NIAGARA PENINSULA CONSERVATION AUTHORITY

TWELVE MILE CREEK WATERSHED PLAN

JENNIFER DURLEY, WATERSHED PLANNING SPECIALIST

EXECUTIVE SUMMARY

The Twelve Mile Creek watershed is located within the Regional Municipality of Niagara including the Town of Pelham, City of Thorold, City of St. Catharines and the Town of Lincoln. The total drainage of the watershed is 178 square kilometres. The Twelve Mile Creek watershed contains 6 subwatersheds including Upper Twelve Mile Creek, Lake Gibson System, Richardson Creek, Francis Creek, Dicks Creek and Lower Twelve Mile Creek. Individual restoration strategies have been prepared for each of the subwatersheds to protect the unique characteristics of each system.

The Upper Twelve Mile Creek subwatershed contains the headwaters of Twelve Mile Creek. This subwatershed contains the highest percentage of natural areas in the watershed and is rich in Carolinian flora. The headwaters also support the only identified cold water streams in the Niagara Region that supports naturally reproducing brook trout populations. The Lake Gibson System is a human-made arrangement of reservoirs located primarily in the City of Thorold that is currently being studied for sediment contamination. The Richardson Creek subwatershed is located primarily in the City of St. Catharines. Richardson Creek flows through rural and agricultural areas before emptying into Martindale Pond. The Francis Creek subwatershed flows through residential areas and also includes a large storm channel that has established aquatic habitat deeming it an important fishery. Dicks Creek also flows through an urban area before meeting up with the Old Welland Canal, which eventually empties into Twelve Mile Creek. Both Francis Creek and Dicks Creek are located in the City of St. Catharines. The Lower Twelve Mile Creek subwatershed experiences water fluctuations and faster flows as a result of the DeCew Power Generating Station. This subwatershed also contains Martindale Pond and the provincially significant Barnesdale Marsh.

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 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 subwatershed strategies include sites for riparian, wetland and upland habitat restoration 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 shading to reduce water temperatures in the headwaters. Special studies including policy tools and urban water conservation programs have also been proposed. The implementation plan identifies responsible stakeholders for each recommended management action. The recommended management actions have been prioritized and include riparian, wetland and upland restoration and creation to enhance water quality, fish habitat and recreation; specific policy tools including municipal and regional official plan amendments; outreach and communication for various aspects of water resources management; and research and monitoring programs to obtain additional data from which the *Twelve Mile Creek Watershed Plan* can be updated and revised every 5 years.

ACKNOWLEDGEMENTS

The Niagara Peninsula Conservation Authority (NPCA) is very grateful to everyone who participated in the Open Houses and Workshops for Phase 1 and Phase 2 of the watershed planning process. We are also very thankful to the Niagara North Federation of Agriculture for offering their services to label and mail the Land Management Issues and Agricultural Best Management Practices survey to their membership in the Twelve Mile Creek Watershed. We also extend our appreciation to all of the survey participants for their participation in the survey. In addition, our appreciation is extended to Alun Hughes for providing a detailed account of the history of the Lake Gibson recreational corridor. Our gratitude is also extended to the Twelve Mile Creek Watershed Plan Steering Committee for their participation in the creation of the *Twelve Mile Creek Watershed Plan.*

TWELVE MILE CREEK WATERSHED PLAN STEERING COMMITTEE:

Dominic DiFruscio, City of Thorold and Chair of the Steering Committee

Don Campbell, Regional Municipality of Niagara

John Durley, Town of Pelham

D. Bruce Timms, City of St. Catharines

Mark Green, City of St. Catharines

Suzanne McInnes, Niagara Peninsula Conservation Authority

Jennifer Durley, Niagara Peninsula Conservation Authority

Roman Olszewski, Peninsula Field Naturalists

John Bacher, Friends of the Twelve

Dave Gonzalez, Friends of Short Hills

David Wiley, Ontario Federation of Agriculture

David Beamer, Niagara Restoration Council

David Griffiths, Friends of Mel Swart Park

Kate Showers, Citizen Representative

David Slaine, Citizen Representative

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INTRODUCTION

The Twelve Mile Creek watershed has been identified as a priority watershed for the completion of a watershed management plan through the recently completed *Niagara Water Quality Protection Strategy (NWQPS) (2003)*. The *NWQPS (2003)* identified 32 Local Management Areas (LMAs). The Twelve Mile Creek watershed is located in LMA 1.6 and LMA 1.7. Combined, these LMAs form the boundary of the Twelve Mile Creek watershed **(Figure 1).**

The Twelve Mile Creek watershed is a highly significant watershed containing the only identified cold water streams within the Niagara Region that supports naturally reproducing brook trout populations. In addition, the watershed contains considerable stands of Carolinian flora, Niagara Escarpment features, Short Hills landscape in the Niagara Region, and approximately 58 percent of the watershed falls within the Greenbelt. The Twelve Mile Creek watershed is also rich in history with the development of commerce routes along the Welland Canal. A watershed management plan will aid in protecting and enhancing the biological, cultural, agricultural, economic and recreational resources of the Twelve Mile Creek watershed.

WATERSHED PLANNING AND TWELVE MILE CREEK

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., Twelve Mile Creek). Watersheds include all water and water-dependent features such as wetlands, forests, urban areas, and agriculture (Pollution Probe 2004).

A watershed management plan is a proactive document created cooperatively by government agencies and the community to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed to protect the health of the ecosystem as land uses change (Ministry of Environment and Energy and Ministry of Natural Resources 1993). The *Twelve Mile Creek 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.

The Twelve Mile Creek Watershed Plan was created in 2 phases with numerous opportunities for public involvement through open houses, workshops and an agricultural land use survey. A summary of the watershed planning process and public events is included in **Appendix A.**

Phase 1 of the Twelve Mile Creek watershed planning process was completed in the Spring of 2005. The watershed characterization produced in Phase 1 contained 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 (NPCA 2005a). The results from Phase 1 have been summarized and presented in the Phase 2 Watershed Plan to provide an introduction to the physical, natural and socio-economic character of the Twelve Mile Creek watershed.

In addition to the characterization produced in the first phase of the watershed planning process, Phase 2 provides a set of watershed objectives that are linked to a comprehensive list of watershed issues derived from the NWQPS (2003), *Twelve Mile Creek Watershed Strategy* (2000), and public open houses and workshops held during 2004-05. Issues specific to agriculture were gathered through the *Land Management Issues and Agricultural Best Management Practices survey* **(Appendix B),** which was distributed to Ontario Federation of Agriculture members through a partnership with the Niagara Peninsula Conservation Authority. The issues derived from these documents and public venues form the foundation of the watershed strategy and subsequent action plan, which are the focus of Phase 2 of the watershed planning process.

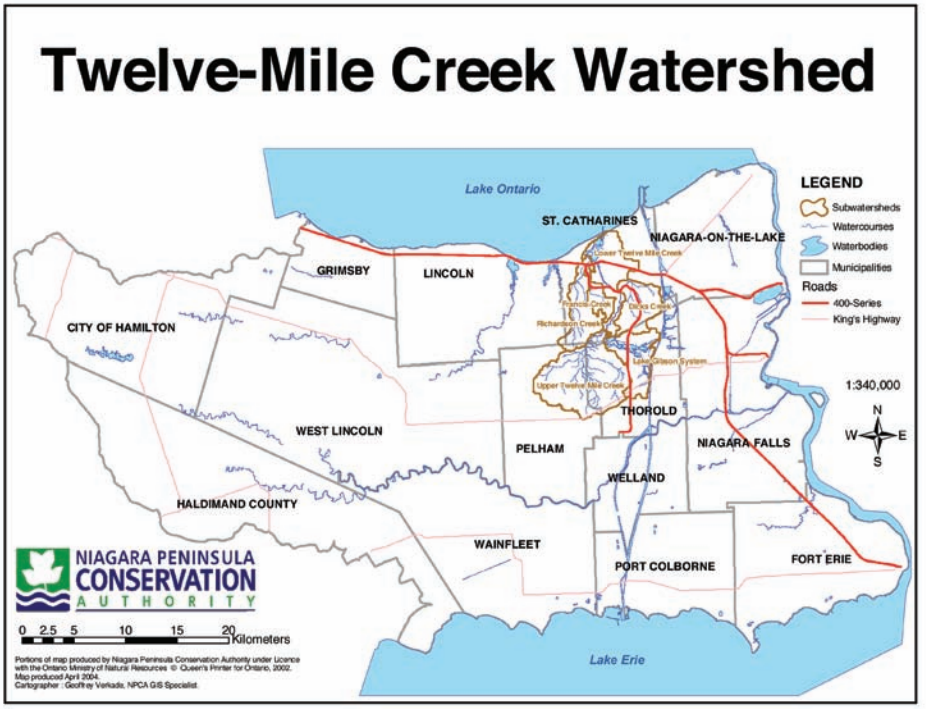


FIGURE 1: GEOGRAPHIC LOCATION OF THE TWELVE MILE CREEK WATERSHED

WATERSHED VISION

Under the Conservation Authorities Act, 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, *NWQPS* (2003) and the watershed challenges and issues outlined above, the Twelve Mile Creek watershed will contribute to an improved quality of life for all living things. There will be enough water, of the necessary quality, to sustain healthy rural and urban communities, in harmony with the natural environment, and rich in species diversity. Citizens and neighbours of the Twelve Mile Creek watershed, and on a greater scale, the Region of Niagara, will share the responsibility of efficient water use, and will respect the long-term sustainability of all water systems and the life that depends on them.

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 Twelve Mile Creek watershed have been categorized based on the watershed's resource components, including the social and built environment. In accordance with the *Provincial Policy Statement* (2005) and public input, natural resources will be managed on a watershed scale in the Twelve Mile Creek watershed as follows:

WATER RESOURCES

- Maintain, enhance or restore stream processes to support human uses, agricultural needs and ecological functions;
- Protect all municipal drinking water supplies and designated vulnerable areas;
- Protect, improve or restore vulnerable surface and ground water sources, sensitive surface water features and sensitive ground water features (e.g., aquifers), and their hydrologic functions;
- Ensure the equitable distribution of available groundwater and surface water supply to protect water quality, aquatic ecosystems and human health;

- Ensure that storm water management practices optimize storm water volumes and minimize contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces;
- Manage and mitigate flooding risks to human life and property within acceptable limits, and;
- Minimize erosion caused by human activity through the establishment and implementation of a comprehensive, priority based erosion control program.

FISH AND AQUATIC HABITAT

- Protect, enhance and restore populations of native species and their habitats in the watershed (e.g., brook trout).

NATURAL HERITAGE AND RESOURCES

- Protect, enhance, reforest and restore Areas of Natural and Scientific Interest and Environmentally Significant Areas, and other woodlands and wildlife habitat in the watershed for the long-term;
- Protect, enhance and restore the stability, diversity, linkages and ecological function between habitats that support terrestrial and aquatic species and communities including species at risk; and
- Preserve wetlands of provincial significance and create, and/or enhance and conserve all other wetlands in the watershed.

URBAN DEVELOPMENT

- Promote environmentally-sound land use decision-making in the watershed for current and future urban development; and
- Identify opportunities to optimize restoration and rehabilitation as part of urban growth and development.

COMMUNICATION AND EDUCATION

- Increase awareness of the linkages between healthy water, healthy lifestyles and the economic viability of rural and urban land uses;
- Promote the wise use of groundwater and surface water resources in terms of human, agricultural and ecological needs;
- Promote the efficient and sustainable use of water resources, including practices for water conservation and sustaining water quality;
- Encourage the creation of partnerships with agencies, organizations and landowners in the watershed.

WATERSHED CHARACTERIZATION

LOCATION AND DESCRIPTION OF TWELVE MILE CREEK AND ITS TRIBUTARIES

The Twelve Mile Creek watershed is located within the Regional Municipality of Niagara including the Town of Pelham, City of Thorold, City of St. Catharines and the Town of Lincoln. The total drainage of the watershed is 178 square kilometres. The Twelve Mile Creek watershed contains 6 subwatersheds including Upper Twelve Mile Creek, Lake Gibson System, Richardson Creek, Francis Creek, Dicks Creek and Lower Twelve Mile Creek **(Figure 1).** The only identified cold water streams within the jurisdiction of the NPCA are the Effingham and St. John's branches of Twelve Mile Creek, which are located in the Upper Twelve Mile Creek subwatershed.

TWELVE MILE CREEK

The main branch of Twelve Mile Creek flows north for approximately 20 kilometres from the headwaters in the Fonthill Kame-Delta Complex, and outlets at the southwest end of Lake Ontario at Port Dalhousie. The topography of the watershed above the escarpment is very irregular due to the deeply eroded gullies and multi-branched nature of the headwater tributaries. Downstream of the escarpment, the creek has been reconstructed and is now characterized by a large river-like stream. Lower Twelve Mile Creek has been used as a channel to transfer water discharged from the Ontario Hydro DeCew Falls Generating Station to Lake Ontario since 1898. As a result, the flows in the creek have been significantly increased. It is estimated that the natural flows in the creek would be only 1 to 2 percent of current flows if water was not diverted for the generating station from the Welland Ship Canal. The natural conditions of Twelve Mile Creek would be a slow moving, meandering stream contained within a larger valley (Public Works and Government Services Canada 1996).

UPPER TWELVE MILE CREEK

Located in the Town of Pelham and the City of Thorold, the Upper Twelve Mile Creek subwatershed contains the headwaters of Twelve Mile Creek. The Twelve Mile Creek headwaters form a complex incised series of valleys in the Fonthill Kame-Delta Complex. This Short Hills area contains the St. John's and Effingham branches, which originate within the headwaters of the creek. They are the only identified cold water streams within the Niagara Region, and they contain naturally reproducing brook and brown trout populations. However, it is possible that the self-sustaining Brown Trout population, which was introduced to the watershed, competes with brook trout habitat and food (Frohlich Personal Communication).

This subwatershed also contains the highest percentage of natural areas in the watershed including Environmentally Sensitive Areas (ESAs), Areas of Natural and Scientific Interest (ANSIs), and Short Hills Provincial Park. The abundance of forested natural areas in this subwatershed has attracted several provincially and regionally rare bird species to the area (e.g., Hooded Warblers and Acadian Flycatcher) (Cheskey 2003), which adds to the natural character of this portion of the watershed.

LAKE GIBSON SYSTEM

Owned by Ontario Power Generation, the Lake Gibson System is a human-made arrangement of reservoirs located primarily in the City of Thorold. This system was created as a result of the DeCew Power Station by the Cataract Power Company of Hamilton in 1898. Water was diverted from Lake Erie via the Welland Canal by the construction of a 7.6 kilometre canal to the Niagara Escarpment just east of DeCew Falls. This constructed canal is called the Power Canal and it is now used to supply water for the DeCew Waterworks, which supplies drinking water to the City of St. Catharines. The DeCew Power Station expanded in 1904 leading to the creation of Lakes Moodie and Gibson. The DeCew Power Station was expanded again in 1947 resulting in the enlargement of Lakes Moodie and Gibson, and the excavation of 3 major channels including an intake channel from the Third Welland Canal north of Allanburg, an equalization channel between the 2 arms of Lake Gibson, and an outflow channel from Lake Moodie to the new penstocks (Hughes Personal Communication).

RICHARDSON CREEK

The Richardson Creek subwatershed is located primarily in the City of St. Catharines. Flowing south to north, Richardson Creek flows through rural and agricultural areas and it meanders north through a wooded and well defined valley before emptying into Martindale Pond. The Green Ribbon Trail is also located at the mouth of Richardson Creek. The length of the main channel of Richardson Creek is approximately 10.5 kilometres.

FRANCIS CREEK

The Francis Creek subwatershed is located in the City of St. Catharines. Francis Creek flows south to north for approximately 6 kilometres through residential areas and valley corridors before meeting Richardson Creek just south of the Queen Elizabeth Way.

In 1983 a large storm channel was proposed to divert floodwaters based on the 100-year flood (Proctor and Redfern Limited 1983). The storm channel was constructed in 3 phases from 1986 through 1988. The channel is approximately 4 metres wide and it runs from Roland Street near Westdale Drive in the City of St. Catharines to Highway 406 where it meets up with the original channel of Francis Creek.

DICKS CREEK

The Dicks Creek subwatershed is located primarily in the City of St. Catharines. Dicks Creek flows through urban areas and the St. Catharines Golf and Country Club before meeting up with the Old Welland Canal. The Old Welland Canal is diverted underground at the Welland Ship Canal and it emerges at Chestnut Street in St. Catharines. It flows parallel to Oakdale Avenue before it is channelled underground to Highway 406. It reappears at Glenridge Avenue and Westchester Crescent where it empties into Twelve Mile Creek (Marshall Macklin Monaghan 1996).

LOWER TWELVE MILE CREEK

The Lower Twelve Mile Creek subwatershed is located in the City of St. Catharines. The lower portion of Twelve Mile Creek has been totally reconstructed. The creek was originally modified as part of the Welland Canal in the 19th Century. The creek was then enlarged to accommodate the tailwater flow from the DeCew Generating Station. Land use in this portion of the watershed is primarily urban with the exception of Martindale Pond. However, the creek has a natural vegetation buffer along its course to Martindale Pond.

Martindale Pond is located in the Lower Twelve Mile Creek subwatershed. The Pond was used as part of the Old Welland Canal system from 1820 until 1932, and for access to a former drydock into the early 1960s. Currently, Martindale Pond acts as an on-line sediment basin that traps material moving between Twelve Mile Creek before it drains into Lake Ontario. The Pond has also been used for rowing since the late 1800s and dredging of the pond has been carried out in 1930 (53,500 cubic metres), in 1966 (180,000 cubic metres), and again in 1997 (110,000 cubic metres). Water levels in the pond are controlled by the St. Catharines Hydro-electric Commission's Heywood Generating Station at Port Dalhousie. The Martindale/Barnesdale provincially significant wetlands are also located in Martindale Pond.

TOPOGRAPHY

The upper portion of the Twelve Mile Creek watershed is characterized by deeply eroded gullies due to the multi-branched pattern of the headwaters of Twelve Mile Creek. The lower portion of the watershed below the Niagara Escarpment is generally flat and typical of valleys found within the Niagara Peninsula (NPCA 2002). Twelve Mile Creek outlets to Lake Ontario through Martindale Pond in Port Dalhousie. The topography of the watershed is illustrated on **Figure 2.**

SURFICIAL GEOLOGY

Above the Niagara Escarpment, the watershed is comprised of stratified clay, silt and sand associated with the Fonthill Kame-Delta Complex and Short Hills development. Below the escarpment, the watershed is dominated by Halton Till deposits made up of silt and clay **(Figure 3).**

FONTHILL KAME-DELTA COMPLEX

The Fonthill Kame-Delta Complex formed along the edges of a re-entrant ice front at the edge of Lake Warren approximately 12,000 years ago. Considerable melting of the glacier that blanketed the area at this time deposited large amounts of outwash sand and gravels into Lake Warren. The complex evolved as Lake Warren shrank toward the Lake Erie basin and developed a large ice marginal delta with gently sloping flanks to the south and steep sloping ice contact faces on the north. Subsequent glacial and post glacial lake stages modified the surface of the Fonthill Kame-Delta Complex, which is evidenced by raised shoreline features between 240 and 260 metres. The Fonthill Kame-Delta Complex is the highest point of land within the Niagara Peninsula, and it is the only place in the Peninsula where the raised shorelines occur.

THE SHORT HILLS

Approximately, 12,900 years ago during the Wisconsin Ice Age, an ice front reached a point where Fonthill is today. South of the Fonthill area the land was flooded by Lake Warren. The ice continued to melt and created 2 more lakes referred to as Lakes Grassmere and Lundy. These lakes flooded the Short Hills area about 12,800-12,700 years ago. Sand, gravel and clay were distributed over the landscape from the lakes and a pre-existing river gorge was completely buried to an elevation of approximately 150 metres above sea level (Friends of Short Hills Park 2000).

The ice front retreated into the Lake Ontario Basin approximately 12,500 years ago, which flooded the land almost to the base of the Niagara Escarpment. This glacial feature is referred to as Lake Iroquois. The pre-glacial river system did not re-establish itself because the ice had deepened and flooded parts of it. Instead, a dendritic drainage pattern flowing from south to north developed in the Short Hills area. In the buried gorge these newly formed streams cut into the deposited sand, gravel and clay, which were carried downstream into the lake. About 11,900 years ago Lake Iroquois drained the area referred to as early Lake Ontario. This changed the gradients of all streams flowing northward, and vast quantities of material were removed from the buried gorge by the flowing waters. V-shaped valleys were cut into the post-glacial sediments by these flowing waters, and the remnants of the upper surface are what we refer to the as the Short Hills (Friends of Short Hills Park 2000).

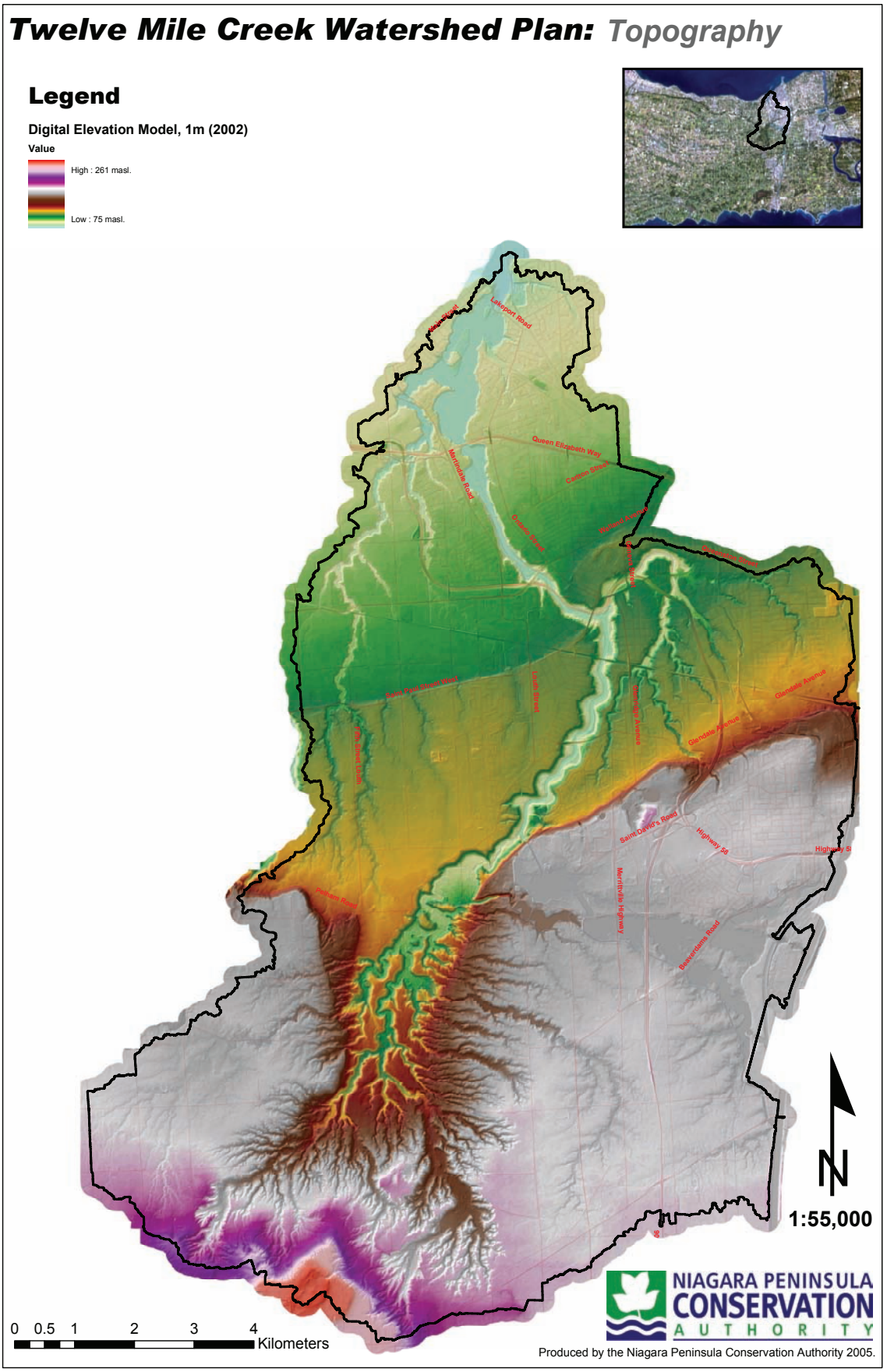


FIGURE 2: TOPOGRAPHY OF THE TWELVE MILE CREEK WATERSHED

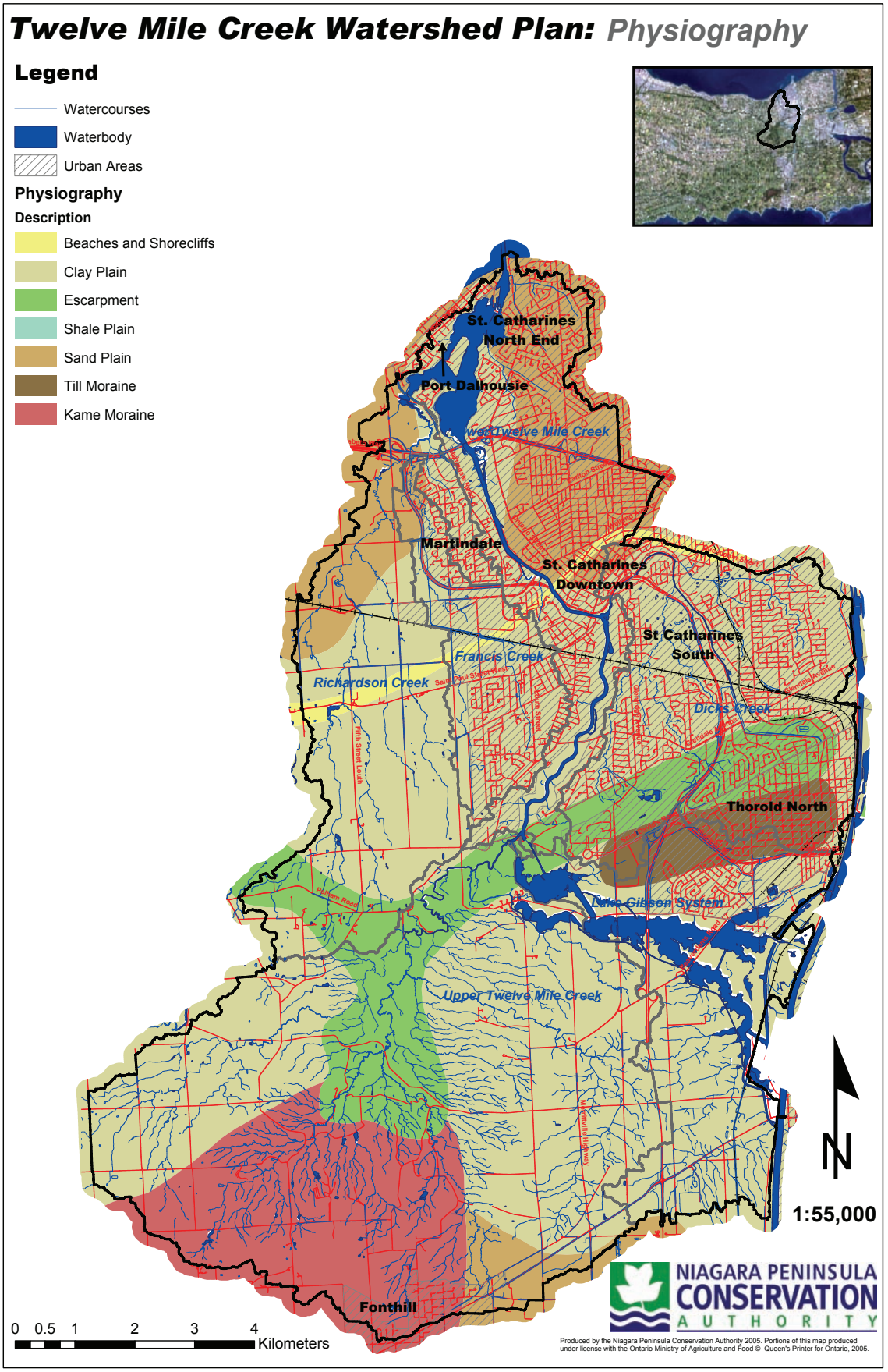


FIGURE 3: PHYSIOGRAPHY OF THE TWELVE MILE CREEK WATERSHED

SOILS

The soils in the Niagara Region were resurveyed and documented in a report entitled The Soils of Regional Niagara (1989) by the Ontario Ministry of Agriculture and Food and Agriculture Canada. This study included geological and physiological features; soil groups and types; soil moisture characteristics; drainage and variability; common properties of soil groups; as well as information related to agricultural soil use and classification. The following soil descriptions and associated map **(Figure 4)** are derived primarily from this document. In the upper portion of the watershed, located above the Niagara Escarpment, the soils are representative of the Fonthill and Ridgeville groups, which are comprised of mainly reddish-hued coarse sandy loam and gravely sand soils. Fonthill soils tend to be rapidly drained and rapidly permeable thereby reducing their water holding capacity. These soils are best suited for grape and fruit tree production. Fonthill soils can grade into Ridgeville soils which are imperfectly drained and often found in depressions. The most common textures of Ridgeville soils are coarse sandy loam and gravely loamy coarse sand. These soils have low fertility values. However, due to their location in the fruit growing area of the Fonthill Kame-Delta Complex, they are used almost exclusively for fruit crops.

