necessary from a previous*	*vegetation type. Reclassify cells lacking forest cover as highest*	Riparian Habitat Guidelines
2 planting site	*restoration project.*	*suitability values.*	
1 woodland present			
CRITERIA: Streambank Erosion Rates (Wetness Index)			
(ripwir)	*Riparian areas identified as having high erosion rates resulting from*	*Generate wetness index surface from topographic analysis.*	Niagara Peninsula Conservation
3 High (10-21)	*upslope contributing area and slope gradient analysis are most*	*Reclassify surface where highest erosion rates have*	Authority
2 Mid (5-10)	*suitable to restoration with bioengineering.*	*highest suitability values.*	
1 Low (0-5)			
CRITERIA: Protected Area			
(careasdr)	*Areas within C.A. boundaries are protected from development*	*Generate straight line distance surface from Conservation Area*	Niagara Peninsula Conservation
3 within conservation area boundary	*pressure and destruction. Areas in close proximity to these*	*boundary polygons. Reclassify surface values according to*	Authority
2 ≤ 30m from conservation area boundary	*boundaries are good areas to restore in terms of establishing*	*restoration suitability.*	
1 > 30m from conservation area boundary	*connectivity.*		

RESTORATION SUITABILITY CRITERIA : WETLAND HABITAT

HABITAT: WETLAND	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: Proximity to Existing Significant Patch (Size)			
(wecoredr)	*Areas within closest proximity to existing wetland patches of highest*	*Select existing patches with highest size significance value.*	Niagara River AOC RAP
3 ≤ 50m	*Natural Heriage Score (core size) will be most suitable to restoration of*	*Generate distance surface from selected patches. Reclassify*	Wetland Extent Guidelines
2 > 50m & < 100m	*increased interior habitat.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Significant Existing Patch			
(wenndr)	*Areas within closest proximity to existing wetland patches of highest*	*Select existing patches with highest size significance value.*	Niagara River AOC RAP
3 ≤ 50m	*Natural Heritage score (nearest neighbor) will be most suitable to*	*Generate distance surface from selected patches. Reclassify*	Wetland Extent Guidelines
2 > 50m & < 100m	*restoration.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Watercourse / Waterbody			
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*	Niagara River AOC RAP
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*	Wetland Extent Guidelines
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*	
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*	
CRITERIA: Soil Drainage			
(sdrainr)	*The drainage class of the underlying soil determines the*	*Generate surface from OMAF soil polygons based on drainage*	North Carolina
3 Alluvial Soil	*amount of water the soil can receive and store before runoff.*	*class. Reclassify surface according to suitability values.*	Coastal Region Evaluation of
2 Very Poorly and Poorly Drained	*The more poorly drained the underlying soil, the more suitable the*		Wetland Significance
1 Imperfectly Drained	*area to wetland restoration.*		
CRITERIA: Land Use Type			
(lurwood)	*In terms of potential conflict, existing land use type is scaled in*	*Generate Land Use surface on Land Use Type value. Reclassify*	Niagara Peninsula Conservation
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*terms of suitability to restoration. Areas classified as scrub, low*	*Land Use values where low conflict land use types have higher*	Authority
2 Recreational, Residential, High Intensity Agriculture	*intensity agriculture, or natural area are much more suitable to*	*suitability values than high conflict land use types.*	
1 Industrial, Built Up Urban	*restoration than areas classified as industrial or built-up urban.*		
CRITERIA: Fish Habitat Classification of Catchment			
(catchfr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*	Niagara Peninsula Conservation
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*	Authority
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*	
1 Marginal			
CRITERIA: Stream Order of Catchment			
(catchsor)	*Catchments which drain to watercourses in headwater streams*	*Generate surface from catchment polygons on stream order*	Niagara River AOC RAP
3 intermittent flow (1st & 2nd order)	*are considered more suitable for restoration than those that drain to*	*value. Reclassify values according to restoration suitability.*	Wetland Extent Guidelines
2 intermittent / permanent flow (3rd order)	*higher ordered streams in terms of water quality improvement.*		
1 permanent flow (> 3rd order)			
CRITERIA: Wetness Index (Topographic Position/slope)			

