NIAGARA PENINSULA CONSERVATION AUTHORITY

# TWENTY MILE CREEK WATERSHED PLAN

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## EXECUTIVE SUMMARY

The Twenty Mile Creek watershed is the second largest watershed within the jurisdiction of the Niagara Peninsula Conservation Authority, and it is located in the City of Hamilton, and the Regional Municipality of Niagara including the Town of Lincoln, Township of West Lincoln, and Town of Grimsby. The total drainage of the watershed is 291 square kilometres. The Twenty Mile Creek watershed contains 5 subwatersheds including the main branch of Twenty Mile Creek, North Creek, Sinkhole Creek, Spring Creek, and Gavora Ditch. Individual restoration strategies have been prepared for each of the subwatersheds to protect the unique characteristics of each system.

The headwaters of the main branch of Twenty Mile Creek originate in the former municipality of Glanbrook, and eventually the creek outlets to Lake Ontario at Jordan Harbour. Several Areas of Natural and Scientific Interest (ANSI) are protected throughout the main branch including the Jordan Harbour/Ball's Falls ANSI. Ball's Falls Conservation Area is also located in this portion of the Twenty Mile Creek Watershed. Several regionally significant wetlands and numerous Environmentally Significant Areas (ESAs) are also located in the Spring Creek subwatershed. The land use in the North Creek subwatershed is predominately rural/agricultural in nature. Therefore, specific restoration and best management practices are required to create new riparian and wetland cover to enhance water quality. The Sinkhole Creek subwatershed contains several sites of known karst topography. Karst areas are underlain by soluble rocks and are characterized by sinkholes, depressions and underground drainage. Originating from a series of agricultural drains, Gavora Ditch is unique because it is the only watercourse in the watershed that flows through a quarry.

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 *Twenty 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 Twenty Mile Creek Watershed. We also extend our appreciation to all of the survey participants for their participation in the survey. Our gratitude is also extended to the Twenty Mile Creek Watershed Plan Steering Committee for their participation in the creation of the *Twenty Mile Creek Watershed Plan*.

## TWENTY MILE CREEK WATERSHED PLAN STEERING COMMITTEE:

Andy Fevez, Chair of the Steering Committee

Norm Johnson, Township of West Lincoln

Carla Carlson, Town of Lincoln and Twenty Valley Association

David Mitchell, City of Hamilton

Don Campbell, Regional Municipality of Niagara

Suzanne McInnes, Niagara Peninsula Conservation Authority

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# INTRODUCTION

The Twenty Mile Creek watershed is the second largest watershed within the jurisdiction of the Niagara Peninsula Conservation Authority. This watershed has been identified as a priority watershed for the completion of a watershed management plan by the Niagara Peninsula Conservation Authority since 1996. The recently completed *Niagara Water Quality Protection Strategy (NWQPS)* (2003) has reconfirmed the need for a *Twenty Mile Creek Watershed Plan* to protect the watershed over the long-term. The *NWQPS* (2003) identified 32 Local Management Areas (LMAs). The Twenty Mile Creek watershed is located in LMA 1.1 and LMA 1.4. Combined, these LMAs form the boundary of the Twenty Mile Creek watershed **(Figure 1).**

The Twenty Mile Creek watershed is a highly significant watershed containing a provincially significant coastal wetland, Carolinian flora, and Niagara Escarpment features, and 32 percent of the watershed falls within the Greenbelt. The Twenty Mile Creek watershed is also an area rich in cultural heritage, and it boasts a reputable tourism industry in the Twenty Valley. Agriculture is the predominant land use in the watershed. Corn, wheat, cereal hay and livestock are common above the escarpment, and orchards, vineyards and greenhouses dominate agricultural land use below the escarpment. A watershed management plan will aid in protecting and enhancing the biological, cultural, agricultural, economic and recreational resources of the watershed.

## WATERSHED PLANNING AND TWENTY 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., Twenty 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 *Twenty 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 *Twenty 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 Twenty Mile Creek watershed planning process was completed in the Spring of 2005 (NPCA 2005a). 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. 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 Twenty Mile Creek watershed.