Mainly lacustrine very fine sandy loam, loamy sand, and sand encircle the Fonthill and Ridgeville soil groups. These soils are from the Grimsby, Vineland, Flamborough, Fox, Brady and Granby soil groups, which also extend into the lower portion of the watershed below the Escarpment. These soils are prime soils for tender fruit crops. However, like most sandy soils they require irrigation. The Vineland soils group is also found in this section of the watershed. Vineland soils are imperfectly drained and moderately to rapidly permeable. The predominant texture associated with this soil type is very fine sandy loam. Vineland soils are suitable for most agricultural crops, but in the Niagara Region they are commonly used for growing fruit crops.

Flamborough soils are found above and below the Niagara Escarpment in the watershed. If tile drained, these soils are suitable for most agricultural crops, and are commonly used for small fruits below the Niagara Escarpment. Fox soils, also found here, are rapidly drained and rapidly permeable making them susceptible to drought conditions. Fox soils tend to grade into imperfectly drained Brady soils or into well-drained Grimsby soils in depressions. Fox soils are almost always used for fruit crops such as sweet cherries. The Brady soils group are imperfectly drained due to groundwater levels that usually rise into subsoil horizons during the winter and spring. Brady soils are commonly used for growing fruit crops below the Escarpment. These soils often merge with Granby soils in low areas. Textures of loamy sand or sandy loam usually dominate this soil group, and artificial drainage is required to grow crops in these sandy soils.

Some of the soils described above extend into the lower portion of the watershed below the Escarpment. However, the following soil groups are found primarily below the Escarpment including soils from the Brantford, Beverly and Toledo groups, which are mainly composed of lacustrine heavy clay. Brantford soils are moderately well-drained and are usually used for field crops in the Niagara Region. Beverly soils are imperfectly drained with groundwater occupying the surface horizons of the soil for a period of time each year. Composed of silty clay textures, Beverly soils are used near the Niagara Escarpment for hardier fruits such as grapes, apples and pears. Toledo soils are also poorly drained soils with a silty clay loam texture. With proper drainage Toledo soils are suitable for grapes, small fruits, hardy tree fruits and most vegetable crops.

The Cashel, Peel and Malton soil groups are also located below the Escarpment in the watershed. These soil groups are characterized by 40 to 100 centimetres of lacustrine silty clay over clay loam till. These soils require drainage and are commonly used for grape production in areas adjacent to the Niagara Escarpment. Sections of the watershed are also comprised of mainly clay loam till of the Oneida, Chinguacousy and Jeddo soils groups. These soils are moderately well-drained, and in the vicinity of the Niagara Escarpment they are commonly used to grow grapes, pears and apples, especially on the coarse, loamy and washed soil phases.

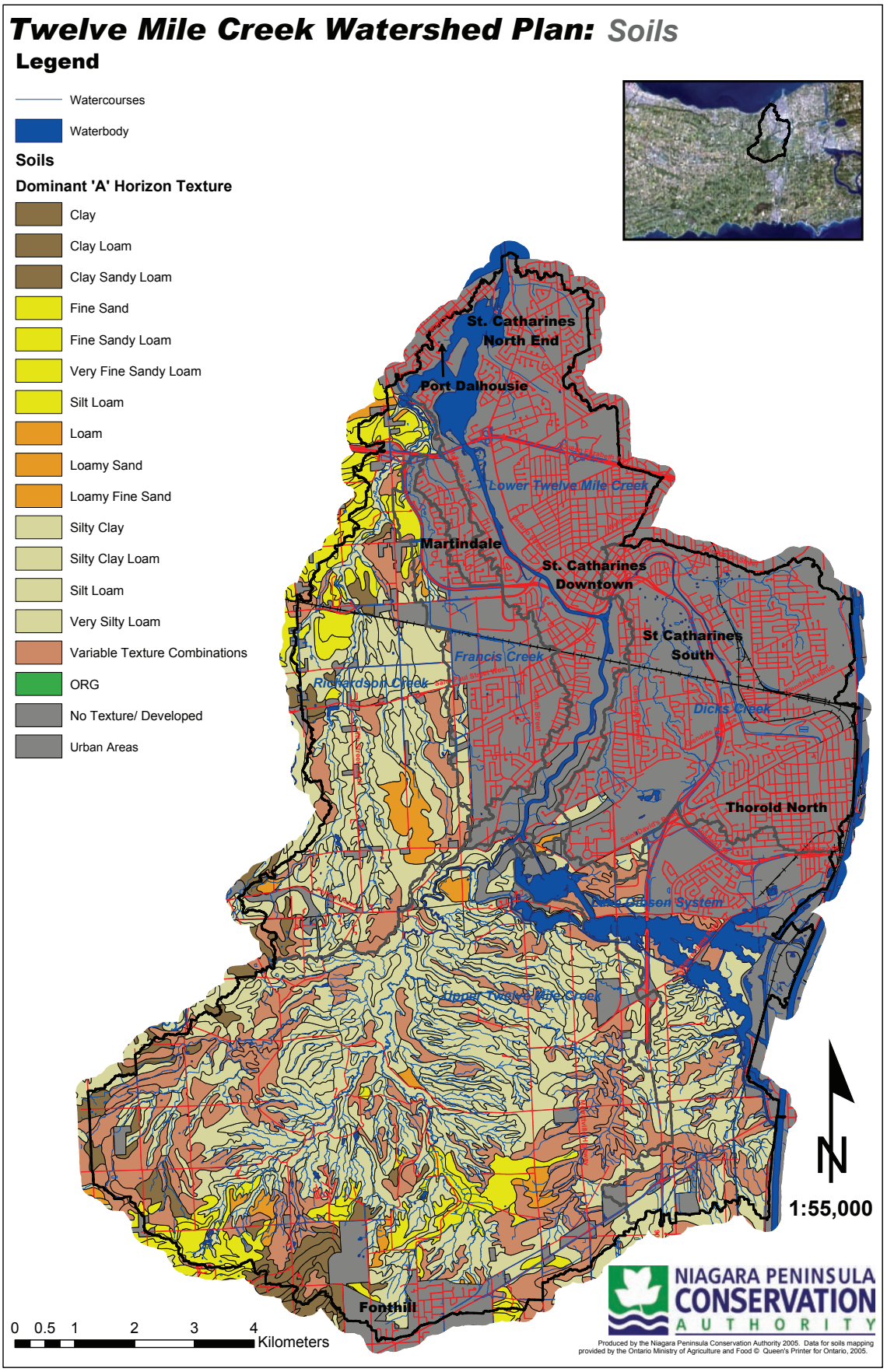


FIGURE 4: SOILS OF THE TWELVE MILE CREEK WATERSHED

LAND USE

The Town of Pelham occupies approximately 20 percent of the watershed. Thirty-three percent of the watershed lies within the City of Thorold. Approximately 46 percent of the watershed lies in the City of St. Catharines, and only a small portion (less than 1 percent) of the watershed lies in the Town of Lincoln. Land use for the Twelve Mile Creek watershed is depicted on **Figure 5**, which has been derived from Official Plan mapping.

In general, the upper portions of the Twelve Mile Creek watershed are characterized by a series of valleys that make up the Short Hills Valley in the Fonthill Kame-Delta Complex. The steep incised valleys of this complex landscape have largely forested slopes and ridges. Numerous tributaries of Twelve Mile Creek flow out of the Fonthill Kame-Delta Complex, forming steep valleys. As a result of this rugged landscape many natural areas remain in this portion of the watershed. For example, Short Hills Provincial Park, St. Johns Conservation Area, and the Lake Gibson wetland complex including Mel Swart Park are located here.

The Lake Gibson system is located above the Niagara Escarpment. This area was first developed for hydroelectricity in 1898, and later expanded in the 1940s. Water for power generation at the DeCew Generating Station is diverted from Lake Erie through a 7.6 kilometre canal from the Welland Ship Canal into Lakes Gibson and Moodie. Some small residential areas in the Town of Pelham including a portion of the Fonthill urban area are also located in the upper portion of the Twelve Mile Creek watershed.

For the most part, the lower portion of the watershed has been developed and includes the western portion of the City of St. Catharines urban area. In addition, the areas along Lake Ontario are significantly developed for non-agricultural uses as are areas adjacent to the northern boundary of Short Hills Provincial Park (*NWQPS* 2003). Despite considerable development in this portion of the watershed, Twelve Mile Creek is buffered by a natural corridor along its length. Numerous parklands are adjacent to the Twelve Mile Creek system including the Waterfront Trail. The lower portion of the watershed also contains the Barnesdale and Martindale provincially significant wetland. Other land uses in this section of the watershed include the Henley Regatta Rowing Course, Port Dalhousie Park, and the Lakeside Beach and Yacht Club.

Agriculture is also a prominent land use in the Twelve Mile Creek watershed. Agriculture in the watershed consists mostly of fruit, grain and oilseed, and miscellaneous speciality crops including sheep and lamb, horse and pony, greenhouse, nursery product, and sod. *The Regional Agricultural Economic Impact Study* (2003) ranked the top 12 agricultural commodity groups in Niagara (based on 2001 Statistics Canada data). The majority of fruit crops are concentrated in St. Catharines and Pelham. Pelham also has the greatest concentration of grain and oilseed crop, poultry and egg, and cattle operations in the watershed. Above the Escarpment agriculture is predominately grain and oilseed production with some cattle and greenhouse productions. Vineyards and orchards are also located in this portion of the watershed. Greenhouse production, nursery, and fruit crops are the main agricultural commodities located in the lower portion of the watershed below the Escarpment primarily in the Richardson Creek and Francis Creek subwatersheds.

Recreational land uses above the Niagara Escarpment include nature appreciation and hiking in Short Hills Provincial Park, and St. Johns Conservation Area. In addition, the Bruce Trail traverses the Twelve Mile Creek watershed along the Niagara Escarpment. Private recreational uses in this portion of the watershed include Lookout Point Golf and Country Club, Brock Golfland, and Bissell's Hideaway Campground (NWQPS 2003). Below the Escarpment, the Henley Regatta Rowing Course is located in Martindale Pond. Port Dalhousie Park and Lakeside Beach and Yacht Club are also situated in this section of the watershed. A portion of Twelve Mile Creek has been identified as a possible site for a white water course for canoe and kayaks (Bergsma 2004). Parklands lie alongside the majority of the banks and shorelines of the Twelve Mile Creek system, and are generally linked to local municipal parks and the Waterfront Trail (*NWQPS* 2003).

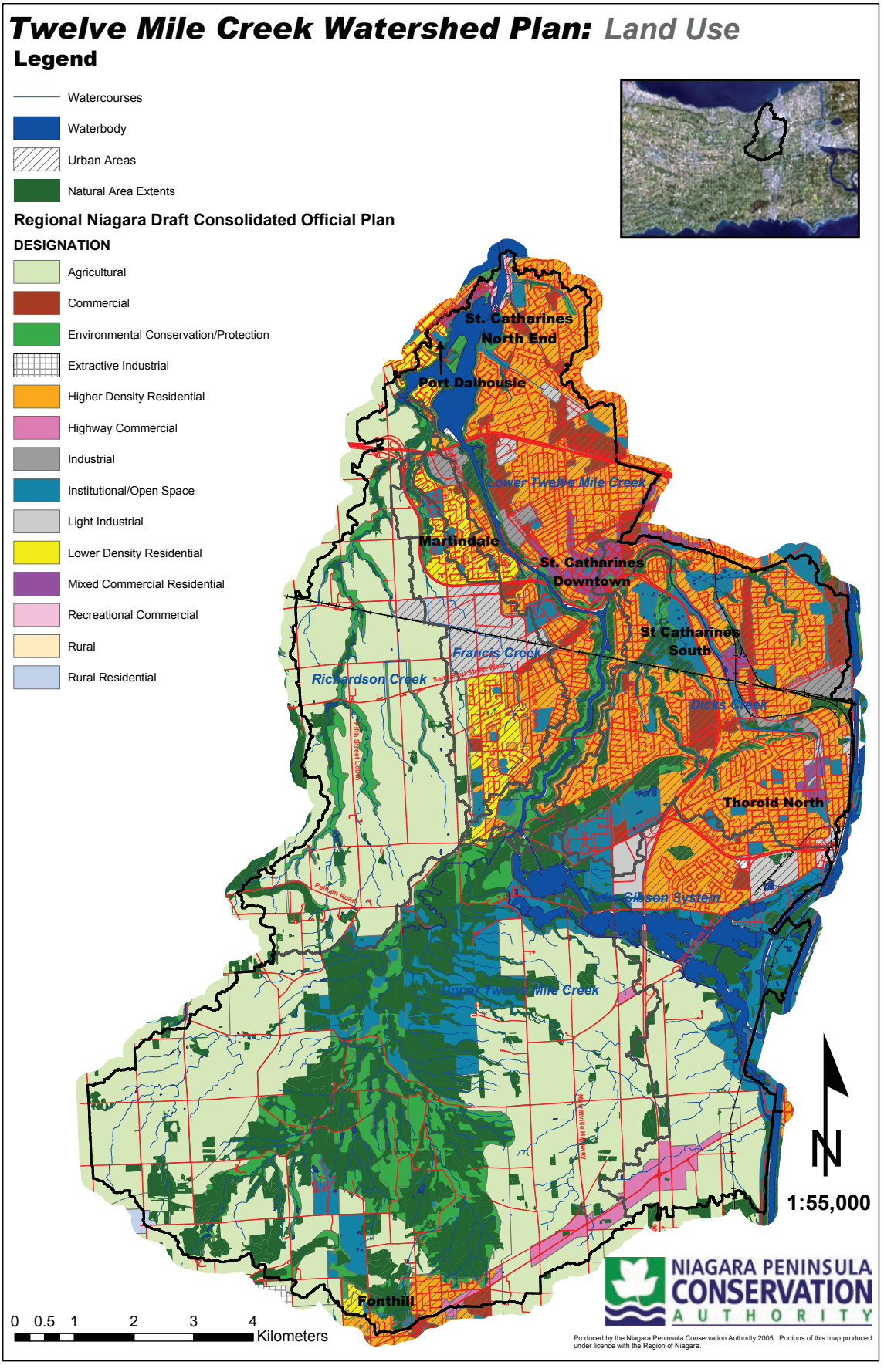


FIGURE 5: LAND USE IN THE TWELVE MILE CREEK WATERSHED

NATURAL HERITAGE CHARACTERIZATION

The NWQPS (2003) calculated the percentage of terrestrial natural areas in each Land Management Area (LMA) **(Table 1).** Results for both LMA 1.6 and 1.7, which make up the Twelve Mile Creek watershed, indicate that low total wetland areas exist in both of the study areas, with a high percentage of forested areas occurring in LMA 1.7. The amount of protected land is considered high in both LMA 1.6 and 1.7, with almost 52 percent of the land base protected in LMA 1.7, which is very high for this portion of the Twelve Mile Creek watershed.

All of the natural heritage areas including wetlands, woodlots, Areas of Natural and Scientific Interest and Environmentally Sensitive/Significant Areas are illustrated on **Figure 6.** This information was compiled as a joint initiative by the Ministry of Natural Resources, Regional Municipality of Niagara, and the Niagara Peninsula Conservation Authority. A description of these areas follows.

NATURAL HERITAGE	LMA 1.6	LMA 1.7
OPEN WETLAND	0.7	0.4
WETLAND FOREST	0.3	0.6
MIXED WETLAND/LOWLAND FOREST	0.4	1.3
MOIST/DRY FOREST	6.7	25.2
TOTAL FOREST	7.4	27.0
TOTAL WETLAND	1.2	1.0
PROTECTED LAND	15.2	51.9

TABLE 1: NATURAL AREAS BY LAND MANAGEMENT UNIT (%) DERIVED FROM NWQPS, 2003)

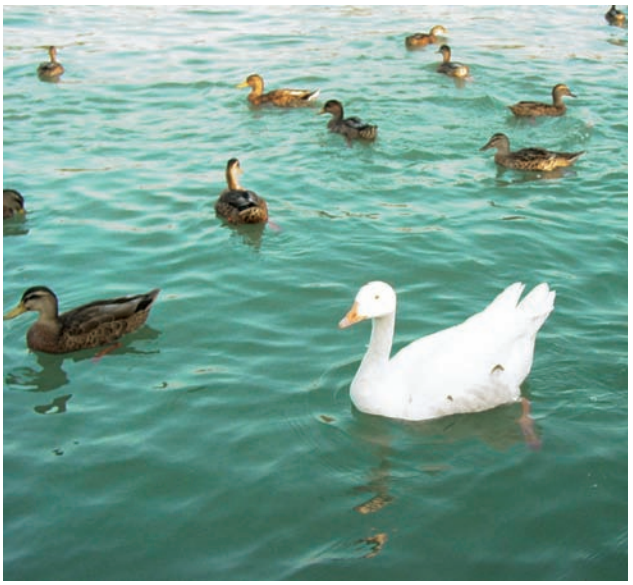
WETLANDS

The Ontario Wetland Evaluation System designates wetlands as "provincially significant" or "locally significant". The *NWQPS* (2003) has mapped wetland areas in the Twelve Mile Creek watershed as provincially significant evaluated wetlands and locally significant evaluated wetlands. Approximately 107 hectares of the 11,190 hectares of land area in the Twelve Mile Creek watershed is evaluated as wetlands.

A total of 3 wetland complexes have been evaluated in the watershed by the Ministry of Natural Resources **(Table 2).** These wetlands have been designated as provincially significant including the Martindale/ Barnesdale Marsh (last evaluated in 1998), Lake Gibson/Moodie wetland (last evaluated in 1985), and the Twelve Mile Creek Wetland Complex (last evaluated in 2004).

The SHORT HILLS WILDERNESS AREA wetland is located in Pelham and is included in the Twelve Mile Creek Wetland Complex. This 14 hectare wetland is comprised of 70 percent swamp and 30 percent marsh. Regionally significant flora found in this wetland includes Broad-leaved Waterleaf, Tulip Tree, Stone-root, and American Columbo.

HURTLEBURT'S WOODS is located in Pelham and it also forms part of the Twelve Mile Creek Wetland Complex. The wetland at this site is comprised of a combination of 97 percent swamp and 3 percent marsh. Ten to 50 percent of the wetland area has mature trees Including the provincially significant Cucumber Tree and Flowering Dogwood.



The LAKE GIBSON/LAKE MOODIE wetland complex is located in Thorold. Covering approximately 63 hectares, this wetland complex is the largest in the Twelve Mile Creek watershed. The wetland at this site is comprised of a combination of 97 percent marsh and 3 percent swamp. The American Bittern and Virginia Rail, 2 regionally significant bird species have also been recorded at this wetland. The Bruce Trail runs through this area and this area is also used for hunting and canoeing.

The BARNESDALE AND MARTINDALE wetlands are located within the city limits of St. Catharines in the northern section of the Twelve Mile Creek watershed. The wetlands cover 55.1 hectares with 76 to 95 percent open water surrounded by peripheral vegetation. The wetland area consists of 100 percent marsh. The provincially significant Tulip Tree is located here. The Barnesdale and Martindale wetlands are part of Martindale Pond. The wetland is most extensive in the southwestern corner of Martindale Pond where it covers the entire mouth of Richardson Creek and a bay located immediately downstream of the Queen Elizabeth Way. Water flow diversions from the Lake Gibson System account for the vast majority of water flow into Martindale Pond. Yagi (1998) estimates that only 1 percent of the flow into Martindale Pond belongs to the upper Twelve Mile Creek System. Water levels in the pond are maintained within an average daily fluctuation regime of 0.5 metres for hydro generation at the Heywood Generating Station.

WETLAND	LOCATION	SIZE (HECTARES)
Twelve Mile Creek Wetland Complex including:		
• Short Hills Wilderness Area	Pelham	14
• De Cew Falls Floodplain	Thorold	2.9
• Hurtleburt's Woods	Pelham	0.64
• Lake Gibson / Moodie	Thorold	62.9
• Martindale / Barnsdale Marsh	St. Catharines	55.1

TABLE 2: WETLANDS IN THE TWELVE MILE CREEK WATERSHED

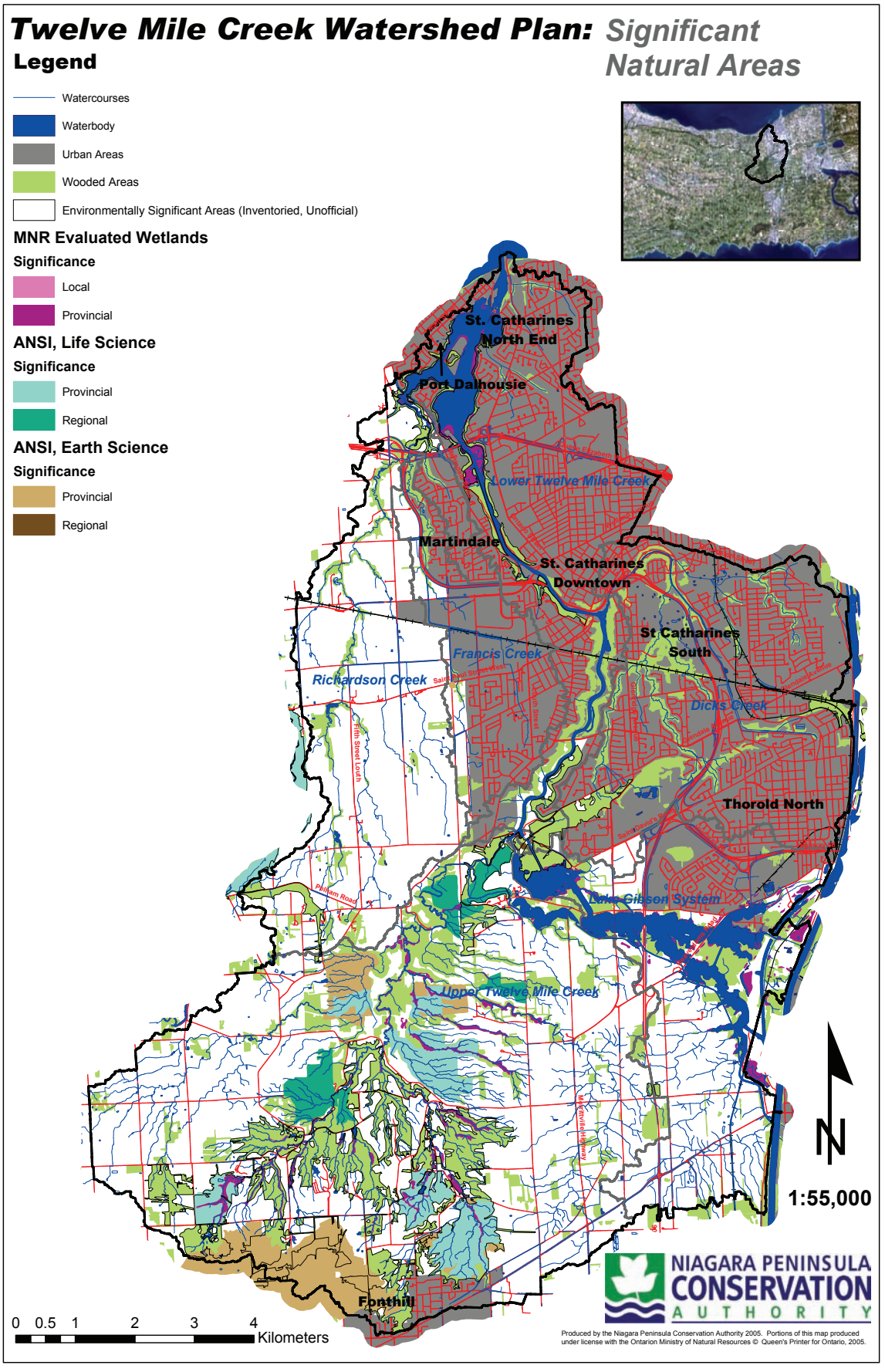


FIGURE 6: NATURAL HERITAGE AREAS IN THE TWELVE MILE CREEK WATERSHED

WOODLANDS

Several sites in the watershed contain Areas of Natural and Scientific Interest (ANSI). These are noted below as they relate to the identified environmentally sensitive areas in the watershed. These areas contain higher natural value but are not necessarily protected though land use policy. Woodland areas in the Twelve Mile Creek watershed are summarized in **Table 3** following this section.