(wetindr)	*The wetness index equation predicts zones of water saturation where*	*Generate wetness index surface from slope gradient and flow*
3 high (10-21)	*steady-state conditions and uniform soil properties are assumed.*	*accumulation. Reclassify surface where highest Wetness Index*
2 mid (5-10)	*It is a function of upslope contributing area and slope gradient. Areas*	*values have highest suitability values.*
1 low (0-5)	*of highest W.I. values are most suitable to wetland restoration.*	
CRITERIA: Forest Cover		
(coverwer)	*Where forest cover is already present, restoration is more suitable*	*Generate surface from woodland polygons. Reclassify values*
3 Forest cover present	*particularly in terms of the establishment of swamp habitat.*	*according to suitability value.*
2 Planting site present		
1 Forest cover present		
CRITERIA: Protected Area		
(careasdr)	*Areas within C.A. boundaries are protected from development*	*Generate straight line distance surface from Conservation Area*
3 within conservation area boundary	*pressure and destruction. Areas in close proximity to these*	*boundary polygons. Reclassify surface values according to*
2 ≤ 30m from conservation area boundary	*boundaries are more suitable to restore in terms of establishing*	*restoration suitability.*
1 > 30m from conservation area boundary	*connectivity.*	
RESTORATION SUITABILITY CRITERIA : UPLAND HABITAT		
HABITAT: UPLAND FOREST	**RATIONALE**	**METHODOLOGY**
CRITERIA: Proximity to Significant Patch (CoreSize)		
(wocoredr)	*Areas within closest proximity to existing forest patches of highest*	*Select existing patches with highest size significance value.*
3 ≤ 50m	*of Natural Heriage Score (core size) will be most suitable to restoration*	*Generate distance surface from selected patches. Reclassify*
2 > 50m & < 100m	*increased interior habitat.*	*surface values where lowest distances have highest suitability*
1 ≥ 100m		*values.*
CRITERIA: Proximity to Significant Patch (Connectivity)		
(wonndr)	*Areas within closest proximity to existing forest patches of highest*	*Select existing patches with highest proximity significance value.*
3 ≤ 50m	*Natural Heritage score (nearest neighbor) will be most suitable to*	*Generate distance surface from selected patches. Reclassify*
2 > 50m & < 100m	*restoration of wildlife corridors.*	*surface values where lowest distances have highest suitability*
1 ≥ 100m		*values.*
CRITERIA: Proximity to Watercourse / Waterbody		
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*
CRITERIA: Land Use Type		
(lurwood)	*In terms of potential conflict, existing land use type is scaled in terms*	*Generate surface from 1992 Landsat 7 Landuse Classification on*
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*of suitability to restoration. Areas classified as scrub, low intensity*	*Land Use Type value . Reclassify Land Use values where low*
2 Recreational, Residential, High Intensity Agriculture	*agriculture, or natural area are much more suitable to restoration*	*conflict land use types have higher suitability values than high*
1 Industrial, Built Up Urban	*than areas classified as industrial or built-up urban.*	*conflict land use types.*
CRITERIA: Fish Habitat Classification of Catchment		
(catchfhr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*
1 Marginal		

REFERENCE
Niagara Peninsula Conservation Authority
Niagara Peninsula Conservation Authority
Niagara Peninsula Conservation Authority
Niagara River AOC RAP Evaluation of Upland Habitat
Niagara River AOC RAP Riparian Habitat Guidelines
Niagara Peninsula Conservation Authority
Niagara Peninsula Conservation Authority

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

Appendix I:
Mitigation Measures for Drain Maintenance

Mitigation Measures implemented in drains. This information was taken directly from Fisheries and Oceans Canada publication *The Drain Primer: A Guide to Maintaining and Conserving Agricultural Drains and Fish Habitat*

MITIGATION MEASURES

Timing

Digging should be done so as to avoid local fish spawning or nursing periods. If done at the wrong time, suspended sediments from the maintenance work might prevent spawning, smother eggs, or kill young fish.

Option: Do the Project in the Summer

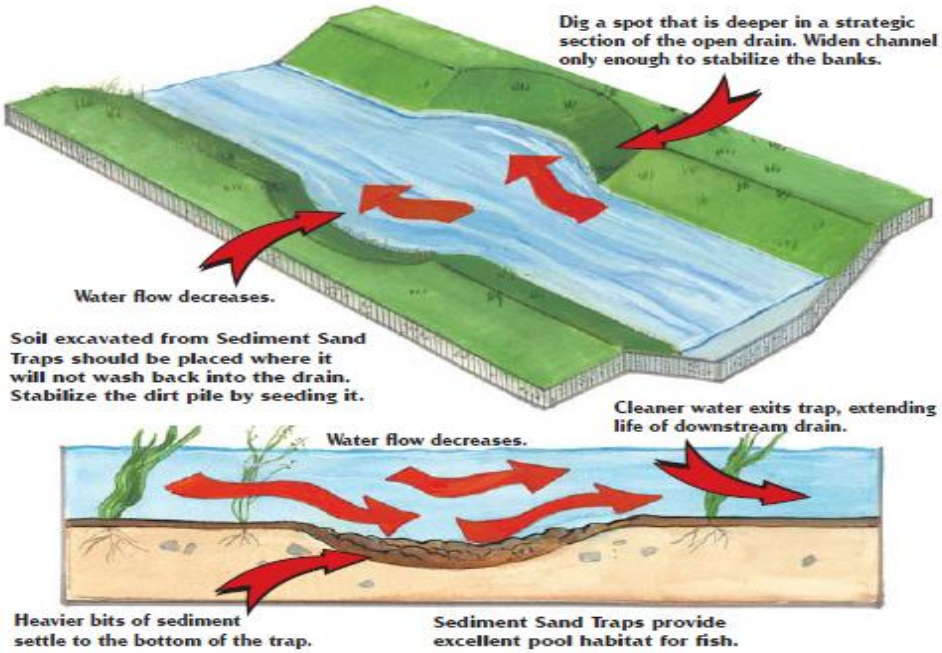
Summer may be a good time to do maintenance work when drains are dry or have little flow. This way the crane or backhoe operators can see exactly what needs to be cleaned out without the obstruction of clouded water. Doing the work when the ditch is relatively dry also ensures that little, if any, sediment will float downstream where it might impact fish. As well, maintenance should be done as quickly as possible in order to limit the amount of disruption to fish migration and habitat

Sediment Controls

If work is undertaken while water is still flowing in the drain, controls need to be put in place to prevent the flow of sediment downstream. The following options are essentially designed for areas with sandy or sandy loam soils.

Option: Sediment Sand Traps

Sediment sand traps are created by strategically digging a spot that is deeper in the open drain. Excessive widening of the channel should be avoided, however the channel should be widened enough to stabilize the banks. This larger hole acts as a settling pond, slowing down water as it drops into the deeper spot. As the water flow decreases, heavier sediments and debris settle to the bottom of the trap, somewhat improving the quality of the water leaving the trap and moving downstream.



The sediment sand trap technique can be low cost when compared to other conventional methods. Farmers and municipalities need only worry about cleaning the trap out, which is a lot cheaper than paying for a full-scale clean out. Less of the drain is disturbed and clean out is quicker. Sand traps should be placed in spots easily accessible so as to avoid having to drive over planted crops in order to get maintenance equipment to the site.