In addition, Regional Niagara has proposed a set of criteria for designating their woodlots in its *Regional Policy Plan Amendment 187* (2005). Under OPA 187 a significant woodland must meet one or more of the following criteria:

a) Contain threatened or endangered species or species of concern;

b) In size, be equal to or greater than: 2 hectares, if located within or overlapping Urban Area Boundaries; 4 hectares, if located outside Urban Areas and north of the Niagara Escarpment; 10 hectares, if located outside Urban Areas and south of the Escarpment;

c) Contain interior woodland habitat at least 100 metres in from the woodland boundaries;

d) Contain older growth forest;

e) Overlap or contain one or more of the other significant natural heritage features listed in Policies 7.B.1.3 (provincially significant wetlands; provincially significant Life Science Areas of Natural and Scientific Interest (ANSIs); significant habitat of threatened and endangered species; and within the Greenbelt Natural Heritage System wetlands, significant valleylands, significant woodlands; significant wildlife habitat; habitat of species of concern, publicly owned conservation lands, savannahs and tallgrass prairies, and alvars) or 7.B.1.4 (significant woodlands; significant wildlife habitat; regionally significant Life Science ANSIs; other evaluated wetlands; significant valleylands; and publicly owned conservation lands); or

f) Abut or be crossed by a watercourse or water body and be 2 or more hectares in area.

In addition to the proposed OPA 187, most of the significant forests in the Twelve Mile Creek watershed are protected through the Niagara Escarpment Natural Areas zoning of the *Niagara Escarpment Plan.*

The TWELVE MILE CREEK RE-ENTRANT VALLEY is located on the south western edge of the City of St. Catharines and extends southward from DeCew Falls to the Fonthill Kame-Delta Complex. Two areas have been defined within the ANSI including Short Hills Provincial Park located in Thorold Township and the Fonthill Kame-Delta Complex located in Pelham Township. Short Hills Provincial Park is representative of kame uplands and valley slopes as well as the Niagara Escarpment incised gorge, cliff and talus features. Four sites within the park have been selected to represent these features including the Twelve Mile Creek Valley, Twelve Mile Creek Bottomlands, Swayze Creek (Dry Falls Valley) and Terrace Creek. All but the Twelve Mile Creek Bottomlands, have been classified as a provincial ANSI.

TERRACE CREEK ANSI AND SWAYZE CREEK ANSI

The Terrace Creek and Swayze Creek ANSIs are representative of escarpment incised valleys, seepage cliffs and rich broadleaf talus forests. The dolostone caprock of the escarpment (the Lockport Formation) forms intermittent cliffs, with extensive talus on the valley slopes at these 2 sites. The Swayze Falls site consists of a 100 metre long gorge with a 20 metre high waterfall, and the Terrace Creek gorge extends for 500 metres with a 10 metre waterfall. These ANSI sites are also representative of the Fonthill Kame-Delta Complex uplands and valley slopes that support moist and dry-mesic broadleaf forests.

TWELVE MILE CREEK VALLEY ANSI

The Twelve Mile Creek Valley contains moist broadleaf kame upland and mixed kame valley slope forests as well as moist broadleaf upland forests. This site provides some of the best examples of the mixed Hemlock-Sugar Maple valley forests in this portion of the watershed. Approximately 8 hectares of this ANSI falls outside of Short Hills Provincial Park.

The Fonthill Kame-Delta Complex is a large glacially-formed hill situated at the Twelve Mile Creek re-entrant valley. This glacial feature was formed at the edge of melting glacial ice that deposited large amounts of sand and gravel at its edge. As the ice melted a large glacial lake formed at this site and most of the materials that form the Fonthill Kame-Delta Complex were deposited underwater in the form of a large river delta traversing in a southerly direction from the ice front. These deposits formed a large asymmetrical "V" shape measuring 4.8 kilometres long by 2.4 kilometres wide. The Fonthill Kame-Delta Complex consists of mainly sands and gravels, thereby providing an excellent resource for aggregate operations. Due to its unique size and morphology, this feature has been declared provincially significant.

The DECEW GORGE ANSI is located on the east side of the Short Hills Valley. This regional ANSI includes 1 kilometre of northwest-facing Niagara Escarpment slopes, bottom lands of Twelve Mile Creek, a spectacular gorge incised into the escarpment and, to the south, Fonthill Kame-Delta Complex uplands and valleys.

The steep-sided gorge at this site in the watershed measures 750 metres in length and has a depth over 40 metres. DeCew Falls drops 20 metres at the head of the gorge. The entire site occupies an area of 38 hectares. The gorge has a very diverse and representative vegetation pattern with some rare species present. For example, the slopes are heavily forested with Hemlock, Maple and Oak, and the wide bottomlands contain sugar maple, white elm and black maple. In total, the gorge supports 38 vegetation community types that sustain 292 vascular plant species with many significant species present. The DeCew Gorge is part of a 2 kilometre long escarpment corridor. To the east, the natural corridor is separated from the Sanitorium Hill escarpment corridor in St. Catharines by the penstocks of the Power Glen generating station, which makes it one of the largest forested tracks (900 hectares) in the Niagara Peninsula section of the Niagara Escarpment.

The FONTHILL SAND VALLEYS ANSI are a 102 hectare provincial ANSI located northeast of the Town of Pelham. This site is in both private ownership (70 percent) and owned by the Town of Thorold (30 percent). The forested area is representative of a series of ridges and valleys cut up to 30 metres deep into the Fonthill Kame-Delta Complex and the Short Hills Valley. It provides some of the best examples of kame valley forests and seepage meadow marshes. The well developed slopes in the Fonthill sand valleys contain diverse vegetation communities; many of them restricted in Ontario to the Deciduous Forest

Region or the Carolinian Life Zone. The Fonthill Sand Valleys is also a Carolinian Canada "Signature Site", which means that individuals, community groups, non-profit organizations, and government agencies have been working together to conserve this site (Johnson 2005). In total, this area supports 22 vegetation communities with 354 vascular plant species.

The ST. JOHN'S VALLEY ANSI is a 48 hectare site including the ST. JOHNS CONSERVATION AREA (operated by the NPCA) and some private lands. This site is situated near the top of Short Hills Valley and includes a series of deeply incised ridges with some valleys up to 30 metres deep. The entire site supports 12 vegetation communities and 501 vascular plants. It contains excellent examples of Sugar Maple-Beech kame valley forests and the drier Oak-Hickory kame upland forests. In addition, the main headwaters of Twelve Mile Creek are located here. The St. Johns Conservation Area contains mature stands of Sugar Maple, Oak, Ash and the largest known population of Tulip Trees on the Niagara Peninsula. The 31 hectare conservation area contains numerous interpretive hiking trails and a stocked trout pond that is an extremely popular fishing destination in the watershed.

The NORTH PELHAM VALLEY ANSI is located on the Fonthill Kame-Delta Complex. It is representative of Fonthill Kame-Delta Complex features including the best representation on the Niagara Peninsula section of mature Hemlock and Beech kame valley slope forests. The North Pelham Valley contains the best example of Skunk Cabbage seeps in the watershed, and it has the only example of a highly-calcareous Tamarack treed and open seepage fen on the Niagara Peninsula. The fen is also significant due to its concentration of northern species. Some of the trees date in excess of 150 years old in the North Pelham Valley. Numerous groundwater seeps that provide a significant headwater source for the Twelve Mile Creek also occur at this site in the watershed.

SHORT HILLS PROVINCIAL PARK is a 735 hectare Natural Environment Park (Friends of Short Hills Park 2000). The park is situated near the mouth of the Short Hills Valley, which is a major re-entrant valley cut into the Niagara Escarpment. As a result, the park contains a natural science ANSI due to rock exposures. In addition, the park also contains a life science ANSI due to large stands of Carolinian flora located within the park's boundaries. The park lands are representative of kame uplands and valley slopes, and moderate representation of incised gorge, cliff and talus features associated with the Niagara Escarpment. Four sites in the park are representative of these features. For example, Terrace Creek and Swayze Creek are characteristic of escarpment incised valleys, seepage cliffs and rich broadleaf talus forests. The portion of the Twelve Mile Creek valley located within the park boundary is representative of moist broadleaf kame upland forest, mixed kame valley slope forests, and moist broadleaf upland forests. The Twelve Mile Creek Bottomland is representative of escarpment bottomland terrace and Fonthill Kame-Delta Complex features. The wet mesic slope and bottomland Black Maple, White Elm, White Ash and Black Walnut forests provide some of the best examples of these vegetation community types on the Niagara Peninsula. In total, the park supports 37 vegetation communities with 428 vascular plant species including a high concentration of significant flora.

ST. JOHN'S WOODLOT occurs on the Fonthill Kame-Delta Complex. Several valleys occur at this site that cut 5 to 10 metres deep through the upland areas, which form a series of ridges, valley slopes and seepage rich bottomlands. This natural area provides a good representation of the Fonthill Kame-Delta Complex upland and valley features including representation of mature broadleaf forests and Skunk Cabbage seeps. Five community types are found in this woodlot, which sustains 93 vascular plant species.

EFFINGHAM FOREST is located on the Fonthill Kame-Delta Complex. This site consists of several east-west trending valleys along the western portion of the site. The eastern portion of the site contains numerous north trending valleys cut up to 15 metres in depth, which can be seen along Sulphur Springs Road. This site provides an example of Fonthill Kame-Delta Complex upland and valley features, with a good representation of moist broadleaf and mixed forests, as well as drier broadleaf forests including Sugar Maple – Beech forests and a large number of Tulip Trees. Like many of the other natural areas in the watershed, this site has also been classified as an Area of Natural and Scientific Interest due to the Fonthill Kame-Delta Complex feature. In addition to containing the headwaters of Twelve Mile Creek, this site supports 12 vegetation communities consisting of 192 vascular plant species and a high concentration of significant flora.

SITE	GEOGRAPHIC LOCATION	SIZE (HECTARES)
North Pelham Valley	Pelham	44
St. John's Valley	Pelham and Thorold	48
Fonthill Sandhill Valleys	Thorold	102
Effingham Forest	Pelham	75
St. John's Woodlot	Pelham	9
DeCew Gorge and Falls	St. Catharines	38
Short Hills Provincial Park	Pelham, St. Catharines and Thorold	735 (total)
• Twelve Mile Creek		100
• Swayze Creek		19
• Terrace Creek		25
• Twelve Mile Creek Bottomlands		32

TABLE 3: WOODLANDS IN THE TWELVE MILE CREEK WATERSHED

WATER QUALITY

Surface water quality is monitored in Twelve Mile Creek through several programs. The Friends of Twelve Mile Creek created a water quality monitoring program in 1997. In 2001 the monitoring program was transferred to the NPCA Water Quality Program, which continues to monitor the 8 stations (TW001-008) set up by the Friends of Twelve Mile Creek using a combination of grab sampling and benthic macroinverterbrate sampling **(Figure 7).**

The NPCA monitors stations TW005 and TW006 in partnership with the Ministry of the Environment (MOE) as part of the Provincial Water Quality Monitoring Network (PWQMN) whereby the NPCA staff collects the water samples and the MOE provides analytical services through their environmental laboratory. TW005 and TW006 are located at the outlets of the St. John's tributary and Effingham tributary. Monthly PWQMN grab samples are collected during the ice-free season and are analyzed for nutrients, metals and general chemistry. Analysis of the data collected to date indicates that water quality at stations TW005 and TW006 routinely exceeds the Provincial Water Quality Objective (PWQO) of 0.03 mg/L for total phosphorus (Michaud Personal Communication).

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

BioMAP samples have been collected by the NPCA in the Twelve Mile Creek watershed since 1997. Several stations have been sampled in the watershed throughout this time period. However, not all stations are monitored annually. For example, TW001, TW003, TW004 and TW008 are sampled as needed to monitor water conditions resulting from specific land uses such as golf courses, landfills, or agriculture. Past results for TW001 indicate impaired water quality; TW003 was identified as falling within a grey zone (not able to determine quality); TW004 reported unimpaired water quality; and TW008 reported impaired water quality. These benthic macroinvertebrate monitoring stations will continue to be monitored on an as needed basis by the NPCA. Stations TW005 and TW006 were sampled in 2004 and will continue to be monitored annually (Diamond Personal Communication). BioMAP samples collected from stations TW005 and TW006 indicate that water quality is unimpaired.

The City of St. Catharines also collects surface water quality data from Twelve Mile Creek. This data is collected in partnership with the MOE as part of the PWQMN. A total of 42 parameters are collected, which include a wide range of chemical and biological parameters. Most of the parameters meet the provincial guidelines. However, pH, aluminium and iron levels are frequently elevated. It is suspected that these elevated parameters are caused by natural processes. For example, Twelve Mile Creek traverses the Niagara Escarpment (limestone), which can elevate these parameters. Like the results from the NPCA surface water quality program, total phosphorus levels are also elevated (Green Personal Communication).

Wet weather, high peak flows and contamination has also been expressed as a concern for Twelve Mile Creek by the City of St. Catharines (Green Personal Communication). In order to combat elevated levels of bacteria after storm events, the City of St. Catharines is completing 9 combined sewer outflow projects over the next 1.5 years. These projects will include, for example, storage tanks and an increase in pipe size to accommodate a 2 year storm event. The majority of these projects will affect the Twelve Mile Creek watershed (Green Personal Communication).

Results from the NPCA Twelve Mile Creek surface water quality monitoring stations TW005 and TW006 are recorded in **Table 4.**

STATION ID	LOCATION	RATIONALE	WATER QUALITY SUMMARY
TW005	Town of Pelham	Upper Headwater Tributary	Total Phosphorus in exceedance of PWQO Unimpaired BioMAP rating
TW006	Town of Pelham	Upper Headwater Tributary	Total Phosphorus in exceedance of PWQO Unimpaired BioMAP rating

TABLE 4: SUMMARY OF NPCA SURFACE WATER MONITORING STATIONS IN THE TWELVE MILE CREEK WATERSHED

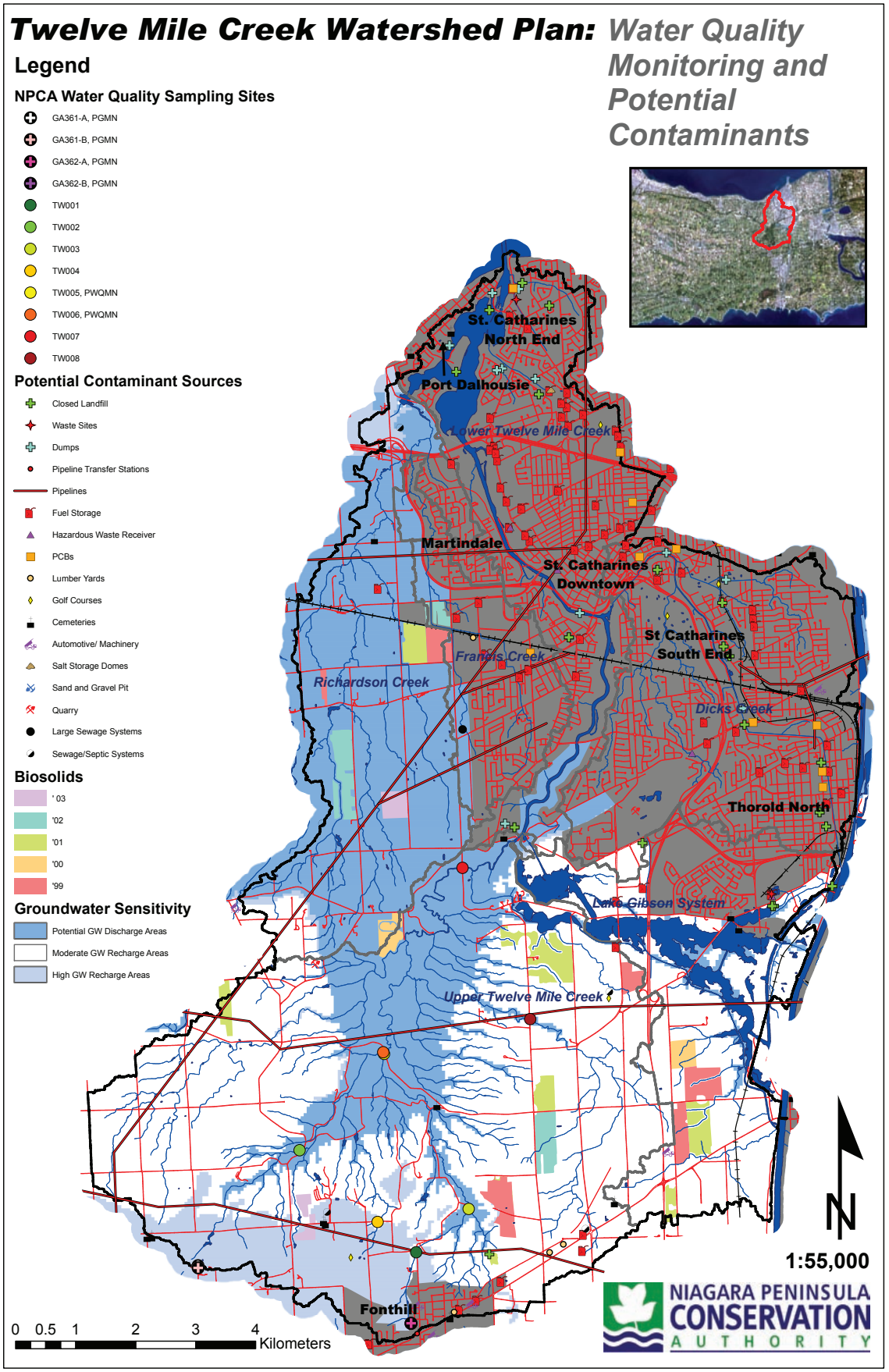


FIGURE 7: WATER QUALITY MONITORING AND RECHARGE AND DISCHARGE AREAS

GROUNDWATER RESOURCES

The NPCA currently monitors 5 groundwater monitoring wells (GA357, GA361A, GA361B, GA362A and GA362B) located throughout the Fonthill Kame-Delta Complex to monitor groundwater levels and quality. These monitoring wells were installed in partnership with the Ministry of the Environment as part of the Provincial Groundwater Monitoring Network (PGMN). All 5 wells are instrumented with dataloggers to record hourly groundwater levels. Results from the first round of water quality samples collected from the wells meet the Ontario Drinking Water Objectives. The first round of samples was analyzed for general chemistry, nutrients, metals, and pesticides as per the PGMN agreement. Eight additional wells have been installed as part of the NPCA Groundwater Study through the Hydrogeologic Assessment of the Fonthill Kame-Delta Complex. NPCA staff anticipates that these wells will eventually become part of the PGMN (Michaud Personal Communication).

A Groundwater Study (2005) has been completed for the land area within the jurisdiction of the NPCA. The study includes a series of maps illustrating recharge/discharge areas, well locations, overburden thickness, bedrock types, groundwater use, contaminant sources, and groundwater susceptibility to contamination.

Potential groundwater recharge and discharge areas are identified on **Figure 7.** Discharge areas are locations where groundwater leaves the aquifer and flows to the surface. Groundwater discharge occurs where the water table (or potentiometric surface) intersects the land surface. Potential discharge areas have been identified in the watershed in the vicinity of Short Hills Provincial Park as well as the remainder of the watershed below the Niagara Escarpment including developed areas. It is important to note, however, that developed areas are no longer acting as groundwater discharge areas due to the degree of impermeable surfaces associated with urban development.

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. A significant potential recharge area is located in the Fonthill Kame-Delta Complex. Water that infiltrates to the water table may carry contaminants with it. Therefore, this area is considered a groundwater sensitive area.

Figure 8 illustrates areas with shallow intrinsic susceptibility. These areas are considered vulnerable to groundwater contamination due to the type of soils and depth of the groundwater table.

AQUATIC HABITAT

Fish habitat falls into 1 of 3 categories in Niagara: Type 1, Type 2 or Type 3, which has been determined by the Ministry of Natural Resources (2000). **(Figure 9).** 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.

Fish habitat type in the Twelve Mile Creek watershed has been delineated for the areas that fall within the Niagara Region according to the Ministry of Natural Resources stream classification data. These areas are depicted on **Figure 9** as critical habitat (Type 1), important habitat (Type 2) and marginal habitat (Type 3). As illustrated, all of Twelve Mile Creek and its tributaries that fall within the jurisdiction of the Niagara Region are classed as critical and important fish habitat.

FISH SPECIES

The Twelve Mile Creek watershed is the only identified coldwater stream in the Niagara Region with a self-sustaining brook trout population. Fish sampling studies conducted by various agencies and organizations in the watershed report 59 fish species occurring throughout the watershed. However, the coldwater system in the upper portion of the watershed makes the Twelve Mile Creek fishery distinct and important in Niagara.