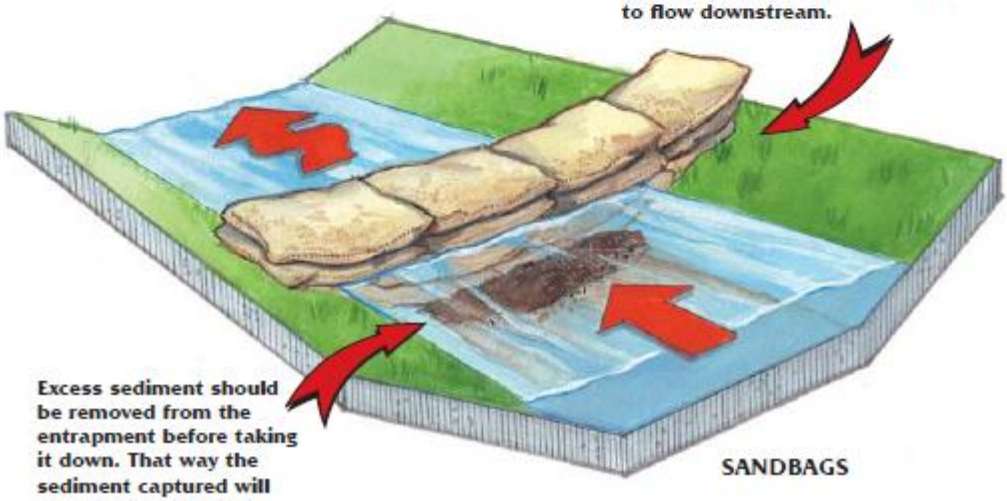
Option: Silt Fences /Straw Bales/Sandbags

Silt fences (those little black curtains we see between construction sites and watercourses), straw bales, and sandbags are inexpensive ways to prevent the flow of sediments downstream. Silt fences or straw bales need to be staked into place downstream of the maintenance site. These two options act as filters removing sediment from water. More than one set of curtains or bales may be required.

Sandbags act much like sand traps. By sandbagging the water back, one creates a settling pond where heavier sediment can drop out, allowing relatively cleaner water to flow downstream.

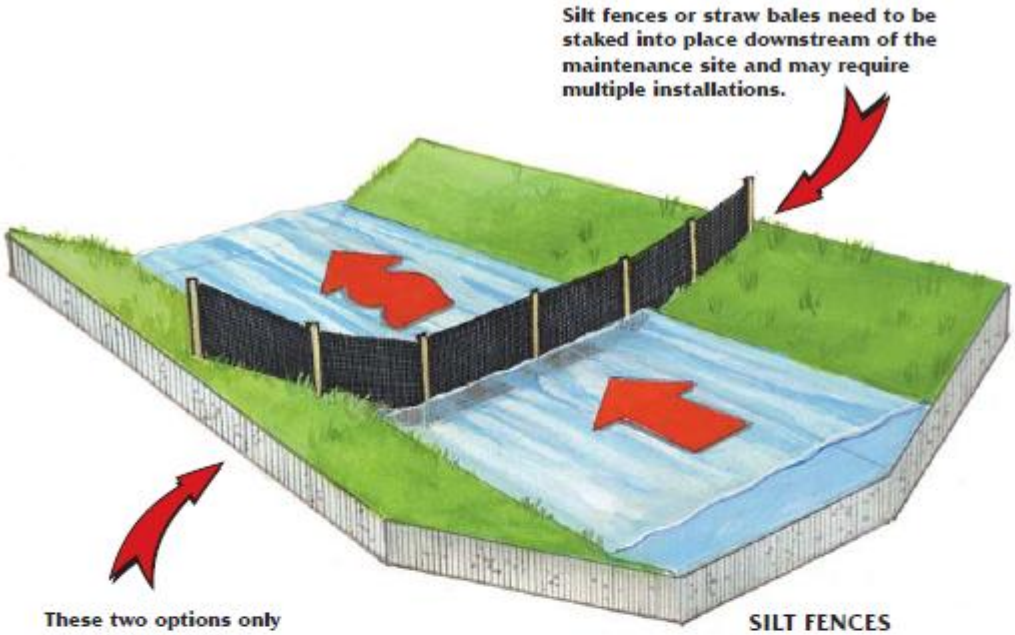
Any of these light-weight channel flow controls are only good for handling relatively low flows in small drainage areas for short periods of time. These options only work when they are properly maintained. Care also needs to be taken when removing these controls. Excess sediment should be removed from the entrapment before taking down a sediment control structure. That way, the sediment captured will not be released back into the stream.