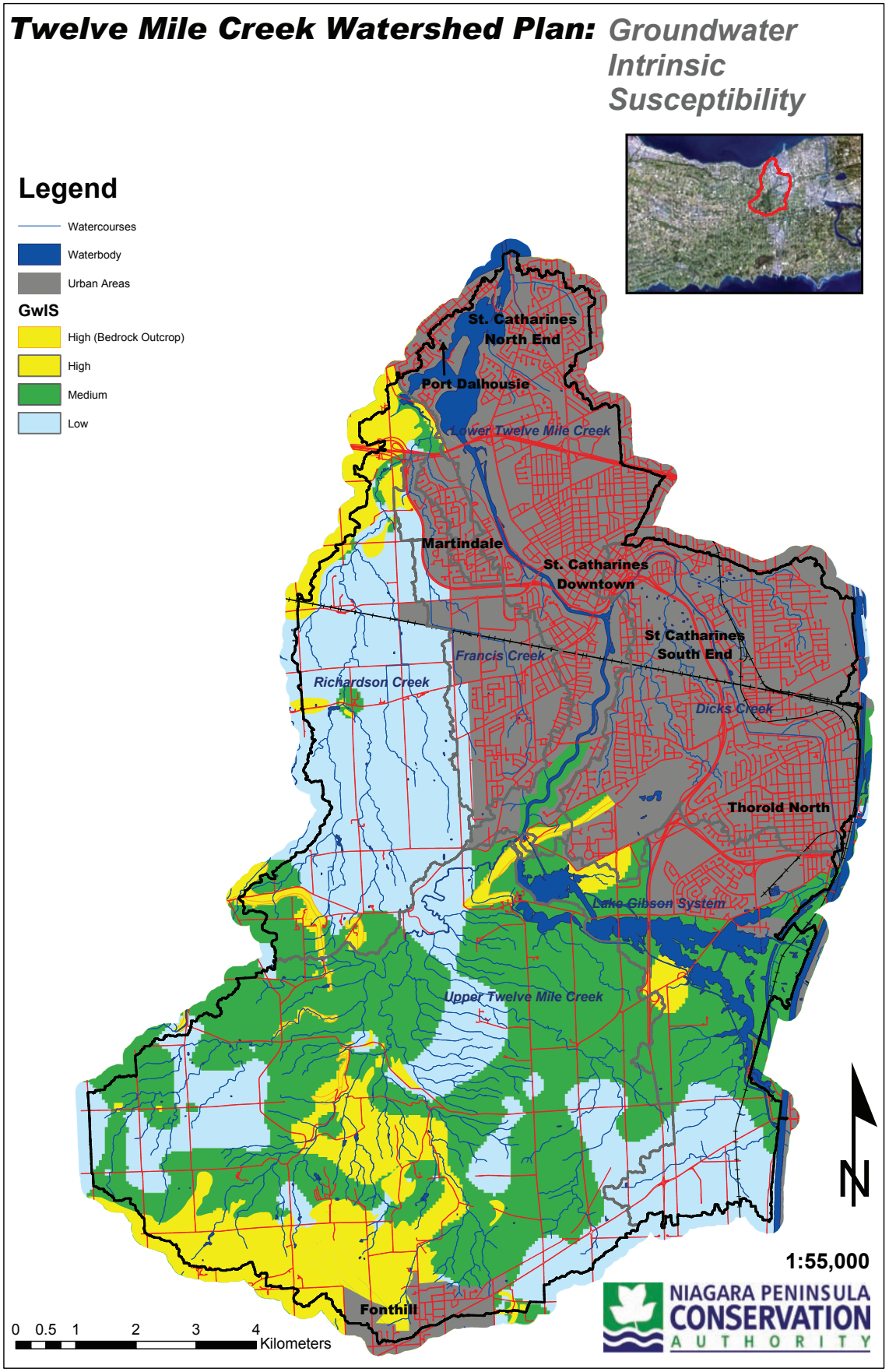


FIGURE 8: GROUNDWATER SUSCEPTIBILITY

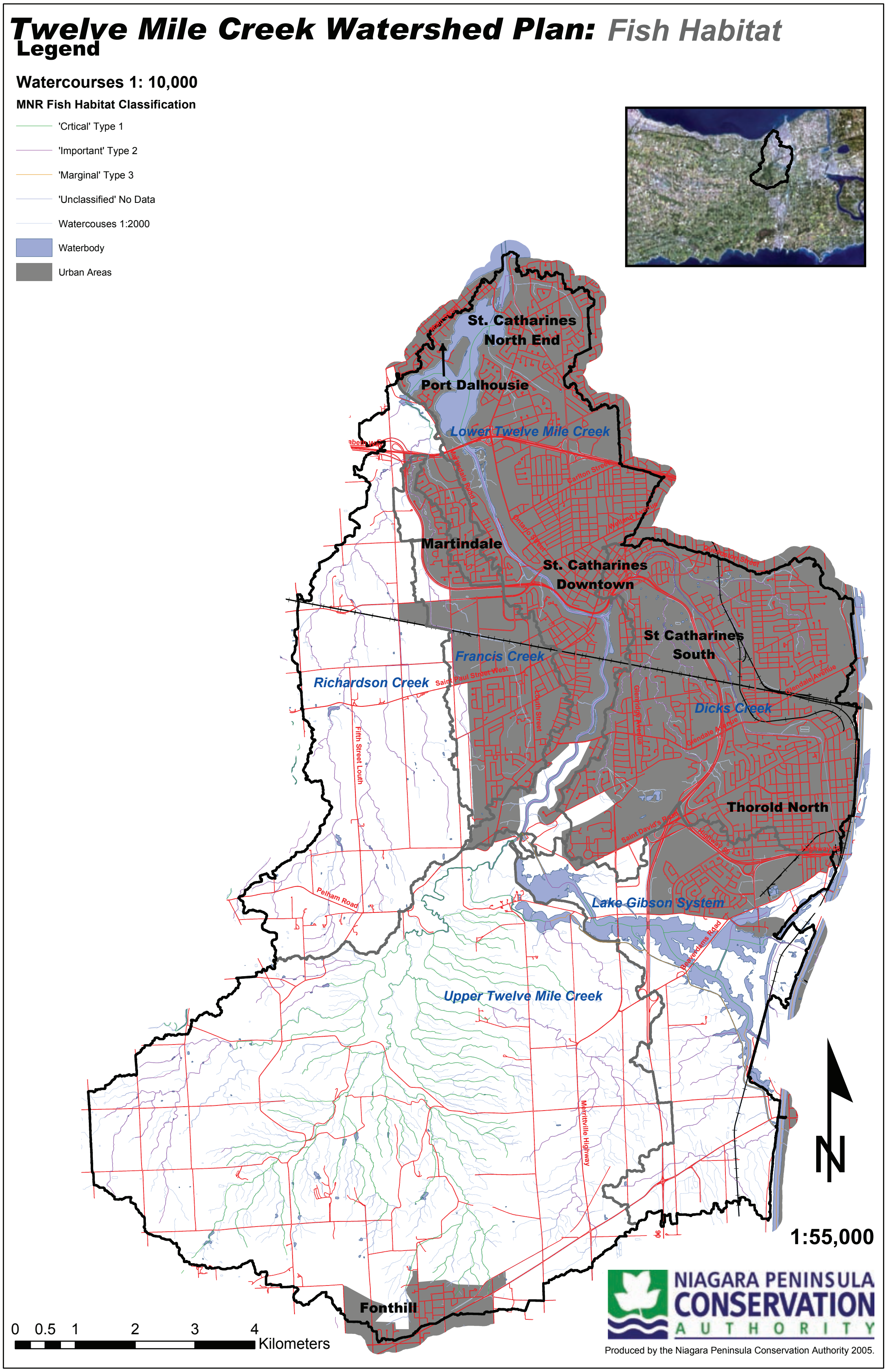


FIGURE 9: FISH HABITAT IN THE TWELVE MILE CREEK WATERSHED

CHALLENGES AND OPPORTUNITIES IN THE TWELVE MILE CREEK WATERSHED

The *NWQPS* (2003) and the *Twelve Mile Creek Watershed Strategy* (2000) summarized a list of key water protection issues. Additional issues have been identified by residents living in the Twelve Mile Creek watershed via public open houses and workshops. A *Land Management and Agricultural Best Management Practice Survey* **(Appendix B)** helped to identify land and water management issues in rural areas of the watershed (Box 1). A description of the challenges facing the Twelve Mile Creek watershed are reported here and specific management strategies are outlined in the watershed strategy included in the following section of this report.

WATER RESOURCES

Healthy watercourses are characterized by stable, naturally vegetated streambanks; good water quality; adequate stormflow and sediment conveyance; consistent baseflow; and native species. Many tributaries in the Twelve Mile Creek watershed are degraded to some degree; in large part to channel erosion and sedimentation. Actively eroding streambanks are a source of sediment and a significant cause of increased turbidity, decreased water quality, and poor aquatic habitat conditions. Erosion along streambanks is exacerbated by urbanization particularly in the upper portion of the watershed.

Numerous water quality problems are associated with urbanization including decreased baseflow, an increase in contaminated runoff, and an increase in the volume and velocity of runoff due to an increase in impervious surface area. The proportion of impervious surface area in an urbanized watershed increases as a result of the loss of natural cover to roads, sidewalks, parking lots and buildings. Urbanization has changed the hydrology and water quality in the Twelve Mile Creek watershed in several ways. The magnitude and frequency of downstream flooding and channel erosion in the upper portion of the watershed has increased. Fewer impacts, in terms of flooding, are experienced downstream in the lower portion of the watershed because Ontario Power Generation controls stream flows for power generation.

Stream degradation can negatively affect property values through the loss of property and increased flooding. In addition, the loss of good quality aquatic habitat for Niagara's only identified self-sustaining brook trout population could also occur without restoration and conservation measures. These issues will be addressed in the watershed strategy as part of this study. The impacts to water quality and quantity in the Twelve Mile Creek watershed are discussed below.

EROSION AND SEDIMENTATION

Increased erosion and sedimentation in watercourses is a result of land use change in the Twelve Mile Creek watershed. Soil erosion from construction sites in the most rapidly developing areas of the watershed is a major concern. Other large sources of sediments include sediment washed off of paved streets and unpaved roads. In addition, high stormwater flows have the

potential to scour soils and destabilize streambanks, thereby carrying bank sediments downstream. Depending on agricultural land management practices, rural areas also present a potential source of sediments. For example, traditional farming practices leave soil bare and tilled at certain times of the year, leaving the soil surface vulnerable to wind and water erosion.

The impacts from erosion and sedimentation are felt economically, ecologically and recreationally in the watershed. For example, sedimentation decreases the aesthetic and ecological quality of a watercourse by way of an increase in turbidity, decrease in light penetration and a subsequent decrease in plant growth resulting in an overall reduction in the quality of aquatic habitat. Increased sediments in streams create sediment islands that block fish migration, and sediment also clogs the gills of fish and aquatic insects. In addition, nutrients and other pollutants can bond with soil particles thereby increasing the detrimental impact of sediments on water resources. Streambank erosion studies have been conducted for the upper portion of the Twelve Mile Creek watershed (NPCA 2005) **(Appendix C)** and the lower portion of the watershed (NPCA 2002). In addition, a *Flood and Erosion Control Study* (1995) was completed for the Juliana, Carter, Secord, Rosedale, Dick's and Francis Creeks. The results of these studies are included in the watershed strategy later in this report.

WATER RESOURCES - WATER QUALITY

- Poor surface and ground water quality
- Lake Gibson/Lake Moodie contamination
- Impacts of road salt and temperature
- Sediment and nutrient inputs including septic systems and fuel tanks
- Review adequacy of historical water quality data
- Total phosphorus in exceedance of PWQOs
- Lack of riparian buffers on tributaries
- Manure and nutrient management
- Stormwater management facilities to treat urban runoff
- Protection of groundwater recharge areas

WATER RESOURCES – WATER QUANTITY

- Water takings for irrigation and the Permit to Take Water Program

FISH AND AQUATIC HABITAT

- Protection and improvement of critical fish habitat
- Impacts of urbanization on fish habitat
- Impact of invasive species on native fish populations
- Removal of fish barriers (e.g., log jams) including barriers to the Lake Gibson System
- Accuracy and compliance of fish habitat classification
- St. Johns Pond – island for shade

NATURAL HERITAGE AND RESOURCES

- Lack of wetlands for water protection
- Impact of invasive species
- Preserve and enhance exiting wetlands and terrestrial habitat in the watershed
- Preserve species diversity and species at risk

URBAN DEVELOPMENT

- Investigate impacts from quarries and golf courses
- Investigate and implement the use of non-point source BMPs such as grassed swales and wetland creation in urban areas
- Combined sewer overflows

COMMUNICATION AND EDUCATION

- Public education programs pertaining to the benefits of riparian buffers
- Roles and responsibilities for water and land management in the watershed; interagency communication and cooperation
- Compensation programs for retired fragile and valley lands
- Compensation programs for conservation easements

BOX 1: TWELVE MILE CREEK WATERSHED CHALLENGES AND ISSUES

PEAK FLOWS AND FLOODING

Several flooding issues have been identified in the Twelve Mile Creek watershed. High and moderate flooding risks have been identified for the City of St. Catharines (NWQPS 2003).

High stormwater flows are a result of increased impervious surfaces associated with development. Undeveloped areas allow for the mitigation of the effects of impervious surfaces by allowing stormwater to slowly return back to the system through natural features such as wetlands and forested areas, thereby reducing peak flows and potential flooding downstream. In addition to flooding, high peak flows can also lead to bank erosion, sedimentation, loss of aesthetics, increased stormwater pollution, and loss of aquatic habitat. In order to curb these potentially negative impacts, new urban developments can be designed to include new stormwater detention methods such as wet detention ponds, or on a smaller scale, residential rain barrels as described below.

URBAN STORMWATER MANAGEMENT

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

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

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 problem in the Twelve Mile Creek watershed at the public workshops and through the *Land Management Issues* and *Agricultural Best Management Practices Survey.* A septic system maintenance and education program could improve local septic system operation and well water quality for groundwater users in the watershed. The watershed strategy will put forth a set of recommendations for this type of watershed initiative.

ROAD SALT

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

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

The Regional Municipality of Niagara undertook a *Salt Vulnerability Study,* which was completed by Ecoplans Ltd. (2005). The study identified vulnerable areas for land use, groundwater, surface water, and natural areas. In the Twelve Mile Creek watershed, the Fonthill Kame-Delta Complex along Regional Road 20 in the Town of Pelham has been ranked as having high groundwater vulnerability due to the high potential for runoff (Ecoplans Ltd. 2005). Salt vulnerable areas will be addressed in the watershed strategy later in this report. In addition, there are numerous local roads within the watershed that are impacted by salt that have not been identified by the regional study.

NUTRIENT MANAGEMENT

Nutrients derived from manure and chemical fertilizers are necessary for farm productions. However, the improper use of nutrients can result in soil-nutrient imbalances and it can impair water quality locally and downstream of the farm. In order to maintain soil and water quality, the Ontario government introduced the *Nutrient Management Act* in 2002. Under this Act, farm producers must develop and implement a nutrient management strategy or a nutrient management plan. A nutrient management strategy is completed by producers to manage the production, storage and use of manure and other nutrients produced and used on a farm. Nutrient management plans are completed for agricultural operations that apply nutrients to the land (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination, and maximize the utilization of fertilizer potential.

IRRIGATION WATER

Irrigation water shortages have been reported by the public at the public open houses held for this study and through the *Land Management and Agricultural Best Management Practices Survey* that was distributed to Ontario Federation of Agriculture members in the Twelve Mile Creek watershed **(Appendix B).** A feasibility study pertaining to taking raw water supplies for irrigation has been completed for the Regional Municipality of Niagara (Stantec Consulting Ltd. 2005). This study investigated 4 districts in Regional Niagara requiring additional irrigation water. Three of these sites are located in the Twelve Mile Creek watershed.

The South District is located in Pelham and includes the Fonthill Kame-Delta Complex. The recommended alternative for irrigation water supply is from groundwater wells. However, in addition to the *Groundwater Study,* a specific assessment would be required to determine any potential drawdown impacts (i.e., dry wells, reduced baseflow) from additional pumping (Michaud Personal Communication). The West District is comprised of lands below the Niagara Escarpment. Several options for this district have been presented based on cost. The most costly alternative recommends taking water from Lake Moodie, Twelve Mile Creek, Welland Canal, Lake Ontario and/or Jordan Harbour. A pipeline distribution system with an intake from Lake Ontario and an open channel distribution system supplied from Lake Moodie or Twelve Mile Creek has also been presented as an option (Stantec Consulting Ltd. 2005). However, an open channel system for irrigation water is not ecologically preferred because it poses a risk of thermal pollution and maintenance leads to habitat destruction (Barrett Personal Communication). A third and least costly alternative is to create off stream reservoirs close to major water sources (Lake Ontario and Twelve Mile Creek).

The recommendations presented in the feasibility study will impact surface and ground water resources and ecological systems in the Twelve Mile Creek watershed. Therefore, additional studies will have to be conducted prior to the implementation of any alternative to ensure a sustainable supply of water for human and ecological use in the watershed.

LAKE GIBSON SYSTEM

The Lake Gibson System is a human created reservoir system used for hydro development. Ontario Power Generation is currently conducting an *Ecological and Human Health Risk Assessment* for the Lake Gibson System. Until the ecological and human health risk assessment is completed and reviewed, little work can be conducted in the lake because preliminary results indicate that risk to the ecological system is at or above acceptable levels. The sediment in the lake should not be disturbed until the results are confirmed and a remediation plan has been identified.

HYDROLOGIC CONNECTION TO BEAVERDAMS CREEK

Several underground connections supply water to the Lake Gibson System. The Davis culvert takes water under the current Welland Canal and under the Third Welland Canal to Lake Gibson. In addition, some of the water from Beaverdams Creek is diverted into the Welland Canal and into Lake Gibson. A third connection, Shriner's culvert, does not empty into Lake Gibson. This water is diverted from the Abitibi-Consolidated Incorporated paper mill in Thorold. It flows into the Third Welland Canal and eventually outlets into Twelve Mile Creek (Hughes Personal Communication; Stantec Consulting Ltd. 2004). *The Environment Effects Monitoring (EEM)* report for the Abitibi-Consolidated Incorporated Mill and Interlake Acquisition Corporation Limited Mill indicates that both plants draw water from the Welland Ship Canal and wastewater undergoes a 3-stage treatment process before being diverted into the old Welland Canal (which eventually outlets to Twelve Mile Creek in St. Catharines). All mill effluents meet the applicable effluent quality guidelines, and benthic studies at the outlet to Twelve Mile Creek do not show any water quality impairment. However, testing indicates a greater abundance of invertebrates within the study area, which is not considered detrimental to the health of the aquatic system or water quality (Stantec Consulting Ltd. 2004).

NIAGARA GREENBELT AND THE PROTECTED COUNTRYSIDE

The Greenbelt Plan (2005) has been created to provide permanent protection to the agricultural land base and the ecological features and functions by designating areas where urbanization should not occur. In the Twelve Mile Creek watershed, Greenbelt areas include lands within the Niagara Escarpment Plan area as well as "Protected Countryside" lands. Lands within the Niagara Escarpment Plan are managed under the *Niagara Escarpment Planning and Development Act* (1985 as amended in 1999), and the Protected Countryside lands are intended to enhance the spatial extent of agriculturally and environmentally protected lands within the Niagara Escarpment Plan area as well as enhance linkages with surrounding major lake systems and watersheds. The Niagara Escarpment Plan area and Greenbelt lands including the Protected Countryside are depicted on **Figure 10** for the Twelve Mile Creek Watershed.

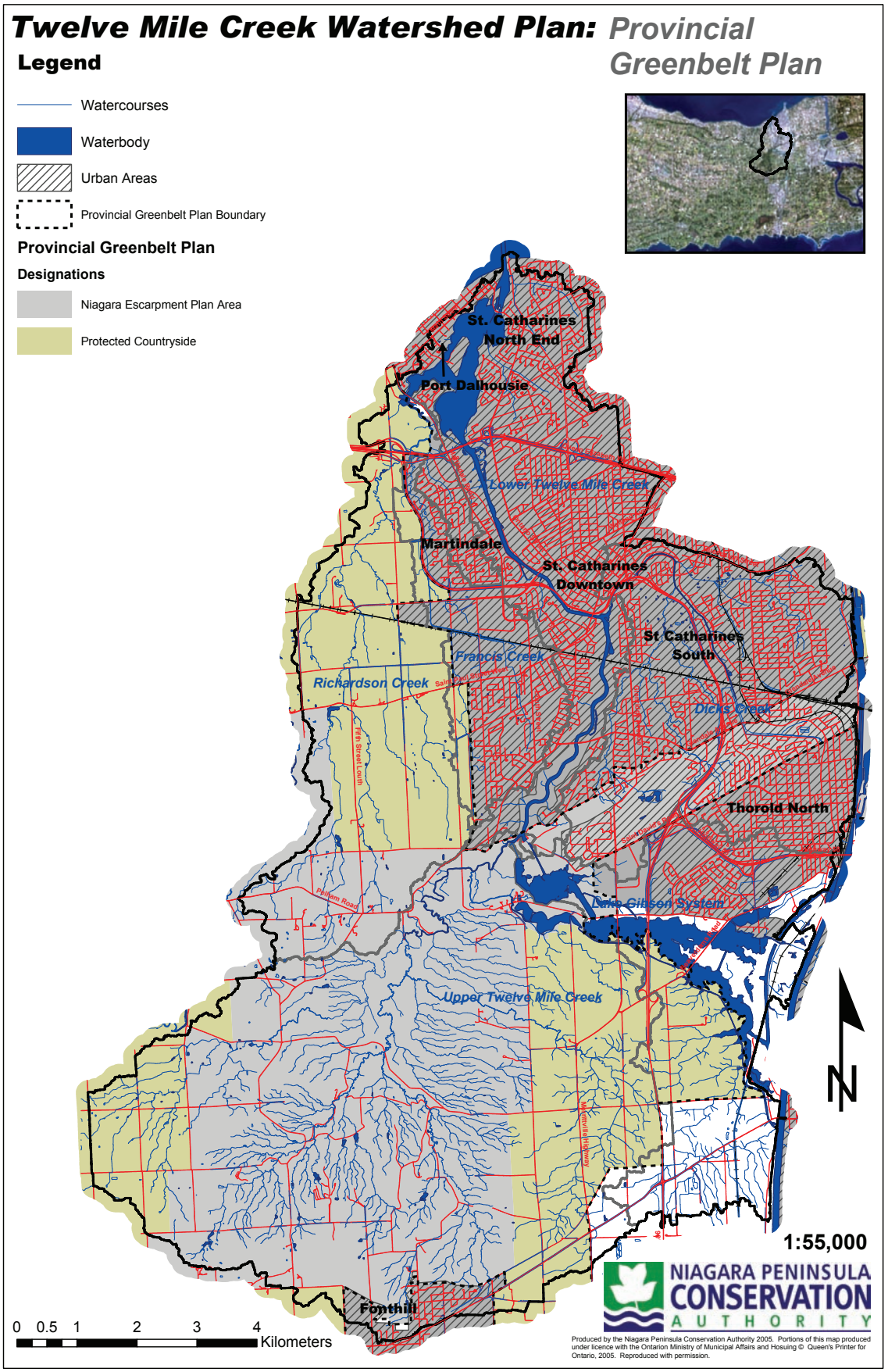


FIGURE 10: GREENBELT AND NIAGARA ESCARPMENT PLAN AREAS

FISH AND AQUATIC HABITAT

The fish community in the upper portion of the Twelve Mile Creek watershed is representative of a cold water fishery. The lower portion of the watershed is characteristic of a tolerant warm water fish community. Different species of fish have varying tolerances to environmental change; therefore, they are considered valuable indicators of environmental and ecosystem health. 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, and
- loss of groundwater recharge capability.

Many residents in the Twelve Mile Creek watershed have commented on the importance of protecting and preserving the unique Twelve Mile Creek cold water fishery. 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 including fish barrier removal.

NATURAL HERITAGE AND RESOURCES

Although municipal official plans include the protection of environmentally significant areas, the loss of natural features still occurs with development. Natural features include, for example, wetlands, forests, and riparian stream cover, and they provide many ecological functions in the Twelve Mile Creek watershed in terms of protecting water quality, reducing peak flows 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 are not replaced with infiltration, detention or restoration measures, receiving watercourses are negatively affected with increased flows and pollutant loads.

WETLAND HABITAT

Wetlands provide very important water quality and ecological functions in a watershed. Currently, the percent of wetland cover in the Twelve Mile Creek watershed is low (NWQPS 2003). Means to increase the numbers and/or size of wetlands in the watershed as well as wetland preservation are included in the watershed strategy because wetlands:

- naturally filter water resources thereby improving water quality,
- act like sponges, slowing the flow of water which reduces the impact of flooding and allows for groundwater recharge,

- help to prevent soil erosion, and
- augments low-flow by raising local water tables, which helps to maintain base flow in streams.

RIPARIAN HABITAT

Any contamination (including sediment) that is added to the system at the headwaters will eventually make its way through the length of the watercourse affecting water uses and users downstream. Riparian vegetation has many benefits including streambank stabilization, terrestrial and aquatic wildlife habitat, and shading and cooling of water. Therefore, riparian vegetation throughout the Twelve Mile Creek watershed should be prioritized for preservation and restoration based on this critical natural feature.

FOREST HABITAT

The amount of forest cover in a watershed determines its ability to support species diversity and enhance water quality. Although the upper portion of the Twelve Mile Creek watershed contains an adequate amount of forest cover, the rest of the watershed is well below adequate levels to protect water quality and provide habitat (NWQPS 2003). Forest cover is beneficial because it:

- reduces flooding and low flow events by intercepting runoff thereby encouraging infiltration,
- improves water quality by slowing the rate of runoff to watercourses, and trapping, using or breaking down some of the pollutants and nutrients found in runoff water,
- improves water quality by lowering water temperatures by 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.

URBAN DEVELOPMENT

In addition to the loss of natural areas and its associated impacts on water quality, quantity and ecological systems, urban development in the Twelve Mile Creek watershed includes land use changes associated with the development site known as Area 1.

AREA 1

Development in the Twelve Mile Creek watershed has been approved in the vicinity of the headwaters area of Twelve Mile Creek. Referred to as "Area 1", this development site is located on Lot 3, Concession 7 in the Town of Pelham just north of Regional Road 20 with proposed accesses to Haist Street and Lookout Street. The northern portion of this property drains to Twelve Mile Creek through the St. John's and Effingham branches of Twelve Mile Creek. Two subdivisions are proposed for the site including the Village of Chestnut Ridge and what is currently referred to as the Weiland Property. A total of 155 single unit homes, 109 townhouse units and 1 retirement home are proposed at this site (Totten Sims Hubicki Associates, et al. 2003).

CITY OF ST. CATHARINES

The City of St. Catharines has no remaining Greenfield areas left for development. However, St. Catharines has been identified in the "Places to Grow" Plan (2005) as an area for concentrating urban growth. As a result, pressure may be directed toward infilling/redevelopment in the Twelve Mile Creek watershed which could put pressure on valley systems as well as water quality and quantity (e.g., a need may arise for retro-fitting stormwater facilities that only address water quantity).

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 Twelve Mile Creek watershed strategy. To facilitate communication between citizens and agencies in the Twelve Mile Creek watershed, a list of the major water resources legislation and agencies governing water management in Ontario is provided in Box 2. In addition to partnering on public and private lands, which has been raised as an important issue by watershed residents, policy tools can be employed to foster environmentally responsible land and water management in the watershed.