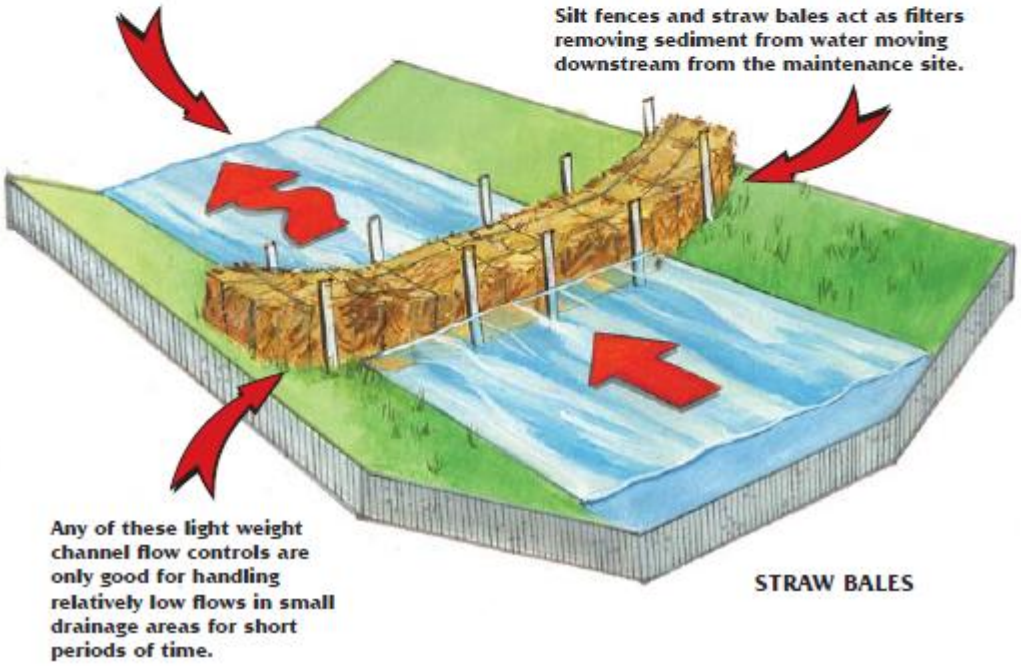
By sandbagging the water back, a settling pond is created. Heavier sediment drops to the bottom, allowing relatively cleaner water to flow downstream.



Excess sediment should be removed from the entrapment before taking it down. That way the sediment captured will not be released back into the stream.

SANDBAGS


Silt fences or straw bales need to be staked into place downstream of the maintenance site and may require multiple installations.
These two options only work when they are properly maintained.
SILT FENCES


Silt fences and straw bales act as filters removing sediment from water moving downstream from the maintenance site.
Any of these light weight channel flow controls are only good for handling relatively low flows in small drainage areas for short periods of time.
STRAW BALES

To extend drain life, save money on routine maintenance and enhance fish and wildlife habitat, banks need to be protected from erosion.

Erosion Control and Bank Stabilization

Eroding drain banks can be costly to farmers, municipalities and the environment. The more soil collapses into a drain, the more that drain's flow is disrupted. The extra soil entering the system is unlikely to be carried very far in the water, resulting in an accumulation of sediment, which in turn fills the drain. Eroding banks may lead to trees and other vegetation falling into the watercourse, further diverting and slowing water flow and leading to more erosion. Eventually, the ability of the open ditch to drain surrounding land is hampered and further maintenance is required sooner than was originally planned. To extend the life of the drain, save money, and help the environment, a number of techniques can be used.

Option: Leave the Banks Alone

Bank erosion is best prevented by not disturbing the banks at all. Stable banks usually have grass, shrubs and trees growing along them. Vegetation adjacent to the bank helps slow down runoff from the fields, which in turn helps to minimize erosion of the bank. As well, the root systems of vegetation along the banks hold the sides together and stabilize the slopes. Environmentally, the stalks and leaves from the different types of plants slow down runoff and act as a filter by trapping sediment, pesticides and other pollutants – improving the quality of water entering the drain.

Option: Plant Bigger Buffers

Other means to prevent erosion, extend the life of the drain and improve habitat is to plant shrubs and trees and to increase the size of the vegetated buffer between the field and drain.

Conservation cropping, such as the soy beans planted to the left of the drain above, can help stabilize the bank, reduce future drain maintenance, and improve habitat for a wide variety of species.

Bigger buffers can help remove more of the sediment carried by field runoff into the open ditch, and thus minimize the need for drain maintenance. This option might involve taking productive land out of operation. The alternative may be to look at planting such crops as hay or alfalfa as buffers along the drain. Once these crops are planted, the land can go a number of years without the need for being plowed up, crops can be harvested annually, and the root systems remain undisturbed.

Option: Work from One Side of Drain

If vegetation needs to be removed from a ditch, it would be best to remove it from one side only. That way, one side of the ditch is better protected from erosion, less movement of equipment is needed, clean-out is quicker, and there is less disruption. Where applicable, it is best to leave the south side of the drainage bank alone as that will ensure shade, cover and food sources for fish.

Option: Remove Vegetation at Intervals

Depending on various circumstances, another option may be to remove vegetation at certain intervals. If an open drain has gone several years without maintenance – trees, shrubs and other brush may have grown to the point where removal of vegetation is required to allow a crane or backhoe access for proper drain clean out.

Mature or young trees should be left on either bank. These trees help stabilize the ditch, provide cover and insect food for fish, and shade the banks and the water. The shade from the trees also helps prevent the growth of vegetation that may create blockages to drain flow.

Rather than clearing out all the vegetation, one can remove for example, 20 metres of vegetation on one side of the bank, skip 20 metres, and then continue so on down the one side of the drain. Then to ensure total bottom clean out, do the same on the opposite bank. Later, when one needs to maintain the drain, vegetation removal and drain maintenance can be done from the spots that were originally left untouched. While this option may be a bit more costly and time-consuming, the landowner is always guaranteed that there will be mature vegetation along the drain to help stabilize it.

Option: Brushing

Brushing involves using large mowers to cut the vegetation along the bank. The trimming of the plants and shrubs should improve water flow and thus cause the drain to naturally deepen on its own, as faster water tends to scour a watercourse. As well, runoff from the surrounding land is less impeded by mature vegetation when entering the drain. Brushing can also be a helpful step in providing access spots for maintenance equipment to the drain bottom. Regardless of the reason for using the technique, the key to brushing is that it leaves the root system untouched. Thus the drain's banks are stabilized, the mulch from the mowing protects the surface from wind and rain erosion, and reseeding the slope is unnecessary. Care must be taken to make sure that the mulch from the brushing that ends up in the waterway is removed so that the drain does not get clogged downstream.

Gentle bank slopes help reduce erosion by reducing runoff speed.

Brushing leaves the root systems intact, stabilizing the banks from erosion. Debris from the brushing protects the banks from wind and rain erosion.

Option: Reseeding

As soon as the drain maintenance is done, one should consider leveling the spoils, or excavated material, created from clear-out and reseed the work area while the soil is still moist in order to reestablish vegetation and stabilize the bank. If immediate revegetation is not an option (maybe the growing season has passed) then using filter cloth, various mulches or erosion blankets made of natural material might help in protecting the banks from erosion.

Option: Sloping

When maintaining a drain, it is preferable to have gentle slopes on the banks rather than steep ones. The steeper the grade, the quicker the water enters the drain, the more unstable banks become, and the more likely erosion will take place.

Straw blankets, such as the one seen above, help protect the exposed area from wind and rain erosion, and incorporate natural materials to help vegetation get reestablished.

Natural channel design features can be incorporated into drains where appropriate. Natural channels are efficient at moving both water and sediment, as well as providing long-term stability for the drain and enhancing fish habitat.