POLICY TOOLS

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

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

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

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

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

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

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

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

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

LAW	DESCRIPTION (RELATED TO WATER PROTECTION)	GOVERNMENT AGENCY
	FEDERAL LEGISLATION	
FISHERIES ACT	Protects fish and fisheries habitat.	Fisheries and Oceans Canada
ENVIRONMENTAL CONTAMINANTS ACT	Prevents dangerous contaminants from entering the environment.	Environment Canada
CANADA SHIPPING ACT	Controls water pollution from ships by imposing penalties for dumping pollutants or failing to report a spill.	Transport Canada
CANADA WATER ACT	Authorizes agreements with provinces for the designation of water quality and quantity management.	Environment Canada
CANADIAN ENVIRONMENTAL PROTECTION ACT	Controls the manufacture, transportation, use, disposal of chemicals and waste that is not adequately regulated by other legislation.	Environment Canada
PEST CONTROL PRODUCTS ACT	Regulates products used to control pests through a registration process based on prescribed standards.	Agriculture Canada
NAVIGABLE WATERS PROTECTION ACT	Prohibits construction in navigable waters.	Transport Canada
INTERNATIONAL RIVERS IMPROVEMENT ACT	Prohibits damming or changing the flow of a river flowing out of Canada.	Foreign Affairs and Environment Canada
	PROVINCIAL LEGISLATION	
ONTARIO WATER RESOURCES ACT	Protects the quality and quantity of Ontario's surface and ground water resources (includes Permits to Take Water).	Ministry of the Environment
ENVIRONMENTAL PROTECTION ACT	Protects Ontario's land, water, and air resources from pollution (includes Certificates of Approval for landfills, sewage treatment, etc.).	Ministry of the Environment
ENVIRONMENTAL ASSESSMENT ACT	Requires an environmental assessment of any major public or designated private undertaking.	Ministry of the Environment
PESTICIDES ACT	Protects Ontario's land, and surface and ground water resources from damage due to improper use of pesticides.	Ministry of the Environment
NUTRIENT MANAGEMENT ACT	The purpose of the Act is to provide for the management of materials, containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development.	Ministry of the Environment
CONSERVATION AUTHORITIES ACT	Ensures the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs (includes floodplains).	Conservation Authorities
LAKES AND RIVERS IMPROVEMENT ACT	Ensures flow and water level characteristics of lakes and rivers are not altered to the point of disadvantaging other water users.	Ministry of Natural Resources
PLANNING ACT	Provides for and governs land use planning including the provision of statements of provincial interest to be regarded in the planning process.	Ministry of Municipal Affairs and Housing
MUNICIPAL ACT	Grants municipalities the power to pass bylaws related to water resources (e.g., bylaws that prohibit negative impacts on drains, dam construction and operation, and straightening of watercourses).	Ministry of Municipal Affairs and Housing
PUBLIC LANDS ACT	Protects and perpetuate public lands and waters for the citizens of Ontario.	Ministry of Natural Resources
PUBLIC UTILITIES ACT	Empowers municipalities to acquire and operate water works and divert a lake or river for their purposes.	Ministry of Municipal Affairs and Housing
DRAINAGE ACT	Facilitates the construction, operation and maintenance of rural drainage works.	Ministry of Agriculture, Food and Rural Affairs
TILE DRAINAGE ACT	Provides for low interest loans to farmers from municipalities for tile drainage on their property.	Ministry of Agriculture, Food and Rural Affairs

BOX 2: MAJOR WATER RESOURCES LEGISLATION GOVERNING WATER MANAGEMENT IN ONTARIO

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

WATERSHED BEST MANAGEMENT PRACTICES

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

- Structural BMPs are practices that require construction activities such as stormwater basins, grade stabilization structures, and crib walls.
- Vegetative BMPs use plants, including grasses, trees and shrubs to stabilize erosion sites.
- Managerial BMPs involve policy changes or operating procedures at a site (Brown, 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 is provided in **Appendix D.**

URBAN BEST MANAGEMENT PRACTICES

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

STORMWATER BEST MANAGEMENT PRACTICES

Stormwater BMPs are techniques, measures, or structural controls that are used to manage the quantity and improve the quality of stormwater runoff in a cost effective manner (EPA 2004). Off-line infiltration basins are an example of a structural stormwater BMP. Stormwater is diverted into the infiltration basin where it is retained to slowly infiltrate into the soil; it is not part of the main channel. Wet ponds are similar to off-line infiltration ponds. However, stromwater is retained for 2 to 3 weeks to allow for the absorption of pollutants and nutrients and then the water is released to the receiving watercourse. Managerial BMPs can also be achieved through municipalities. Municipalities can encourage and/or regulate land use planning and management by developing ordinances to manage stormwater impacts by limiting pavement, preserving open space, and delineating areas in the watershed for more on-site stormwater management facilities. Additional examples of structural, managerial and vegetative BMPs can be found in **Appendix D.**

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 (NWQPS 2003). Sediment control BMPs, water quality BMPs and nutrient management

BMPs can be employed to mitigate the impacts of these activities on watercourses and wetlands. Examples of agricultural BMPs are provided below and a more thorough list of agricultural BMPs can be found in **Appendix D.**

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% and is effective in improving water quality. Windbreaks also control sediment and simply consist of rows of trees planted around the edge of fields to reduce soil erosion by wind.

WATER QUALITY BEST MANAGEMENT PRACTICES

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

NUTRIENT MANAGEMENT PRACTICES

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

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 wetland, riparian 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 Twelve Mile Creek watershed strategy. A summary of the wetland, riparian and forest habitat restoration guidelines have been reproduced in **Appendix E.**

WATERSHED STRATEGY

For convenience, and to make restoration recommendations more manageable and easier to implement, the watershed planning strategy has been divided into separate restoration plans for each of the 6 subwatersheds. The 6 subwatersheds are: Upper Twelve Mile Creek, Lake Gibson System, Richardson Creek, Francis Creek, Dicks Creek, and Lower Twelve Mile Creek.

Restoration areas have been identified based on riparian, wetland and upland restoration suitability mapping produced by the NPCA. The criteria for each restoration category (riparian, wetland and upland) were derived from several sources including Environment Canada's (2004) framework for guiding habitat rehabilitation **(Appendix E).**

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 subwatershed 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 F).** 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 F**, and the top 3 criteria for each restoration category are presented below.

The criteria used to identify *riparian habitat suitability* include, for example, STREAMBANK EROSION RATES. This criterion is used because riparian areas identified as having high erosion rates resulting from an upslope contributing area and slope gradient analysis are most suitable to restoration with bioengineering. The PROXIMITY TO A WATERCOURSE OR WATERBODY identified riparian suitability because these areas contribute to both riparian buffers and floodplains, and restoration in these areas will improve the hydrological, habitat and water quality functions in the watershed. LAND USE TYPE is ranked third in terms of identifying suitable areas for riparian restoration. Areas classified as scrub, low intensity agriculture, or natural areas are much more suitable to restoration than areas classified as industrial or urban.

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

Upland habitat restoration suitability is also evaluated based on LAND USE TYPE. WETLAND BUFFER HABITAT THRESHOLDS (0-240M) are also used, which include areas within the 0-240 metre span of a wetland because they contribute to a range of habitat functions when vegetated. Vegetation within the closest proximity to a wetland provides the greatest benefit to that wetland. The third 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 F.** A series of habitat restoration suitability maps are provided **(Figures 11-13).** In addition to the identification of areas suitable for riparian, wetland and upland restoration, areas where ecological corridors could be enhanced have also been provided **(Figure 14).**

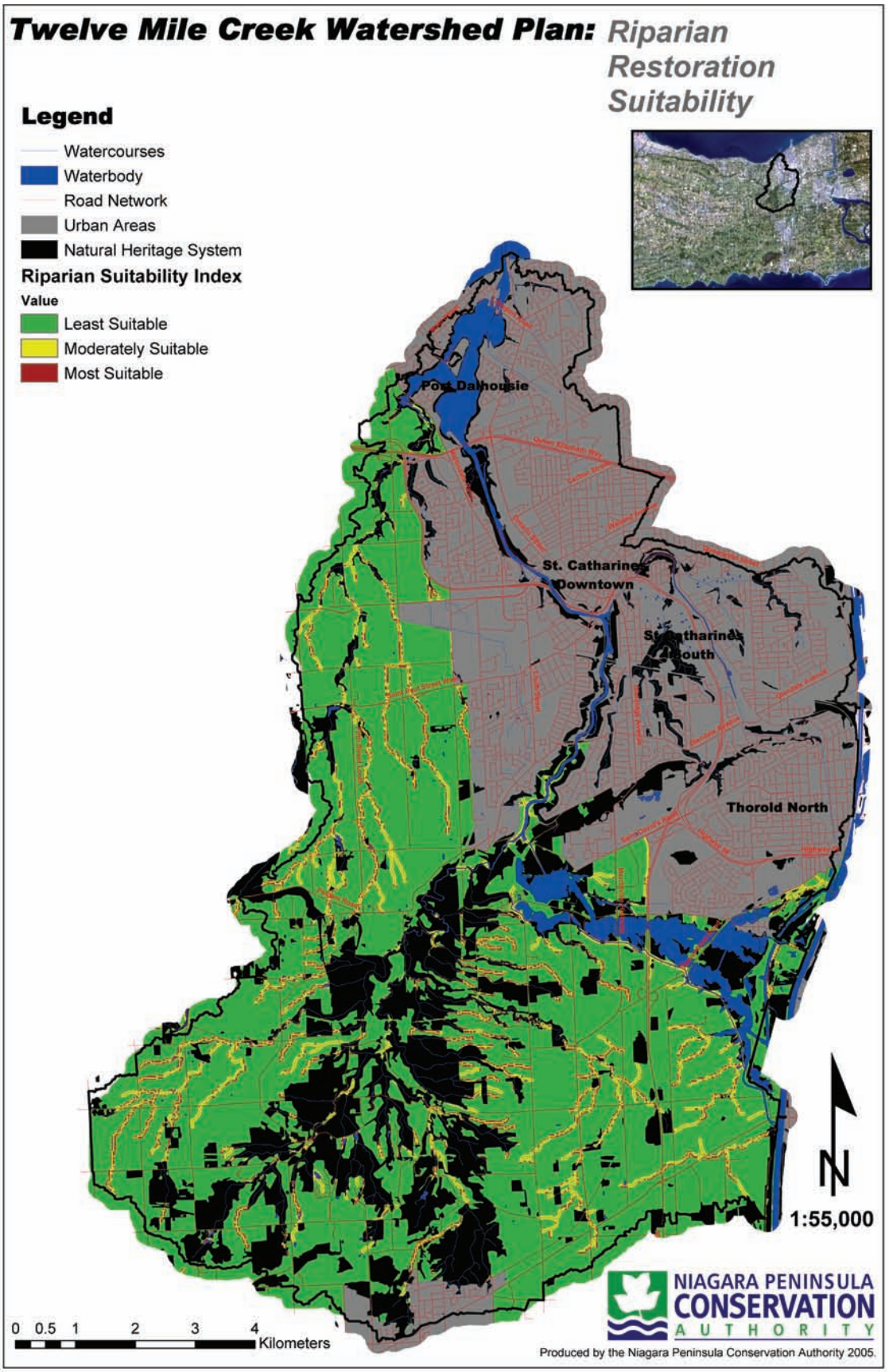


FIGURE 11: RIPARIAN RESTORATION SUITABILITY

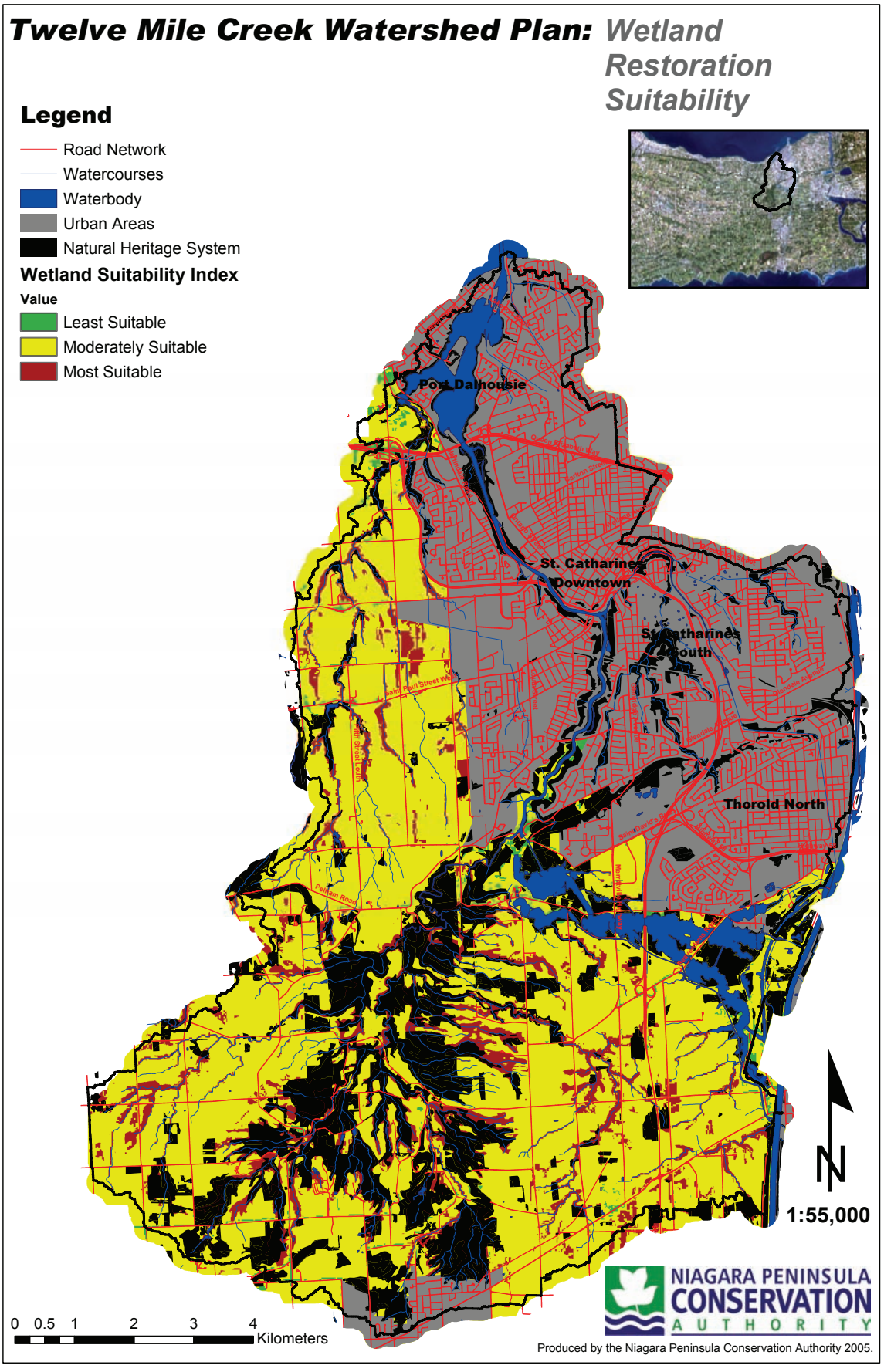


FIGURE 12: WETLAND RESTORATION SUITABILITY

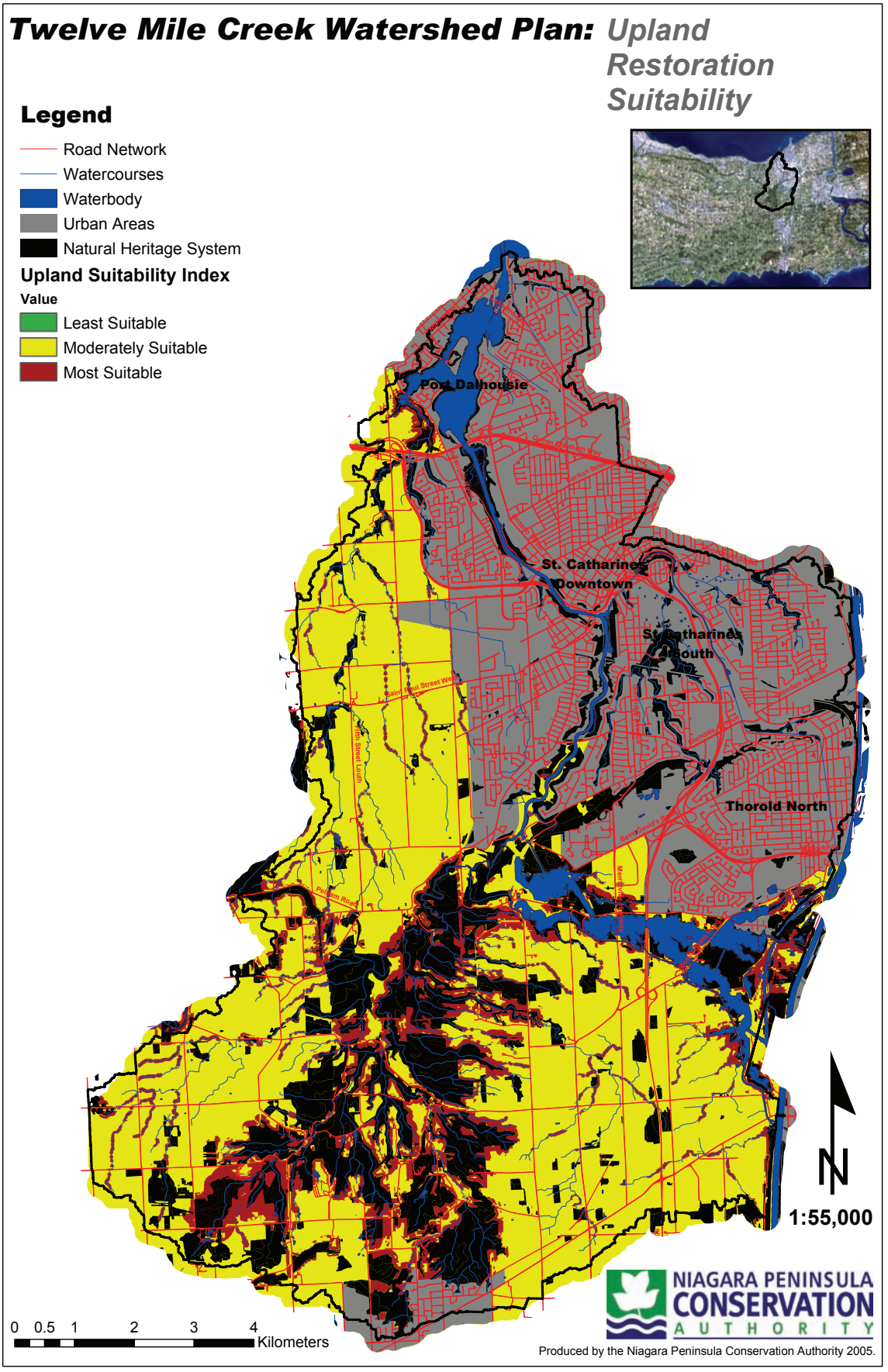


FIGURE 13: UPLAND RESTORATION SUITABILITY

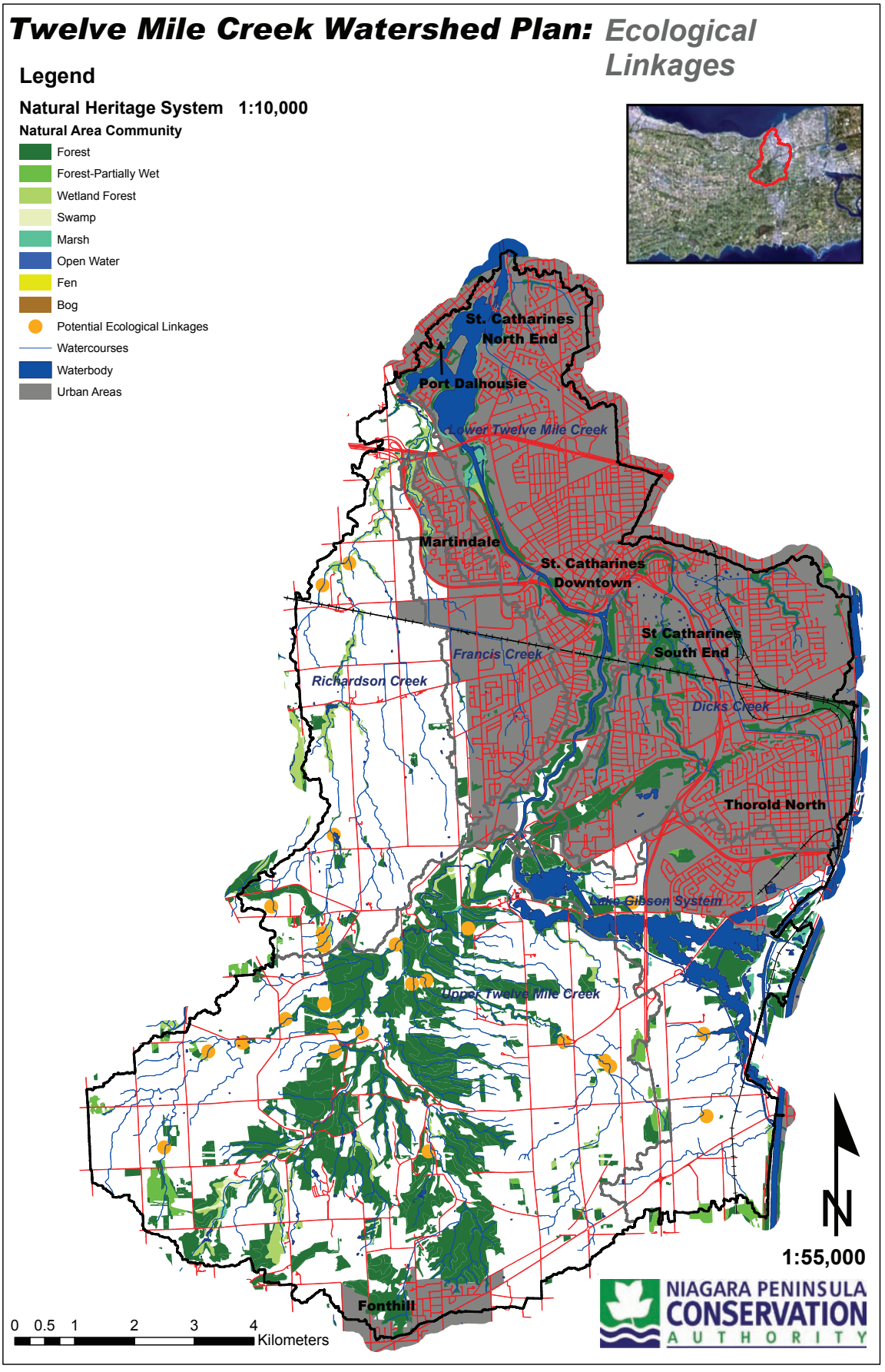


FIGURE 14: ECOLOGICAL CORRIDORS

UPPER TWELVE MILE CREEK RESTORATION STRATEGY

This portion of the Twelve Mile Creek watershed has the most potential for ecological restoration. Opportunities for riparian buffers, wetland enhancement and creation, as well as upland reforestation to enhance and create ecological linkages are abundant provided public and private partnerships can be established in the watershed. Maintaining and enhancing the integrity of the Carolinian forest community is also a priority in this subwatershed.

The Upper Twelve Mile Creek Restoration Strategy identifies 4 zones with specific stewardship and restoration recommendations **(Table 5).**

1) SHORT HILLS PROVINCIAL PARK: Partnerships with agencies and organizations should be developed to achieve riparian, wetland and upland restoration in Short Hills Provincial Park. Several sites within the park have been identified for riparian and upland restoration within the park that extend outside of the park boundary. Keeping within a park planning framework that recognizes the greater park ecosystem (the area of influence -- ecological, social and economic -- surrounding a park can be called the greater park ecosystem [Ontario Parks 2005]), restoration of these sites and partnerships with Ontario Parks and the Friends of Short Hills Park should be given priority to enhance ecological linkages and protect the ecosystems of this natural environment park. Wetlands within the park boundary should be enhanced and suitable sites that have been identified to expand or create new wetlands should be investigated.

In addition to the suitability analysis completed as part of this strategy, the *Vegetation Management Plan for Short Hills Provincial Park* (1997) should also be consulted.

2) CATARACT ROAD TO REGIONAL ROAD 20: The eastern portion of the subwatershed would benefit from restoration activities focused on creating and improving buffer strips along the tributaries feeding the main branch of Twelve Mile Creek within Short Hills Provincial Park.

3) ROLAND ROAD TO REGIONAL ROAD 20: The St. Johns tributary provides temperatures cold enough to support a brook trout population. Erosion and sedimentation are 2 issues currently affecting the headwaters of this branch of Twelve Mile Creek at Marlene Stuart Streit Park. Specific restoration strategies that will reduce the amount of sediment and road salt entering this site from Regional Road 20 have been identified in **Appendix C.** Additional erosion sites throughout this portion of the subwatershed are also identified in **Table 5.** Several areas in this portion of the subwatershed would benefit from riparian buffers and upland reforestation.

4) EFFINGHAM ROAD TO PELHAM ROAD: The western portion of the subwatershed would benefit from restoration activities focused on creating and improving buffer strips along the tributaries feeding the main branch of Twelve Mile Creek within Short Hills Provincial Park. In addition, the headwaters of the Effingham tributary are located in this portion of the watershed. This tributary also supports brook trout. Therefore, the wetland located in the headwaters should be protected and enhanced to help maintain the cold water fishery. Upland restoration will also help to improve ecological linkages and provide additional protection for the wetland located in this portion of the watershed.

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND & ECOLOGICAL LINKAGES
SHORT HILLS PROVINCIAL PARK	• Buffer strip planting along watercourses on the east side of the park	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit within the park boundary	• Continue to reforest agricultural areas in the park to increase interior forest based on the Shorts Hills Provincial Park Vegetation Management Plan (1997) • Maintain and enhance ecological linkages within the park including linkages that extend outside of the park boundary
CATARACT ROAD TO REGIONAL ROAD 20	• Buffer strip planting along watercourses adjacent to Short Hills Provincial Park to enhance water quality and fish habitat within the largely forested provincial park • Many sections of stream running through agricultural lands with little or no buffer flow into the park; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat	• Enhance existing wetlands currently located along watercourses flowing out of Short Hills Provincial Park • Create new wetlands in areas where the wetness index and soil drainage permit; priority should be given to areas adjacent to or in the vicinity of Short Hills Provincial Park to create larger contiguous habitat	• Reforest areas adjacent to and in the vicinity of Short Hills Provincial Park to increase interior forest • Maintain and enhance ecological linkages adjacent to Short Hills Provincial Park
ROLLAND ROAD TO REGIONAL ROAD 20	• Buffer strip planting to enhance water quality, especially in the headwaters of Twelve Mile Creek (Marlene Stuart Streit Park – see project opportunities below)	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit	• Reforest areas adjacent to and in the vicinity of the St. Johns Conservation Area to increase interior forest • Maintain and enhance ecological linkages adjacent to St. Johns Conservation Area
EFFINGHAM ROAD TO PELHAM ROAD	• Buffer strip planting along watercourses • Many sections of stream running through agricultural lands with little or no buffer; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat	• Enhance existing wetlands as natural flood storage reservoirs and groundwater recharge areas • Create new wetlands in areas where the wetness index and soil drainage permit; priority should be given to areas where wetlands already exist or adjacent to forested areas to create larger contiguous habitat areas	• Large area suitable for reforestation west of Effingham Road; reforestation of this site will enhance ecological linkages

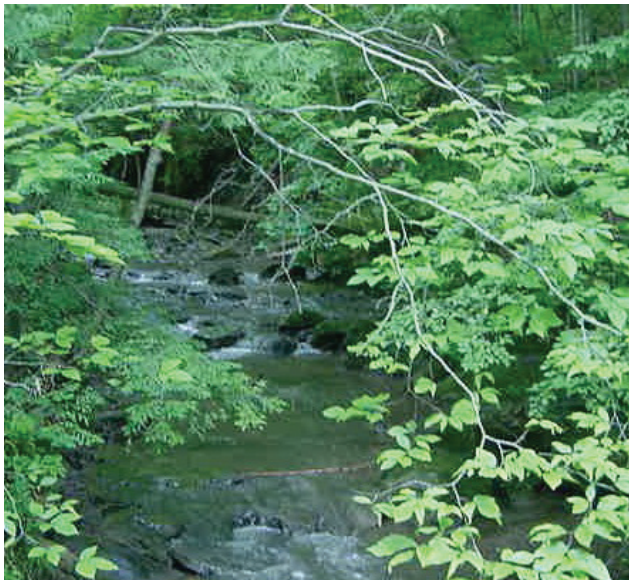
TABLE 5: UPPER TWELVE MILE CREEK SUBWATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
MARLENE STUART STREIT PARK	Several restoration actions have been identified through the Upper Twelve Mile Creek Watershed Erosion Study (2005) to enhance water quality and fish habitat. These actions include minimizing slope erosion and sediment input through hard and/or soft engineering methods, planting riparian buffer strips, culvert removal, and minimizing the impacts of road salt on the headwaters through the creation of retention ponds or constructed wetlands. In addition to these actions, reducing the amount of sediment to the system at the headwaters will enable the on-line pond upstream to be taken off-line. Currently, the pond is acting as a sediment trap and due to the lack of vegetative cover it is heating the water, which reduces the quality of the cold water fishery located in this subwatershed.
ST. JOHN CONSERVATION AREA	The on-line pond at St. Johns Conservation Area is contributing to higher temperature water being released into Twelve Mile Creek. Methods to maintain temperatures suitable for brook trout should be investigated for the pond to maintain optimal temperatures in the creek. One possible solution involves creating a rock trench underground to cool the water.
SHORT HILLS PROVINCIAL PARK	A preliminary investigation was conducted in Short Hills Provincial Park to determine the occurrence and type of erosion in the park as part of the Upper Twelve Mile Creek Watershed Erosion Study (2005). Four erosion sites in the park (3 along the main branch of Twelve Mile Creek, and 1 along a tributary of Twelve Mile Creek) were identified. 1. Bridge crossing over Twelve Mile Creek along Gilligan Road: Failure of the gabion baskets and log revetment requires technical study. 2. Twelve Mile Creek adjacent to Gilligan Road: A large culvert that has been relocated from further upstream and the resultant debris jam should be removed. 3. Twelve Mile Creek at the steel pedestrian bridge on the Black Walnut Trail: Bank erosion has occurred and a tree has fallen into the creek due to a human created rock "chute" in the creek. The chute should be dismantled to eliminate further erosion and the tree should be removed. 4. Scarlet Tanager Trail and Black Walnut pedestrian bridge: Bank erosion is occurring along the banks of a tributary of Twelve Mile Creek along this trail system, which is also eroding into the trail and threatening public safety. Downstream of the erosion, a pedestrian bridge is in danger of failing due to bank erosion.
OTHER KNOWN EROSION STUDIES	The Upper Twelve Mile Creek Watershed Erosion Study (2005) identified several other erosion sites on private property. Additional erosion sites will be addressed as they become known. 1. 2857 McSherry Lane: Sediment is accumulating in the deeper sections at this site, toe erosion is evident, and rock deflectors are no longer functioning properly. In addition, the stream is lacking a riparian buffer. 2. 2030 Hollow Road: Sediment is accumulating in the deeper sections at this site, toe erosion is evident, and the formation of an oxbow may change the stream's velocity and impact downstream reaches. 3. 30 Roland Road: The stream channel is constricted at this site due to the remnant of a foot bridge, which is contributing to a slump upstream of the bridge remnant. Sediment is also depositing behind the dam and several debris jams can be found at this site. 4. 60 Roland Road: Bank erosion and scour are occurring along the outside bends within this reach, which has resulted in deep pools. A live cribwall was installed in August 2005 to remedy the erosion problem at this site. Continued monitoring should occur to ensure the cribwall was successful. 5. Sulphur Spring Road near Orchard Hill Road: Damage to the road is a concern for this reach of Twelve Mile Creek due to the proximity of the stream to the road. Erosion of the bank and the road is present just upstream from the studied section.
GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES	The Groundwater Study (2005) has identified several areas with high intrinsic susceptibility. The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Additional studies should be conducted in this subwatershed to ensure that current and future land uses do not conflict with the protection of groundwater resources in susceptible areas as part of the NPCA's Groundwater Study (2005) and proposed Source Protection Plan.

TABLE 5: UPPER TWELVE MILE CREEK SUBWATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR FURTHER STUDY
TWELVE MILE CREEK TEMPERATURE STUDY	A temperature study is currently underway in the upper portion of the Twelve Mile Creek watershed to better understand and prevent the degradation and disruption of sensitive brook trout habitat and populations. The objectives of the water temperature monitoring program in the upper portion of the Twelve Mile Creek watershed are to: identify areas in the St. John's and Effingham tributaries where summer stream temperature exceeds the upper limit for brook trout; determine the impacts of on-line ponds on the stream temperature regime; establish baseline water temperature data for the St. John's and Effingham tributaries; and target areas for brook trout habitat restoration. Once completed, recommendations from this study should be implemented to improve water quality and fish habitat especially in known fish spawning areas.
BROOK TROUT SPAWNING AREAS	A redds (spawning area for fish) study in the Upper Twelve Mile Creek subwatershed to confirm brook trout spawning areas should be conducted.
RIPARIAN BUFFER EDUCATION AND FUNDING PROGRAM	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's education program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
SEPTIC SYSTEM EDUCATION AND FUNDING PROGRAM	Improperly functioning septic systems and abandoned septic systems are a known threat to water quality. A septic system education and funding program should be developed and implemented to ensure that private septic systems are functioning properly, and to ensure that abandoned systems are decommissioned.
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.

TABLE 5: UPPER TWELVE MILE CREEK SUBWATERSHED RESTORATION ACTIONS



LAKE GIBSON SYSTEM RESTORATION STRATEGY

The Lake Gibson System is a human created reservoir system used for hydro development. The challenge for this subwatershed is to enhance the ecological community that has formed in and around this created aquatic system with a focus on riparian, wetland and upland restoration. Until the ecological and human health risk assessment of Lake Gibson is reviewed and completed, little work can be conducted in the lake because preliminary results indicate that risk to the ecological system is at or below acceptable levels.

The Lake Gibson Restoration Strategy identifies 2 zones with specific stewardship and restoration recommendations **(Table 6).**

1) LAKE GIBSON SYSTEM (INCLUDING LAKE MOODIE):

The Lake Gibson/Moodie reservoir system would benefit from increased riparian cover as well as wetland enhancement and creation. In addition, ecological linkages with adjacent forested areas in the Upper Twelve Mile Creek watershed should be maintained and enhanced. Partnership with the Friends of Mel Swart Park should be continued so that agencies, organizations and individuals can continue to contribute to the betterment of the Lake Gibson ecosystem. Partnering with these organizations may enable restoration in the subwatershed to be implemented on a greater scale due to the ability to attract outside funding and access to other resources.

2) REMAINDER OF THE LAKE GIBSON SYSTEM SUBWATERSHED:

The remainder of the Lake Gibson System subwatershed is primarily urbanized. Therefore, naturalization of the watercourses and upland areas are not suitable for restoration. However, a rain barrel program should be implemented to encourage water conservation.

Rain barrels are low cost water conservation devices that reduce runoff volumes in order to delay and/or reduce peak runoff flow rates during a storm event. During a storm, water from rooftops is captured and stored in a rain barrel, which reduces the undesirable impact of runoff that would otherwise flow quickly into receiving waters that contribute to flooding and erosion problems in a watershed. Residential irrigation can account for up to 40% of domestic water consumption. Therefore, rain barrels aid in water conservation and they reduce the demand on the municipal water system during the summer months. Disconnecting rooftop downspouts from storm and sanitary systems and collecting rain water in rain barrels will benefit water quality, reduce erosion and sediment along watercourses as well as conserve water in the watershed.

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND
LAKES GIBSON SYSTEM (INCLUDING LAKE MOODIE)	• Buffer strip planting along watercourses • Shoreline of Lake Gibson has been identified as moderately suitable for riparian restoration	• Create new wetlands in areas where the wetness index and soil drainage permit (priority should be given to areas near existing wetlands and woodlands to enhance ecosystem function)	• Reforest areas adjacent to existing forested areas to increase interior forest • Maintain and enhance ecological linkages with adjacent forested areas in the Upper Twelve Mile Creek watershed
REMAINDER OF THE LAKE GIBSON SYSTEM SUBWATERSHED	The remainder of the Lake Gibson subwatershed is primarily urbanized. Therefore, naturalization of the upland areas are not suitable for restoration based on the suitability mapping created for this study.		
SPECIAL STUDIES	**RECOMMENDATIONS FOR FURTHER STUDY**		
LAKE GIBSON SEDIMENT REMEDIATION	Ontario Power Generation (OPG) has completed an ecological and human health risk assessment of the Lake Gibson system. The risk assessment determined that the lake water is safe as an emergency drinking water supply. However, risk to the ecological system is at or below acceptable levels. It is recommended that the results and recommendations arising from this study be reviewed and partnerships between the Niagara Peninsula Conservation Authority, City of Thorold and OPG be formed to address feasible restoration actions.		
URBAN RAIN BARREL PROGRAM	A rain barrel program should be researched, designed and implemented to encourage water conservation in the subwatershed. Part of this program will involve the creation and implementation of a downspout disconnection by-law for the City of Thorold, similar to the by-law adopted by the City of St. Catharines. The City of St. Catharines' By-Law 91-364 prohibits the direct connection and discharge of roof water into the municipal sanitary or combined sewer system.		
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.		

TABLE 6: LAKE GIBSON SYSTEM RESTORATION ACTIONS

DICKS CREEK SUBWATERSHED RESTORATION STRATEGY

The Dicks Creek subwatershed is primarily urbanized. However, large portions of the Niagara Escarpment that traverse this subwatershed are forested and every effort should be made to maintain and enhance the Carolinian forest found here. The St. Catharines Golf and Country Club and Burgoyne Woods Park are also located in the subwatershed and several small, forested tributaries of Twelve Mile Creek run through these properties. The challenge for this urban forested area will be to ensure that the integrity of the natural corridor to the Niagara Escarpment is maintained and enhanced.

The Dicks Creek Subwatershed Restoration Strategy identifies stewardship and restoration recommendations, as well as projects and special studies **(Table 7).**

1) NIAGARA ESCARPMENT CORRIDOR: This section of the subwatershed has the potential to improve the ecological system in the upper portion of the Twelve Mile Creek watershed by providing a forested corridor for the movement of flora and fauna. The current link from Burgoyne Woods Park should also be maintained for the movement of wildlife throughout the Twelve Mile Creek watershed.

2) REMAINDER OF THE DICKS CREEK SUBWATERSHED: The remainder of the Dicks Creek subwatershed is primarily urbanized. Therefore, naturalization of the watercourses and upland areas are not suitable for restoration. However, a rain barrel program in the urban area should be implemented to reduce rain water from entering combined sewer systems, and to encourage water conservation.

It is important to note, however, that the City of St. Catharines already has a downspout disconnection program in place. Therefore, a rain barrel program would benefit water conservation efforts in the St. Catharines portion of the subwatershed since storm water is not entering sanitary or combined sewers. However, a program for low-flow adapters (e.g., faucets, shower heads, toilets, etc.) should be implemented to reduce water use.

Several sites have been identified as having erosion potential in the Dicks Creek subwatershed (Aquafor Beech 1995). A total of 4 sites have been listed as having high priority; 5 sites were given moderate priority and 12 sites were given low priority. All of these sites require, to some degree, engineered erosion control works. Therefore, the locations of these sites have been included in **Appendix C.**

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND
NIAGARA ESCARPMENT CORRIDOR	Due to the high degree of urbanization in the Dicks Creek subwatershed, few areas are suitable for riparian, wetland and upland restoration. Priority should continue to be placed on preserving and enhancing the exiting natural heritage of the Niagara Escarpment.		
REMAINDER OF THE DICKS CREEK SUBWATERSHED	The Dicks Creek subwatershed is primarily urbanized. Therefore, naturalization of the upland areas are not suitable for restoration based on the suitability mapping created for this study.		
PROJECT OPPORTUNITIES	**RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS**		
GLENRIDGE QUARRY NATURALIZATION SITE	The Glenridge Quarry Naturalization Site was an active municipal landfill site. The official grand opening of the site, which now includes a trail system, children's environmental science displays, a naturalized pond and boardwalk, and links to the Bruce Trail, took place in 2004. The NPCA is now responsible for some maintenance of the site. Opportunities to enhance the existing restoration activities or create new opportunities at the site should be explored.		
SPECIAL STUDIES	**RECOMMENDED ACTIONS FOR FURTHER STUDY**		
URBAN RAIN BARREL PROGRAM	A rain barrel program should be researched, designed and implemented to encourage water conservation in the subwatershed. Part of this program will involve the creation and implementation of a downspout disconnection by-law for the City of Thorold, similar to the by-law adopted by the City of St. Catharines. The City of St. Catharines' By-Law 91-364 prohibits the direct connection and discharge of roof water into the municipal sanitary or combined sewer system.		
ECOLOGICAL LINK TO THE NIAGARA ESCARPMENT	An ecological link from Burgoyne Woods Park to the Niagara Escarpment should be preserved and enhanced for the movement of flora and fauna throughout the Twelve Mile Creek watershed. In addition, studies should be conducted to gain a better understanding of wildlife movement through this corridor including any impediments to movement that wildlife may encounter.		
RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured to the edge of the creek. The NPCA's education 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.		
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.		

TABLE 7: DICKS CREEK SUBWATERSHED RESTORATION ACTIONS

FRANCIS CREEK SUBWATERSHED RESTORATION STRATEGY

The Francis Creek subwatershed is also primarily urbanized. A unique opportunity for ecological restoration has presented itself in this subwatershed resulting from the channelling of the creek in 1988. Since its construction, a Type 2 (Important) fish habitat has established itself in the channel. As a result, restoration opportunities to maintain and improve the fishery should be investigated. The new hospital site in the City of St. Catharines is bounded by Francis Creek. An opportunity may exist to form a partnership between the hospital, City of St. Catharines and the NPCA for future restoration work in the channel.

The Francis Creek Restoration Strategy identifies 2 areas with specific stewardship and restoration recommendations **(Table 8).**

1) FRANCIS CREEK: The City of St. Catharines currently maintains Francis Creek as a storm channel. The channel is approximately 4 metres wide and it runs from Roland Street near Westdale Drive to Highway 406 where it meets up with the original channel of Francis Creek. The channel has been classified as Type 2 fish habitat. Riparian planting may not be feasible at this site because the City of St. Catharines is required to maintain the channel for stormwater flows to prevent flooding of adjacent lands. The challenge for this system will be to enhance aquatic habitat without compromising the ability of the storm channel to convey floodwaters.

2) REMAINDER OF THE FRANCIS CREEK SUBWATERSHED: The remainder of the Francis Creek subwatershed is primarily developed. Therefore, naturalization of the watercourses and upland areas are not suitable for restoration. However, a rain barrel program in urban areas should be implemented to reduce rain water from entering combined sewer systems, and to encourage water conservation.

It is important to note, however, that the City of St. Catharines already has a downspout disconnection program in place. Therefore, a rain barrel program would benefit water conservation efforts since storm water is not entering sanitary or combined sewers. However, a program for low-flow adapters (e.g., faucets, shower heads, toilets, etc.) should be implemented to reduce water use.

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND
FRANCIS CREEK SUBWATERSHED	The Francis Creek subwatershed is primarily urbanized. Therefore, naturalization of the upland areas are not suitable for restoration based on the suitability mapping created for this study with the exception of the Francis Creek storm channel, which has been noted as a project opportunity for this subwatershed.		
PROJECT OPPORTUNITIES	**RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS**		
FRANCIS CREEK CHANNELLED SECTION	The City of St. Catharines currently maintains Francis Creek as a storm channel. Riparian planting is not feasible at this site because the City of St. Catharines is required to maintain the channel for stormwater flows to prevent flooding adjacent lands. However, ecological habitat projects that will enhance the aquatic ecosystem present in the drain and that will not compromise the ability of the storm channel to convey floodwaters are possible. For example, pools can be created within the channel to enhance fish habitat (Barrett Personal Communication).		
SPECIAL STUDIES	**RECOMMENDED ACTIONS FOR FURTHER STUDY**		
URBAN RAIN BARREL PROGRAM	A rain barrel program should be researched, designed and implemented to encourage water conservation in the subwatershed. The City of St. Catharines already has a by-law (By-Law 91-364) that prohibits the direct connection and discharge of roof water into the municipal sanitary or combined sewer system.		
RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's education 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.		
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.		

TABLE 8: FRANCIS CREEK SUBWATERSHED RESTORATION ACTIONS

LOWER TWELVE MILE CREEK SUBWATERSHED RESTORATION STRATEGY

The section of Twelve Mile Creek that flows through this portion of the watershed was modified as part of the Welland Canal in the 19th Century. The creek was enlarged again to accommodate the tailwater flow from the DeCew Generating Station. Land use in this subwatershed is primarily urban with the exception of Martindale Pond, and the creek is mainly forested along its course to Martindale Pond. Currently, Martindale Pond acts as an on-line sediment basin that traps material moving from Twelve Mile Creek into Lake Ontario. Water levels in the pond are controlled by the St. Catharines Hydro-electric Commission's Heywood Generating Station at Port Dalhousie. The Martindale/Barnesdale provincially significant wetlands are also located in Martindale Pond.

The Lower Twelve Mile Creek Restoration Strategy identifies 2 areas with specific stewardship and restoration recommendations **(Table 9).**

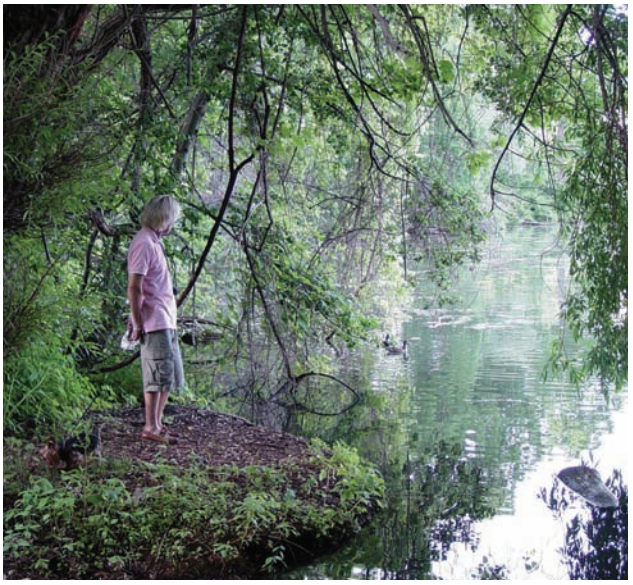
1) MARTINDALE POND/BARNESDALE MARSH:

Martindale Pond is owned by the City of St. Catherines. The Pond was used as part of the Old Welland. Canal system from 1820 until 1932, and for access to a former drydock into the early 1960s. The pond has also been used for rowing since the late 1800s and dredging of the pond has been carried out in 1930 (53,500 cubic metres), in 1966 (180,000 cubic metres), and again in 1997 (110,000 cubic metres). Several sites in Martindale Pond are experiencing erosion. For example, minor to significant erosion around most the pond at the shoreline is occurring, and several landowners backing on to the pond have attempted to control the erosion occurring on their properties with little success (Green Personal Communication). The challenge for the pond will be to reduce erosion, which will enhance the aquatic ecosystem and reduce damage to private property. In addition, biodiversity can be enhanced in the watershed with wetland and upland restoration.

The Barnesdale and Martindale wetlands are part of Martindale Pond. The wetland is most extensive in the southwestern corner of Martindale Pond where it covers the entire mouth of Richardson Creek and a bay located immediately downstream of the Queen Elizabeth Way. The challenge for the wetland is to preserve and enhance the integrity of the wetland in part by improving water quality upstream.

2) REMAINDER OF THE LOWER TWELVE MILE CREEK SUBWATERSHED:

The remainder of the Lower Twelve Mile Creek subwatershed is primarily developed. Therefore, naturalization of the watercourses and upland areas are not suitable for restoration. However, a rain barrel program and low-flow adaptors program in urban areas should be implemented to encourage water conservation in the watershed. In addition, several sites along the main branch of Twelve Mile Creek require cleaning up due to large amounts of trash being deposited in and along the creek. Organized clean-up days with local groups should be investigated for this urbanized section of Twelve Mile Creek.



RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND
MARTINDALE POND/ BARNESDALE MARSH	• Vegetated buffers currently found along the pond should be maintained and enhanced to protect the shoreline from erosion and to enhance water quality especially in the vicinity of the provincially significant wetland • Riparian habitat should be established along the shore of Martindale Pond in the residential area near Martindale Road	• Create new wetlands in areas where the wetness index and soil drainage permit (priority should be given to areas near the Barnesdale Marsh to link with the Richardson Creek wetland complex) • Toe erosion along the south shore of Martindale Pond could be eliminated with the creation of a series of wetlands along the shoreline	• Reforest areas adjacent to existing riparian buffer for Barnesdale Marsh; this area has been identified as most suitable for upland restoration
REMAINDER OF THE LOWER TWELVE MILE CREEK SUBWATERSHED	• Buffer strip planting along the main branch of Twelve Mile Creek that currently has no buffer; lands moderately suitable for riparian planting have been identified where the creek flows out of the Lake Gibson System subwatershed • Maintain and enhance existing buffer along the main branch of Twelve Mile Creek that flows through this urbanized subwatershed	• Create new wetlands in areas where the wetness index and soil drainage permit; lands moderately suitable for wetland creation have been identified where the creek flows out of the Lake Gibson System subwatershed	• Reforest areas along the main branch of Twelve Mile Creek where the creek flows out of the Lake Gibson System subwatershed; these areas have been identified as most or moderately suitable for upland restoration

TABLE 9: LOWER TWELVE MILE CREEK SUBWATERSHED RESTORATION ACTIONS

PROJECT OPPORTUNITIES	RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS
TWELVE MILE CREEK CLEAN-UP DAYS	Several areas along the main branch of Twelve Mile Creek in the Lower Twelve Mile Creek subwatershed have been subjected to large quantities of trash. For example, between St. Paul Street to the QEW (behind Ontario Street) dumping of garbage has been noted, which is contributing to poor water quality and fish habitat, unpleasant odours, as well as degraded aesthetic appeal. Partnerships with the agencies and organizations in the watershed can be used to organize clean-up days for the creek.
LOWER TWELVE MILE CREEK EROSION PROJECT OPPORTUNITIES	The Lower Twelve Mile Creek Study (2002) identified several erosion sites in the Lower Twelve Mile Creek subwatershed. 1. Rotary Park Slope: The slope from Rotary Park to the bank of Twelve Mile Creek has been eroded by rill and gully erosion caused by overland flow and seeps. Planting shrubs along the slope will help to consolidate eroding soils, restrict invasive species introduction, and provide shelter and forage areas for fauna. 2. Riverview Trail: Improper trail use and overland flow has produced patches of bare ground, soil loss, and bank erosion at this site. Planting shrubs will provide a sufficient root mass to stop erosion and soil loss. 3. Pelham Road Stormwater Detention Wetland: Stormwater discharge from a stormwater outfall is creating large gullies at this site. A constructed wetland is underway that will eliminate gully erosion by dissipating stormwater and enhance stormwater quality thereby improving water quality throughout this portion of the subwatershed. 4. Twelve Mile Creek Park: Gully, bank and slope erosion are found throughout this park. Naturalizing this site would aid in reducing erosion along the banks of Twelve Mile Creek. 5. Land Adjacent to General Motor's Plant on Ontario Street: The slope at this site is poorly vegetated and there is evidence of rill and gully erosion due to overland flow from the impermeable surfaces found at the valley crest.
WETLAND ENHANCEMENT PROJECTS	The Lower Twelve Mile Creek Study (2002) identified wetland enhancement sites in the Lower Twelve Mile Creek subwatershed. 1. Glendale Wetland: This small wetland can be enlarged to include a stormwater outfall. Expansion of the wetland will increase amphibian breeding habitat and enhance water quality in the subwatershed. 2. Riverview Wetland: This site is a former oxbow of Lower Twelve Mile Creek that is now a modified on-line pond. Restoration efforts should focus on changing the pond from a still-water pond to a stable vegetated wetland community to enhance aquatic habitat and water quality. 3. Old Welland Canal Wetland: This small pond/wetland should be expanded and enhanced with submergent, emergent and floating plant material. 4. Welland Vale Wetland: Enhancement of this wetland should include improving aquatic habitat for fish species that prefer slow moving, well vegetated areas for spawning. 5. Queen Elizabeth Way Wetlands: Two wetlands occupy this site. Focus should be directed toward enhancing and diversifying the existing species composition.
UPLAND ENHANCEMENT PROJECTS	1. Martindale Pond East Shore: The focus of this area in Martindale Pond is on naturalizing the shore and upland areas to create a continuous ecological corridor. 2. Southern and Northern Tips of Henley Island: These upland areas are suitable for short grass prairie planting to enhance biodiversity and habitat complexity in the watershed.
SPECIAL PROJECTS	**RECOMMENDED ACTIONS FOR FURTHER STUDY**
MARTINDALE POND TECHNICAL STUDY (EROSION)	Several sites in Martindale Pond are experiencing erosion including the entire perimeter of the pond, which shows evidence of minor and moderate erosion. A technical study should be completed for the shoreline of Martindale Pond to determine the causes, rate and impacts of erosion control structures implemented by landowners backing on to the pond. This study should also propose methods to eliminate or reduce erosion along the shoreline of the pond.
MARTINDALE POND RIPARIAN BUFFER EDUCATION PROGRAM	Many landowners keep their properties manicured to the edge of Martindale Pond. An education program aimed at educating landowners about the benefits of buffer zones along watercourses should be created and implemented specifically for Martindale Pond. In addition, landowners should be made aware of 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.
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.

TABLE 9: LOWER TWELVE MILE CREEK SUBWATERSHED RESTORATION ACTIONS

RICHARDSON CREEK SUBWATERSHED RESTORATION STRATEGY

Richardson Creek flows through rural and agricultural areas. The creek flows through a wooded and well defined valley before it empties into Martindale Pond. The challenge in this subwatershed stems from the lack of riparian vegetation along many sections of the creek. Several sections of this watercourse flow through agricultural areas with little or no buffer that eventually flow into Barnesdale Marsh, which is a provincially significant wetland, thereby contributing sediment and contaminants to the creek system. However, significant restoration work has been completed at the mouth of the creek (Green Ribbon Trail).

The Richardson Creek Restoration Strategy identifies 2 zones with specific stewardship and restoration recommendations **(Table 10).**

1) CONFLUENCE OF FRANCIS AND RICHARDSON CREEKS: The confluence of Francis and Richardson Creeks are forested. This forest cover acts to reduce the amount of sediment entering Martindale Pond. This area should be maintained and enhanced. Wetland suitability has also been identified in this area. Wetlands will further enhance the site by increasing diversity and improving water quality by acting as a natural filter.

2) RICHARDSON CREEK SUBWATERSHED: A riparian planting program in this primarily rural watershed will aid in improving water quality and fish habitat as well as increase species diversity. In addition to a riparian planting program, other agricultural best management practices (sediment control BMPs, water quality BMPs and nutrient management BMPs) can be implemented to improve overall water quality and fish habitat in the watershed. The NPCA's best management practices education program should be promoted to ensure the agricultural community is aware of land management options and sources of funding for environmental projects on their land.

RESTORATION OPPORTUNITIES	RECOMMENDED RESTORATION STRATEGIES		
	RIPARIAN	WETLAND	UPLAND
CONFLUENCE OF RICHARDSON AND FRANCIS CREEKS	• Maintain and enhance riparian cover at the confluence of Francis and Richardson Creeks to enhance water quality	• Create wetlands in suitable areas at the confluence of Francis and Richardson Creeks to enhance water quality and modifly flow into Barnesdale Marsh during peak storm flows	• Maintain and enhance ecological linkages at the confluence
REMAINDER OF THE RICHARDSON CREEK SUBWATERSHED	• Buffer strip planting along watercourses • Many sections of the stream running through agricultural lands with little or no buffer the eventually flow into Barnesdale Marsh; riparian buffers will help to reduce sediment and cool the water to enhance water quality and fish habitat	• Create new wetlands in areas where the wetness index and soil drainage permit (priority should be given to areas near existing wetlands and woodlands to enhance ecosystem function)	• Very few areas are suitable for upland restoration in this subwatershed; therefore priority should be placed on planting buffer strips and wetland creation • Maintain and enhance ecological linkages with adjacent forested areas in the northern portion of the subwatershed
PROJECT OPPORTUNITIES	**RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS**		
RICHARDSON CREEK WETLAND	This site consists of an expansive area that includes the mouth of Richardson's Creek. The Lower Twelve Mile Creek Study (2002) recommends the creation and planting of wetlands that would raise the pond bed to a depth suitable for the growth of emergent and submergent vegetation. This project would enhance the Martindale Pond ecosystem by increasing spawning and nursery habitat as well as the total amount of useable habitat available to fauna in the pond.		
SPECIAL PROJECTS	**RECOMMENDATIONS FOR FURTHER STUDY**		
REGIONAL NIAGARA IRRIGATION STUDY (2005)	The Regional Niagara Raw Water for Irrigation Feasibility Study (2005) recommends taking water from the Lower Twelve Mile Creek System to the Richardson Creek subwatershed. Additional studies will have to be conducted prior to the implementation of this alternative to ensure a sustainable supply of water for human and ecological use in the watershed.		
AGRICULTURAL BEST MANAGEMENT PRACTICES PROGRAM	The NPCA's education 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 of 75% of the cost of a project with caps between $5,000 and $12,000.		
SEPTIC SYSTEM EDUCATION AND FUNDING PROGRAM	Improperly functioning septic systems and abandoned septic systems are a known threat to water quality. A septic system education and funding program should be developed and implemented to ensure that private septic systems are functioning properly, and to ensure that abandoned systems are decommissioned.		
POLICY TOOLS	Policy tools such as stormwater management policies should be developed and included in regional and municipal Official Plans to ensure environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction.		

TABLE 10: RICHARDSON CREEK SUBWATERSHED RESTORATION ACTIONS

TARGETS

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

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

The Twelve Mile Creek watershed currently contains approximately 1.5 percent wetland cover and approximately 30 percent forest cover. Based on the above guidelines, an additional 8.5 percent of wetland cover is required to create minimum desirable habitat proportions in the Twelve Mile Creek watershed. Wetland creation should be concentrated in the lower portion of the watershed in areas where wetlands were historically located. Forest cover is already at 30 percent in the watershed. Therefore, measures to protect and enhance existing forest cover should be implemented to ensure no net loss of forest cover. Riparian cover in the watershed ranges between 30-35 percent in the watershed (a range is provided because only one side of a watercourse may be vegetated which affects the calculation). Based on this calculation, approximately 40-45 percent of the watershed requires a vegetative buffer. The guidelines represent *minimum* desirable habitat proportions for riparian, wetland and forest habitat. Additional restoration above the minimum target is encouraged once these targets have been met. Existing natural heritage feature and areas in the watershed should be conserved and enhanced whenever possible.

IMPLEMENTATION RESPONSIBILITIES AND RECOMMENDED MANAGEMENT ACTIONS

The above Twelve Mile Creek restoration strategy is of no use unless it is guided by an implementation framework. An implementation framework follows that has been designed to account for the watershed plan objectives, which were derived from key issues in the watershed. The implementation framework is guided by the Government of Canada's vision and funding program for integrated community sustainability planning, which envisions all parties involved to focus limited financial and human resources in ways that well best serve common objectives at all levels of government (Godfrey 2005). To this end, the implementation framework identifies project stakeholders 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 Twelve Mile Creek watershed include planning and regulatory actions (e.g., Official Plan amendments), project opportunities on private and public lands (e.g., riparian buffer planting, wetland creation), and areas requiring additional research and monitoring (e.g., ecological linkages, water temperature monitoring) in the watershed.

The cost of most projects is identified in the table. If the project is identified as ongoing then it is likely an action that requires continual updating such as the five year review process for regional and municipal Official Plans. An existing program already has funding, but the project and subsequent funding has a termination date. Therefore, these types of projects do not have a specific dollar amount attached to them. The recommended actions have also been identified in terms of their implementation. Beige denotes short term implementation, blue represents medium term implementation and green 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 green. Projects that have specific funding requirements or require approvals, for example, are often represented in beige and blue, thereby indicating short term or medium term implementation respectively.

To assist landowners in implementing projects on their properties, the framework is followed by a list of known funding sources for environmental projects accessible to individual landowners and non-profit groups.

IMPLEMENTING THE WATERSHED PLAN OBJECTIVES

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS												RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
WATER RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	OPG	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Maintain, enhance or restore stream processes to support human uses, agricultural needs and ecological functions.		▲	▲										Include water quality protection in regional & municipal planning documents		ONGOING
	▲			●	●	●		●					Continue to monitor temperature in Twelve Mile Creek		2,000 START UP COST
	▲				●			●					Implement measures to improve the water temperature regime (e.g., St. John's Pond)		75,000
	▲	●	●	▲	●			●					Continue to restrict new on-line pond construction		ONGOING
	▲	▲	▲			●					●	●	Monitor phosphorus levels to achieve below 30 g/L		16,000/yr*
Protect all municipal drinking water supplies and designated vulnerable areas. Protect, improve or restore vulnerable surface and ground water sources, sensitive surface water features and sensitive ground water features (e.g., aquifers), and their hydrologic functions.	▲	●	●	●	●	●				●	●		Develop and implement a Source Water Protection Plan		EXISTING FUNDING
	▲	●	●		●	●	●						Implement the Groundwater Management and Protection Strategy proposed in the *Groundwater Study* (2005)		EXISTING PROGRAM
	▲	●	●		●	●	●						Develop and implement a specific Groundwater Management and Protection Strategy for medium and high susceptibility areas identified in the *Groundwater Study* (2005)		EXISTING FUNDING
	▲	●	●			●					●	●	Develop and implement a water well decommissioning program		15,000/yr*
	▲	●	●			●							Identify and map surface and groundwater "hot spots" to determine areas with poor water quality including salt vulnerable areas		EXISTING FUNDING
		▲	▲							●			Develop and implement by-laws for the elimination of lawn fertilizers, pesticides and herbicides		EXISTING PROGRAM
	▲									●	●	●	Continue to promote and implement the NPCA Water Quality Improvement Program		160,000/yr*
	▲	▲	▲							●	●	●	Implement a septic system awareness and educational program		15,000/yr*
	●	▲	▲										Incorporate surface and ground water protection policies into municipal & Regional Official Plans		ONGOING
Ensure the equitable distribution of available groundwater and surface water supply to protect water quality, aquatic ecosystems and human health.	●	●	●			▲			▲	●	●	●	Improve monitoring of base flows and water use (e.g., Permit to take Water)		ONGOING
	▲	●	●		●	●	●		●				Develop a Twelve Mile Creek watershed water budget for the upper portion of the watershed as part of the *Source Protection Plan*		50,000
	●	●	▲		●			●	●		●		Review and thoroughly investigate the recommendations from the *Feasibility Study – Raw Water for Agricultural Irrigation Purposes* (2005) prior to implementation		EXISTING PROGRAM

LEGEND

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

IMPLEMENTING THE WATERSHED PLAN OBJECTIVES

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS												RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
WATER RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	OPG	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Ensure that storm water management practices optimize storm water volumes and minimize contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.	▲	▲	▲										Create and implement Stormwater Management Policies and Stormwater BMPs		EXISTING FUNDING
		▲										●	Create and implement Downspout Disconnection By-laws for the Town of Pelham and the City of Thorold (City of St. Catharines already has a Downspout Disconnection By-law in place)		100 DOWNSPOUT/ 600 HOME
	●	▲	▲									●	Create, fund and implement an urban Rain Barrel Program		60/HOME
Manage and mitigate flooding risks to human life and property as per the Conservation Authorities Act.	▲	●	●								●	●	Permit no new development in the 1 in 100 year storm flood plain		ONGOING
	▲	●	●										Maintain flood warning system		ONGOING
	▲	●	●								●	●	Continue to implement regulations adopted under Section 28 of the *Conservation Authority Act*		ONGOING
Minimize erosion caused by human activity through the establishment and implementation of a comprehensive, priority based erosion control program.	▲	●	●		●	●				●	●	●	Implement the recommendations from the *Upper Twelve Mile Creek Watershed Erosion Study* (2005) and the *Lower Twelve Mile Creek Study* (2005)		15,000-25,000/yr*
FISH & AQUATIC HABITAT															
Protect, enhance and restore populations of native species and their habitats in the watershed (e.g., brook trout).	▲	●	●		●			●	●	●	●	●	Where possible remove barriers to fish movement		14,000
	▲	●	●		●			●	●	▲	●	●	Develop a Fisheries Management Plan for Twelve Mile Creek and its tributaries		35,000
	▲				●	●		●		▲	●	▲	Where possible, remove, relocate or modify online ponds		10,000/yr**
	▲	●	●						●	●	●	●	Plant buffer strips around watercourses and wetlands		25,000/yr (5,000/250m)**
	▲				▲								Conduct a redds study (fish spawning sites) in the Upper Twelve Mile Creek subwatershed		1500 - 2000

LEGEND

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

IMPLEMENTING THE WATERSHED PLAN OBJECTIVES

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS												RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
NATURAL HERITAGE AND RESOURCES	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	OPG	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Protect, enhance, reforest and restore Areas of Natural and Scientific Interest and Environmentally Significant Areas, and other woodlands and wildlife habitat in the watershed for the long-term.	▲	●	●	●	●					▲			Complete a comprehensive biological inventory and map of natural heritage areas including wetlands		EXISTING FUNDING
	●	▲	▲		●								Update Regional and Local Official Plans to current Provincial standards for natural heritage areas		ONGOING
Protect, enhance and restore the stability, diversity, linkages and ecological function between habitats that support terrestrial and aquatic species and communities.	▲								●	●	●	▲	Implement the reforestation program based on the upland suitability mapping targeting interior forest or forest expansion opportunities		12,000/yr (1,500/acre)**
	▲	▲	▲	●						●	●	●	Utilize conservation easements, land dedication and acquisition to secure critical linkages (cost refers to acquisition)		EXISTING FUNDING
Preserve wetlands of provincial significance and create, and/or enhance and conserve all other wetlands in the watershed.	▲	▲	▲	▲	▲								Continued review of new developments and building permits; ensure compliance with PPS		ONGOING
	▲	●	●		▲			●		●	●	●	Create new wetlands or enlarge existing wetlands based on wetland suitability mapping		10,000/yr - 20,000/project**
URBAN DEVELOPMENT															
Promote environmentally-sound decision-making in the watershed for current and future urban development.	●	▲	▲	●	●								Identify significant natural areas and linkages in planning documents and policies to ensure they are buffered from development		ONGOING
Identify opportunities to optimize restoration and rehabilitation as part of urban growth and development.	▲	▲	▲										Continue to implement *NPCA Plan Input and Review Policies* (NPCA 1993 as amended 2003;2005)		ONGOING

LEGEND

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

IMPLEMENTING THE WATERSHED PLAN OBJECTIVES

WATERSHED PLAN OBJECTIVES	RESPONSIBLE AGENCIES AND GROUPS												RECOMMENDED MANAGEMENT ACTIONS	IMPLEMENTATION	COST
COMMUNICATION AND EDUCATION	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	NEC	MNR	MOE	OMAFRA	DFO	OPG	CONSERVATION GROUPS	AGRICULATURAL COMMUNITY	PRIVATE LANDOWNERS			$
Promote awareness of the linkages between healthy water, healthy lifestyles and the economic viability of rural and urban land uses.	▲											▲	Continue creating demonstration sites to educate landowners about the water quality benefits of riparian buffers		EXISTING PROGRAM
	▲	●	●							●	●	●	Continue to recognize groups and individuals for their environmental efforts in the watershed		ONGOING
Promote the wise use of groundwater and surface water resources in terms of human, agricultural and ecological needs.	●	▲	▲							▲		●	Disseminate material pertaining to alternative fertilizer use for residential lawns		EXISTING PROGRAM
	▲	●	●										Present plan findings and successes to municipal and regional government officials and policy makers		ONGOING
Promote the efficient and sustainable use of water resources including practices for water conservation and sustaining water quality.	▲	●	●	●	●	●	●	●	●	●	●	▲	Develop communication networks with agricultural groups, Niagara College, Brock University, and others for information sharing and project implementation		ONGOING
	▲									●	●	●	Continue the NPCA's *Water Quality Improvement Program* whereby landowners are provided incentives to carry out projects on their land		80,000/yr***
Encourage the creation of partnerships with agencies, organizations and landowners in the watershed.	▲	▲	▲						▲	▲	▲	●	Continue meeting with the Watershed Committee made up of local representation (government organizations, landowners) to annually re-evaluate the Watershed Plan's components, and provide input on new or revised restoration initiatives in the watershed		ONGOING
	▲												Create and disseminate a *Watershed Report Card* highlighting restoration initiatives in the watershed after 3-5 years of plan implementation		12,000/ REPORT CARD

LEGEND

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

* Includes project costs and NPCA staff salaries
** Based on grant ceiling under the NPCA's Water Quality Protection Program for landowners
*** Water Quality Improvement Program annual budget for projects only.

FUNDING SOURCES FOR ENVIRONMENTAL PROJECTS

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

WATER QUALITY IMPROVEMENT PROGRAM

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

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

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

CONSERVATION LAND TAX INCENTIVE PROGRAM

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

THE MANAGED FOREST TAX INCENTIVE PROGRAM

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

FARM PROPERTY CLASS TAX RATE

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

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

MONITORING

Monitoring serves 2 purposes in watershed planning. Monitoring is required to update the watershed plan as land uses change and new issues are identified, and monitoring also serves to measure the success of restoration projects in terms of enhancing and protecting water quality for all users in a watershed.

Monitoring the achievement of a watershed plan's objectives involves continually reviewing the *Twelve Mile Creek Watershed Plan*. The *Plan* will be reviewed by the NPCA Restoration Team and the Twelve Mile Creek Watershed Committee (comprised of non-government organization, watershed municipality 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 Twelve Mile Creek watershed. A complete review and necessary revisions will occur ever 5 years.

In addition to monitoring the objectives or outcomes of the *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 includes:

- Water quality sampling, benthic studies (BioMap), and water temperature monitoring through the NPCA's Water Quality Monitoring Program. This data can be used as an indicator of whether or not the recommendations provided in the *Watershed Plan* have maintained and/or improved the physical and chemical characteristics of water quality in the watershed. Continued groundwater monitoring should also be included as part of the water quality monitoring program.
- Biological life measurements, such as insects, habitat and fish sampling. Habitat areas are recorded as a Geographic Information System layer and updated bi-annually to evaluate changes in habitat size or fragmentation.

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

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

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

The overall objectives of the Twelve Mile Creek monitoring program are to:

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

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

- improve the AGNPS model calibration; and

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

CONCLUSION

The Twelve Mile Creek watershed is comprised of 6 subwatersheds; all with a unique environmental character and subsequent set of watershed issues. A wide-ranging set of watershed issues have been gathered resulting in a comprehensive set of watershed objectives that includes water resources, fish and aquatic habitat, natural heritage and resources, urban development, and communication and education.

The watershed objectives have formed the basis of restoration strategies at the subwatershed level for riparian, wetland and upland habitat that has been derived from detailed restoration suitability mapping. In addition, project opportunities on private and public lands have been identified such erosion control and shading to reduce water temperatures in the headwaters. Special studies, including policy tools and urban water conservation programs, have also been proposed.

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

The Niagara Peninsula Conservation Authority will oversee the implementation of the Twelve Mile Creek watershed strategy and recommendations made in this report with the assistance of the Twelve Mile Creek Watershed Project Committee, which is comprised of non-government organizations and municipalities from the watershed. Watershed plan progress will be communicated annually by means of a qualitative report card that details progress in the watershed.

Together the watershed strategy and recommended management actions aim to contribute to an improved quality of life for all living things, and provide enough water to sustain healthy rural and urban communities in harmony with the natural environment and rich in species diversity. In addition, the Twelve Mile Creek Watershed Plan identifies the need to educate citizens about efficient water use so that they will respect the long-term sustainability of all water systems and the life that depends on them.

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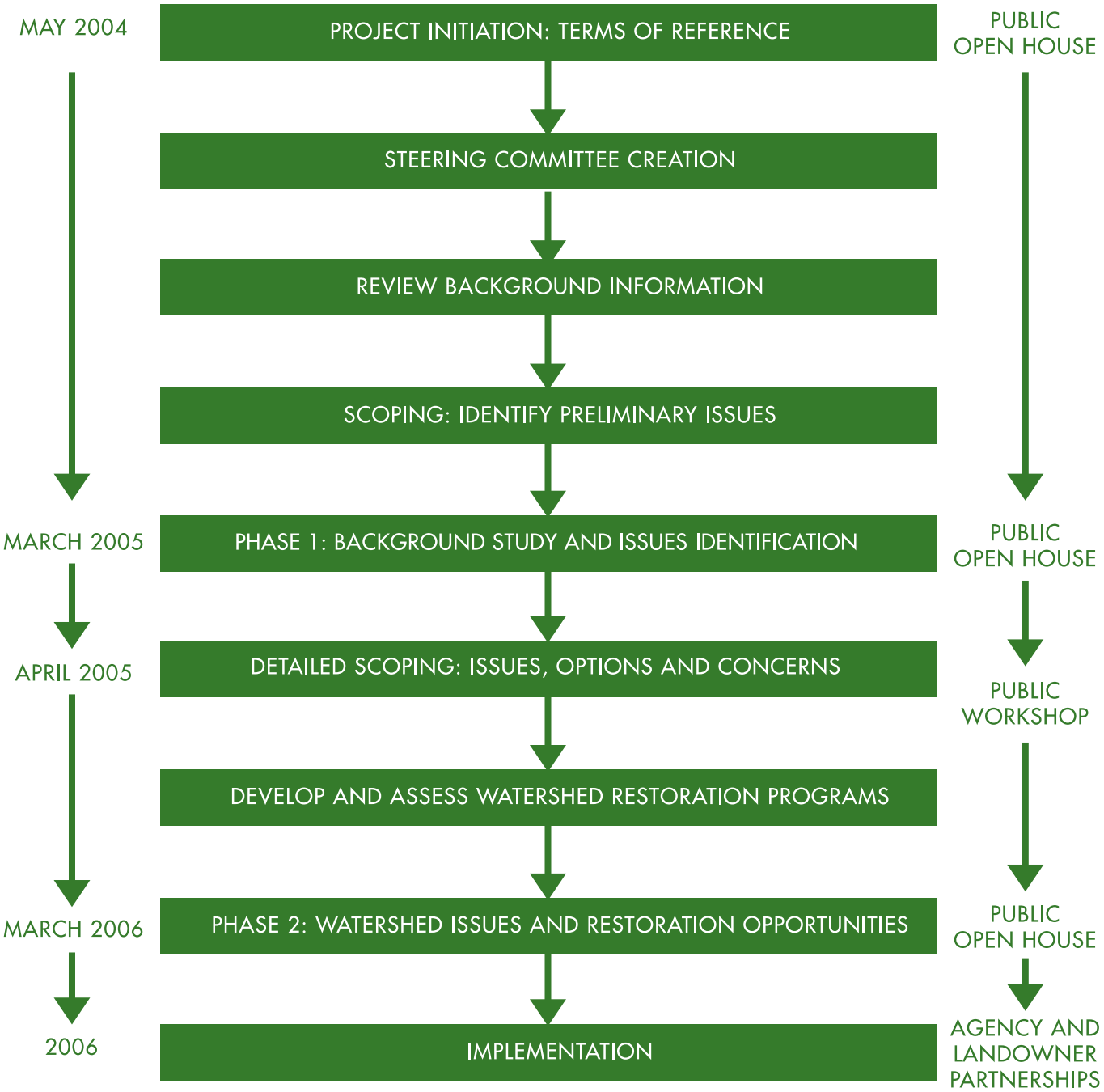
NIAGARA PENINSULA CONSERVATION AUTHORITY

TWELVE MILE CREEK APPENDICES

APPENDIX A

WATERSHED PLANNING PROCESS AND PUBLIC CONSULTATION



APPENDIX B

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.

❑ Glanbrook ❑ Grimsby ❑ Lincoln ❑ Pelham ❑ Stoney Creek ❑ West Lincoln

2. Do you live in the Twenty Mile Creek watershed or the Twelve Mile Creek watershed? (Please refer to the enclosed map.)

❑ Twenty Mile Creek watershed ❑ Twelve Mile Creek watershed ❑ Not Sure

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

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

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

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

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

and/or how many livestock do you have? _____

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

8. Are you a member of any agricultural associations?

❑ Yes ❑ No

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

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

❑ Yes ❑ No ❑ Not Sure

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

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

❑ Yes ❑ No

LAND MANAGEMENT ISSUES AND CONCERNS

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

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

FIRST CONCERN: _____

_____

_____

SECOND CONCERN: _____

_____

_____

THIRD CONCERN: _____

_____

_____

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

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

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

_____

BEST MANAGEMENT PRACTICES AND RESTORATION RESOURCES

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

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

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

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

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

_____

_____

_____

_____

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

_____

_____

_____

_____

_____

APPENDIX B

COMMUNICATION

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

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

19. Please provide any additional comments:

_____

_____

_____

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THANK YOU

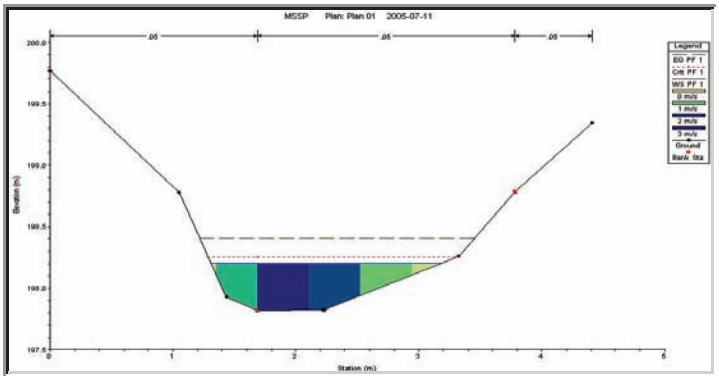
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, 33 Park Lane Road, Pelham	Stream Order:	2
Date:	2005-06-15		

Section Location

Photo:: (looking downstream) incised channel, steep bed and bank slopes, organic debris along the bed, toppled tree on left bank



Cross Section

Reach

Stream Length Surveyed (m):	35
Mean Slope of Stream:	0.042

Channel Measurement

Maximum Depth (m):	1.6
Mean Depth (m):	1.049
Average Width (m):	6.15
Width to Depth Ratio:	5.86

Channel Calculation

Cross Sectional Area (m2):	0.75
Wetted Perimeter (m):	2.68
Hydraulic Radius (m):	0.28
Est. Resistance Factor (n):	0.1
Calc. Mean Velocity (m/s):	1.92
Discharge (m3/s)	0.98

SOILS:	Loose sediment, gravel to cobble
BANK VEGETATION:	Sparse, exposed tree roots
DESCRIPTION OF EROSION:	Erosion of surveyed section - incised channel with steep bed and bank slopes, organic debris deposited on bed, tree toppled over on left bank.
RESTORATION RECOMMENDATION:	Stabalize the upstream reach and possibility of creating a dentention pond.
OTHER:	There are other problems within this area including: slope erosion on hill adjacent to Park Lane Road parking lot, culverts from RR-20 are incising into the valley slope, one section has no buffer zone and is well manicured, some culverts are partially blocked, on-line pond downstream is acting as a sediment trap, and water contamination due to excess road salt.

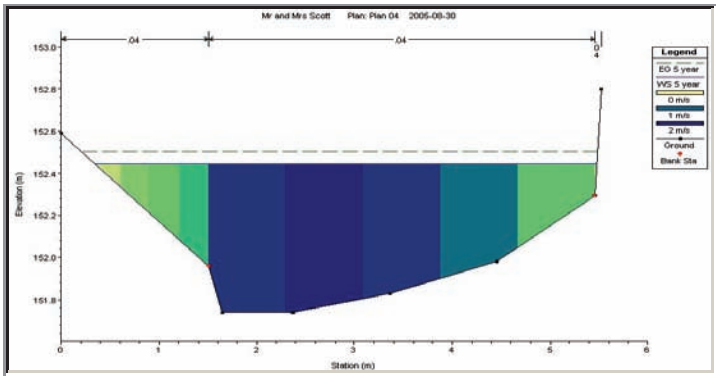
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, 2857 McSherry Lane, Thorold	Stream Order:	4
Date:	2005-07-12		

Section Location

Photo:: (looking downstream) accumulation of sediment in deeper sections, bank erosion



Cross Section

Reach

Stream Length Surveyed (m):	65
Mean Slope of Stream:	0.0038

Channel Measurement

Maximum Depth (m):	1.12
Mean Depth (m):	0.921
Average Width (m):	5.73
Width to Depth Ratio:	6.23

Channel Calculation

Cross Sectional Area (m2):	3.58
Wetted Perimeter (m):	6.52
Hydraulic Radius (m):	0.55
Est. Resistance Factor (n):	0.04
Calc. Mean Velocity (m/s):	1.15
Discharge (m3/s)	2.51

SOILS:	Loose sediment
BANK VEGETATION:	Sparse
DESCRIPTION OF EROSION:	Accumulation of sediment in deeper sections, bank erosion along top of bank.
RESTORATION RECOMMENDATION:	Plant native vegetation along the banks to stabilize banks, reduce sediment, and provide shade to decrease temperatures.
OTHER:	Rock deflectors have been placed along the channel and some of the rock has become mobile.

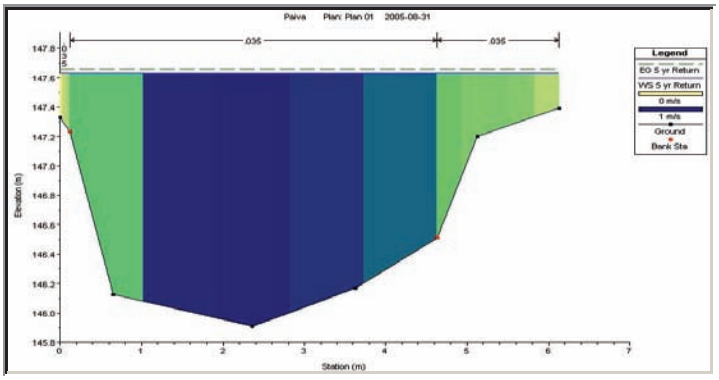
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, 2030 Hollow Road, Thorold	Stream Order:	4
Date:	2005-07-20		

Section Location

Photo:: Possible formation of an oxbow. This picture shows the length of land in between the two stream bends



Cross Section

Reach

Stream Length Surveyed (m):	60
Mean Slope of Stream:	0.0037

Channel Measurement

Maximum Depth (m):	1.48
Mean Depth (m):	1.15
Average Width (m):	4.39
Width to Depth Ratio:	3.81

Channel Calculation

Cross Sectional Area (m2):	9.07
Wetted Perimeter (m):	9.09
Hydraulic Radius (m):	0.998
Est. Resistance Factor (n):	0.035
Calc. Mean Velocity (m/s):	1.94
Discharge (m3/s)	4.99

SOILS:	Loose sediment
BANK VEGETATION:	Adequate, at some locations vegetation is overhanging creating shade, there are also exposed tree roots
DESCRIPTION OF EROSION:	Possible formation of an oxbow within this reach, there is also accumulation of sediment along the bed and erosion at the toe of the bank.
RESTORATION RECOMMENDATION:	Armouring the streambank to prevent further erosion of the bend or let the oxbow form. If the second option is chosen, then further research should be conducted to determine possible downstream effects.
OTHER:	

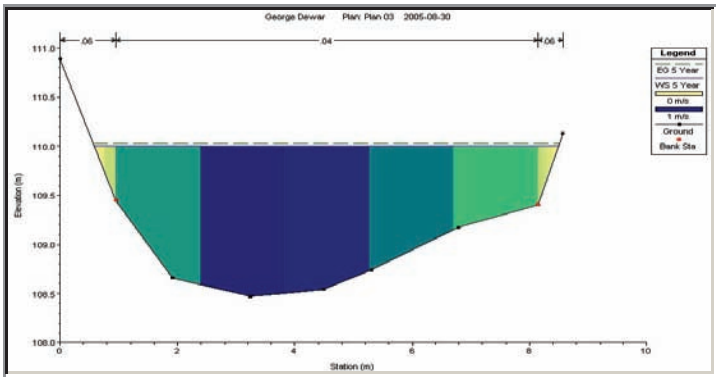
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, 30 Roland Road, Pelham	Stream Order:	4
Date:	2005-07-12		

Section Location

Photo:: (looking downstream) partial dam sticks out into the creek forcing water through a constricted channel. A large slump has resulted upstream on left stream bank.



Cross Section

Reach

Stream Length Surveyed (m):	45
Mean Slope of Stream:	0.0075

Channel Measurement

Maximum Depth (m):	2.42
Mean Depth (m):	1.97
Average Width (m):	11.98
Width to Depth Ratio:	6.08

Channel Calculation

Cross Sectional Area (m2):	19.14
Wetted Perimeter (m):	12.75
Hydraulic Radius (m):	1.5
Est. Resistance Factor (n):	0.06
Calc. Mean Velocity (m/s):	1.61
Discharge (m3/s)	6.34

SOILS:	Sediment and cobble
BANK VEGETATION:	Dense, there is shading along the stream
DESCRIPTION OF EROSION:	The partial dam has caused water to pool upstream contributing to slumping on left bank. Water is forced to accelerate through the constriction causing erosion on the right bank. Deposition is occuring in behind the dam on the left bank.
RESTORATION RECOMMENDATION:	Remove the partial dam from stream.
OTHER:	A number of debris jams are also present within this section.

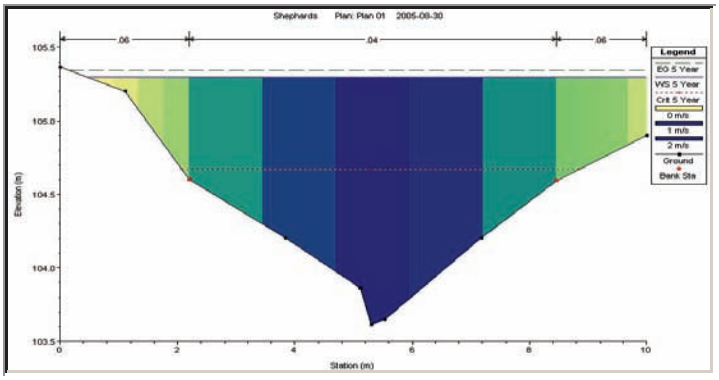
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, 60 Roland Road, Pelham	Stream Order:	4
Date:	2005-07-14		

Section Location

Photo:: (looking upstream) excessive bank erosion along outside bends resulting in deep pools, sediment accumulation is occurring in these deep sections



Cross Section

Reach

Stream Length Surveyed (m):	55
Mean Slope of Stream:	0

Channel Measurement

Maximum Depth (m):	1.74
Mean Depth (m):	1.35
Average Width (m):	7.11
Width to Depth Ratio:	5.27

Channel Calculation

Cross Sectional Area (m2):	11.97
Wetted Perimeter (m):	11.66
Hydraulic Radius (m):	1.027
Est. Resistance Factor (n):	0.06
Calc. Mean Velocity (m/s):	1.54
Discharge (m3/s)	7.28

SOILS:	Loose sediment
BANK VEGETATION:	Fairly dense in locations providing shade over stream
DESCRIPTION OF EROSION:	Along the outside bends excessive deepening is occuring, sediment deposition is accumulating in deeper sections.
RESTORATION RECOMMENDATION:	The Niagara Peninsula Conservation Atuthority Restoration Team has constructed 2 live crib walls in August, 2005 to prevent further erosion and stabilize the reach
OTHER:	Other than the pooled areas, the slope of the stream through the surveyed reach remains constant. The streambed deepens adjacent to a wall of rectangular blocks protecting the driveway. The wall should be monitored to identify excessive toe scour which would cause instability for the wall.

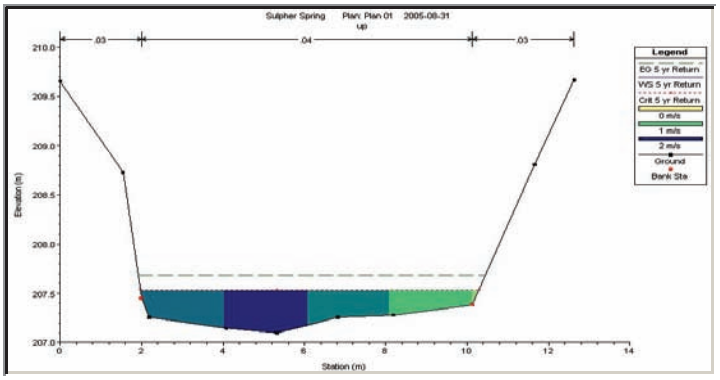
12 MILE CREEK WATERSHED

Existing Conditions

Location:	12 Mile Creek, Sulphur Spring Road (near Orch	Stream Order:	3
Date:	2005-07-06		

Section Location

Photo:: (looking downstream) Sulphur Spring Road runs adjacent to the stream and is therefore affected by bank erosion



Cross Section

Reach

Stream Length Surveyed (m):	52
Mean Slope of Stream:	0.033

Channel Measurement

Maximum Depth (m):	2.56
Mean Depth (m):	1.89
Average Width (m):	14.51
Width to Depth Ratio:	7.68

Channel Calculation

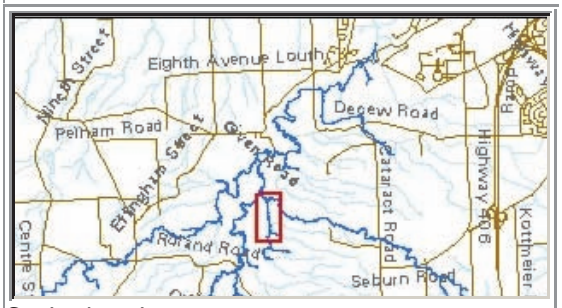
Cross Sectional Area (m2):	3.58
Wetted Perimeter (m):	9.18
Hydraulic Radius (m):	0.389
Est. Resistance Factor (n):	0.03
Calc. Mean Velocity (m/s):	1.81
Discharge (m3/s)	4.33

SOILS:	Fairly large boulders and cobble with limited sediment
BANK VEGETATION:	Dense, shading occurs along the reach, tree roots are exposed
DESCRIPTION OF EROSION:	Sulphur Spring Road runs adjacent to stream and therefore is affected by bank erosion.
RESTORATION RECOMMENDATION:	Plant vegetation or build a bank protection structure along road before any further damage to the road occurs.
OTHER:	

12 MILE CREEK WATERSHED

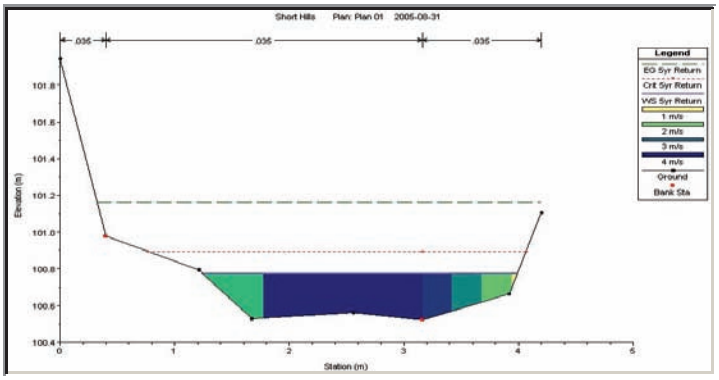
Existing Conditions

Location:	Short Hills Provincial Park (Unnamed Creek)	Stream Order:	2
Date:	2005-07-28		



Section Location

Photo:: (looking upstream) slumping has occurred along outside bend beside Scarlet Tanager Trail



Cross Section

Reach

Stream Length Surveyed (m):	105
Mean Slope of Stream:	0.0052

Channel Measurement

Maximum Depth (m):	1.49
Mean Depth (m):	1.01
Average Width (m):	4.44
Width to Depth Ratio:	4.4

Channel Calculation

Cross Sectional Area (m2):	0.69
Wetted Perimeter (m):	3.25
Hydraulic Radius (m):	0.212
Est. Resistance Factor (n):	0.035
Calc. Mean Velocity (m/s):	1.33
Discharge (m3/s)	1.47

SOILS:	Sand, pebbles, cobbles
BANK VEGETATION:	Dense, stream is shaded, tree roots exposed
DESCRIPTION OF EROSION:	Bank erosion is threatening the Scarlet Tanager Trail due to slumping. There is also erosion adjacent to a foot bridge on the Black Walnut Trail.
RESTORATION RECOMMENDATION:	The Scarlet Tanager Trail should be moved over so that the trail is not so close to stream bank. Native vegetation can be planted along the bank to stop further erosion.
OTHER:	Other problems include excessive deposition underneath a bridge crossing over 12 Mile Creek along Gilligan Road. A culvert from upstream has become mobile and deposited within 12 Mile Creek changing the morphology of the stream in this section, also a large tree has fallen into 12 Mile Creek along Black Walnut Trail in the park.

APPENDIX D

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
	STRUCTURAL BMPs
EXPLORE NEW VENDOR-SUPPLIED "ULTRA-URBAN" TREATMENT OR STORAGE TECHNIQUES	New stormwater treatment and storage techniques are now available that are advantageous for controlling flow, nutrients, and sediments especially in already developed areas with no possible detention.
SEDIMENT FOREBAY IN DETENTION REQUIREMENTS	Sediment forebays allow polluted sediments to settle out before water is discharged into the detention pond, thereby increasing treatment time and capacity.
CONSERVATION TILLAGE/ AGRICULTURAL FILTER STRIPS	Alter agricultural practices to encourage naturally vegetated buffers/filters around streams and rivers.
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.
OFF-LINE INFILTRATION BASIN	Design new development drainage corridors to include an infiltration basin which is not part of the main channel to capture water and retain it until it infiltrates 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.
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.
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.
RETROFIT STORMWATER BASINS TO RETAIN FIRST FLUSH	Modify older basins that were designed to control only the 100-year storm into multi-functional stormwater wetlands or conventional wet ponds.
WET POND	In new development areas include wet ponds that use a permanent storage pool to capture or transform dissolved pollutants thereby holding water for 2-3 weeks and releasing it slowly back to the environment.
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.

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
STRUCTURAL BMPs	
FULL INFILTRATION TRENCH	Design new development 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.
STREAM CHANNEL RESTORATION/STABILIZATION	Construct pipe outlets and bank stabilization measures to prevent streambank erosion due to excessive discharge velocities (usually bioengineered).
"DAYLIGHTING" STORM SEWERS	Eliminate a storm sewer or culvert and replace it with an open, vegetated channel.
RETROFITTING EXISTING STORMWATER DETENTION BASINS	Modify older basins that were designed to control only the 100-year storm into multi-functional stormwater wetlands or conventional wet ponds to manage first flush stormwater.
GREEN PARKING LOTS	Install new bioretention areas, infiltration areas, underground vaults, or other practices to detain and clean parking lot storm water before discharging. Encourage businesses to share parking space, require that vegetated spaces in parking lots be used to treat stormwater, encourage mass transit, encourage permeable spillover parking.
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.
CHECK DAMS IN VEGETATED SWALES	Where possible, install check dams along vegetated swales to slow water flow. This measure improves sediment and pollutant removal.
NON-STRUCTURAL BMPs	
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.
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.
ADOPT A STORMWATER ORDINANCE (OR REVISE EXISTING ORDINANCES)	This policy tool can be used to control and treat stormwater discharges to prevent flooding, minimize downstream channel erosion and protect water quality.
ENCOURAGE AND/OR REGULATE LAND USE PLANNING AND MANAGEMENT	Develop ordinances to manage storm water impacts by limiting pavement, preserving open space, defining locations for more on-site storm water management facilities, and zone/sizing criteria for on-site facilities.
ENCOURAGE AND/OR ENFORCE 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.
PROVIDE INCENTIVES FOR CONSERVATION IN SITE PLANNING	Methods include buffer flexibility, property tax credits, density bonuses, transferable development rights, providing credits for natural area conservation, disconnecting roof runoff, and routing sheetflow to buffers.

APPENDIX D

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
NON-STRUCTURAL BMPs	
RAIN GARDENS AND RAIN BARRELS IN SMALLER, PRIVATELY OWNED LANDSCAPES	Encourage or require homeowners and developers to install small basins in individual yards, sited where they can capture a small amount of local water before it enters a neighbourhood system.
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.
CATCH BASIN CLEANING	Catch basins hold sediment as it enters the stormwater pipe system, but once it becomes full of sediment, it can no longer catch sediment. Therefore, basins should be cleaned twice annually.
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.
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.
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.
REQUIRE USE OF EROSION CONTROL METHODS DURING CONSTRUCTION	Limit erosion and sedimentation by limiting the extent of bare and eroding soil, and treating saturated water before it runs off site by: • limiting total bare soil exposed by phasing, • protecting bare soil through mulching and revegetation, • diversion of flow around disturbed areas, and • sediment removal through detention by imposing time restrictions on construction.
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.
PROTECT RECEIVING WATERS FROM BANK EROSION	Stabilize existing steep slopes with bioengineering methods, and preserve and plant trees along streams to reduce bank erosion.
CATCH BASIN CLEANING PROGRAM	Catch basins should catch sediment as it enters the stormwater pipe system, but once it becomes full of sediment, it no longer catches sediment. Basins should be cleaned at least twice annually.

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
NON-STRUCTURAL BMPs	
DEVELOP A MECHANISM SO THAT LAND CLEANING PRACTICES ARE COORDINATED WITH SITE PLANNING	Much of the degradation of natural features occurs when the land is cleared. If the preservation of features is included in the planting, then subsequent clearing could be limited to necessary areas.
ESTABLISH BETTER ENFORCEMENT, FINES TO ENSURE COMPLIANCE	May include hiring more staff to inspect and enforce regulations.
EDUCATION OF PLANNING COMMISSIONERS AND DEVELOPERS	Create a regular mechanism to inform planners and developers as to their responsibilities and opportunities in site design and review.
ENCOURAGE AND COORDINATE "OPEN SPACE DEVELOPMENT" TO PROTECT NATURAL FEATURES	Create ordinances that allow and encourage "open space development" which leaves undisturbed natural features and a certain percentage of open space on a site. Township coordination 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.
ESTABLISH OR REVISE TREE REPLACEMENT PROGRAMS	Woodland mitigation and Tree Replacement standards and ordinances often only encourage the establishment of monoculture or non-native horticultural species that do not "replace" what was lost.
CREATE VOLUNTARY INCENTIVES FOR PRESERVATION OF FARMLAND AND OPEN SPACE	Work with agencies, organizations and individuals to understand what programs have worked in other communities (tax incentives, growth areas/boundaries, Agricultural zones and so forth).
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.
CREATE A NATURAL AREAS PROGRAM TO MANAGE NATURAL AREAS	This program would guide restoration activities in the watershed, educate land-owners on how to do restoration and/or manage their land, organize volunteers, and encourage stewardship.
CONDUCT ZONING ORDINANCE REVIEW	Establish a committee to conduct a formal review of zoning ordinances from a planning perspective for open space and natural features protection/restoration.
PLAN FOR RECREATION	Utilize natural features inventory and growth projections to protect recreation needs, and match that with natural areas that may facilitate that need.
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.
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.
COORDINATE AGENCY MONITORING EFFORTS	Enhance community staff and training to conduct periodic, regular sampling at key stations in your community to track changes.

APPENDIX D

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
NON-STRUCTURAL BMPs	
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. Friends of Twelve Mile Creek should be involved in this program.
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.
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.
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.
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.
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 Twelve Mile Creek 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.
INVITE THE PUBLIC TO REVIEW THE WATERSHED MANAGEMENT PLAN BEFORE IT IS FINAL AND WHEN REVISIONS ARE MADE	Distribute drafts of the plan to interested groups for review, hold meetings, and so forth to share ideas and involve key people.
LAND ACQUISITION	Jurisdictions can purchase property uniquely valuable to the community. Land purchases protect wells, wetlands, and strips bordering waterways. Publicly owned land is used for parks and recreation and preserved as open space to recharge groundwater, infiltrate stormwater, and provide habitat.

BEST MANAGEMENT PRACTICES MENU

MANAGEMENT ALTERNATIVE	DESCRIPTION
NON-STRUCTURAL BMPs	
INCENTIVE OR BONUS ZONING	This action promotes cluster development. It permits higher density development than normal in return for maximizing open and/or public use space or other amenities.
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.
FUNDING OPPORTUNITIES	
NEW/REVISED ORDINANCES	If necessary, an ordinance should be created or revised to meet water quality/quantity needs so that planning decisions based on that regulation is defensible.
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 ordinances, natural features inventories, zoning priorities, and so forth to ensure that stormwater measures are not in conflict with the master plan.

APPENDIX E

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

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

APPENDIX E

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

APPENDIX F

RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

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

RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

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

RESTORATION SUITABILITY CRITERIA: WETLAND HABITAT

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

RESTORATION SUITABILITY CRITERIA: WETLAND HABITAT

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

APPENDIX F

RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

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

RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

HABITAT: UPLAND FOREST	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: 0-240M WETLAND BUFFER HABITAT THRESHOLDS (sigwetdr) 3 < 50m 2 50m - 120m 1 120m - 240m	Areas within these buffer distances contribute to a range of habitat functions when vegetated. Vegetation within closest proximity to the wetland provides the greatest benefit to that wetland. These areas are thus considered most suitable to restoration.	Generate straight line distance surface from wetlands. Reclassify surface values where habitat threshold distances have highest suitability value.	Niagara River AOC RAP Wetland Extent Guidelines
CRITERIA: PROTECTED AREA (careasdr) 3 within conservation area boundary 2 ≤ 30m from conservation area boundary 1 > 30m from conservation area boundary	Areas within C.A. boundaries are protected from development pressure and destruction. Areas in close proximity to these boundaries are good areas to restore in terms of establishing connectivity.	Generate straight line distance surface from Conservation Area boundary polygons. Reclassify surface values according to restoration suitability.	Niagara Peninsula Conservation Authority
CRITERIA: SLOPE (slopedr) 3 ≥ 10 degrees 2 < 10 degrees 1 0 degrees	Considers the presence of forest cover in terms of hydrological and mechanical contribution to slope stability and erosion control. As slope increases, restoration suitability increases.	Generate slope surface from DEM. Reclassify surface where higher slope values have higher suitability values.	North Carolina Coastal Region Evaluation of Wetland Significance
CRITERIA: FOREST COVER (coverwor) 3 woodland not present 2 planting site 1 woodland present	The amount of forest cover must be increased in order to meet habitat targets. It is obviously more suitable to restore forest habitat where it does not presently exist, or where infilling may be necessary from a previous restoration site.	Generate surface from natural vegetation polygons based on vegetation type. Reclassify areas lacking forest cover as highest suitability values.	Niagara River AOC RAP Evaluation of Upland Habitat

RIPARIAN

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

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

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

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

RIPARIAN

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

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

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

* Min Value

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

WETLANDS

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

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

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

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

WETLANDS

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

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

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

* Min Value

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

WOODLANDS

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

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

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

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

WOODLANDS

NORMALIZED VALUES

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

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

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

* Min Value

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

1. Using raster calculator, add together each surface * relative weight
2. Divide sum by total of relative weights
   Ie. (s1*w1 + s2*w2 + s3*w3 + ...) / (w1 + w2 + w3 + ...)
3. Compare result to manual weighting result

NIAGARA PENINSULA CONSERVATION AUTHORITY

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