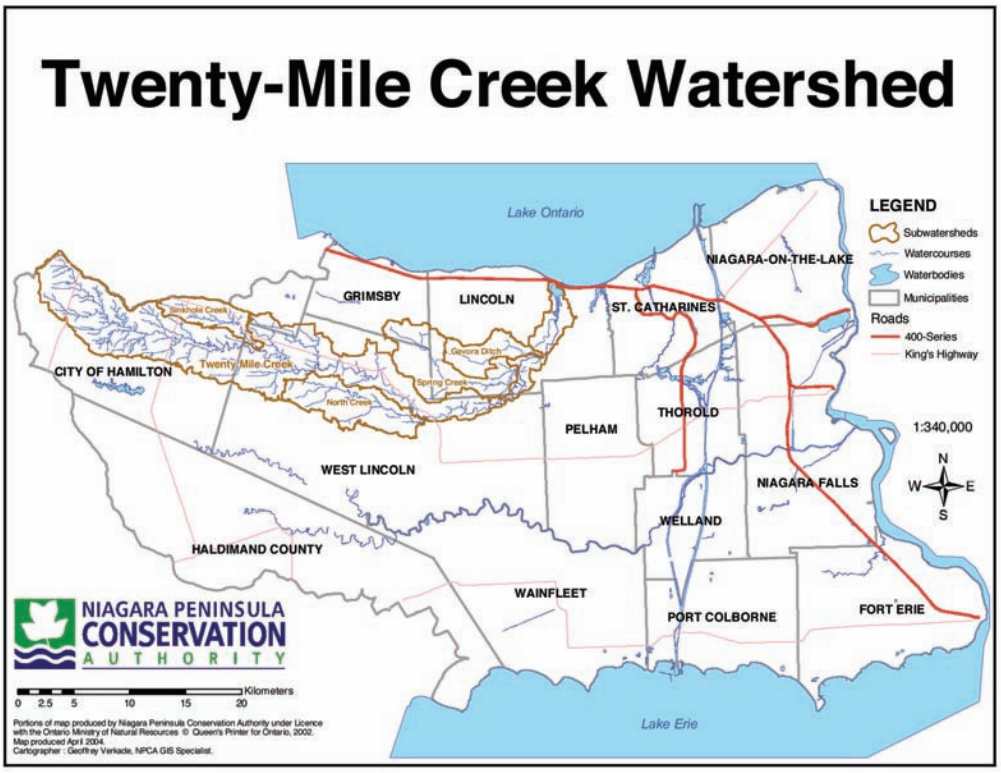


FIGURE 1: GEOGRAPHIC LOCATION OF THE TWENTY MILE CREEK WATERSHED

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), *Twenty Mile Creek Geomorphology Study* (1999), 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.

## 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 Twenty 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 Twenty Mile Creek watershed, 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 Twenty 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 Twenty Mile Creek watershed to:

### WATER RESOURCES

- maintain, enhance or restore stream processes to support human uses, agricultural needs and ecological functions;
- protect all municipal drinking water supplies, and protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ground water features, and their hydrologic functions (including karst environments);
- 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 minimize storm water volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces;
- manage and mitigate flooding risks to human life and property within acceptable limits, and;
- minimize erosion caused by human activity through the establishment and implementation of a comprehensive, priority based erosion control program.

### FISH AND AQUATIC HABITAT

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

### NATURAL HERITAGE AND RESOURCES

- protect, enhance, reforest and restore woodlands and wildlife habitat in the watershed for the long-term;
- protect, enhance and restore the stability, biodiversity, linkages and ecological function between habitats that support terrestrial and aquatic species and communities; and
- preserve wetlands of provincial significance 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

- promote 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 and encourage the efficient and sustainable use of wildlife habitat in terms of ecological needs;
- promote the efficient and sustainable use of water resources, including practices for water conservation and sustaining water quality; and
- encourage the creation of partnerships with agencies, organizations and landowners in the watershed.

# WATERSHED CHARACTERIZATION

## LOCATION AND DESCRIPTION OF TWENTY MILE CREEK AND ITS TRIBUTARIES

The Twenty Mile Creek watershed is located on the south shore of Lake Ontario, and it is located within the City of Hamilton and the Regional Municipality of Niagara including the Town of Lincoln, Township of West Lincoln, and the Town of Grimsby. Approximately two-thirds of the watershed falls within the Niagara Region. The total drainage area of the watershed is 291 square kilometres. Above the escarpment, the watershed is rarely wider than 5 to 6 kilometres with a dendritic drainage pattern. The Twenty Mile Creek watershed contains 5 subwatersheds including the main channel of Twenty Mile Creek, Gavora Ditch, Spring Creek, North Creek and Sinkhole Creek **(Figure 1).**

### TWENTY MILE CREEK

Flowing parallel to the Niagara Escarpment, the headwaters of Twenty Mile Creek originate along the former municipality of Glanbrook and Town of Ancaster (now part of the City of Hamilton) and continue into the Niagara Region. The topography is relatively flat throughout the portion of the watershed that lies above the escarpment. Twenty Mile Creek flows east through predominately agricultural lands and through the Town of Smithville before it veers north and drops 26 metres over the Niagara Escarpment at Ball's Falls Conservation Area. The creek enters Lake Ontario at Jordan Harbour, west of St. Catharines.

Base flow in Twenty Mile Creek drops to zero during the summer months, and some water is retained in the channel in pools (Harrington and Hoyle Limited, *et al.* 1999). Numerous Environmentally Sensitive/ Significant Areas (ESAs) are found within the subwatershed boundary of the main branch of Twenty Mile Creek. In addition, a series of woodlots in and around Smithville containing regionally significant wetlands are also located in the subwatershed of the main branch. Several Areas of Natural and Scientific Interest (ANSI) are protected throughout the main branch including the Jordan Harbour/Ball's Falls ANSI. Ball's Falls Conservation Area is also located in this portion of the Twenty Mile Creek watershed. The drainage area for the main branch of the Twenty Mile Creek is 171 square kilometres. Karst features have been identified in the Twenty Mile Creek watershed.

### SPRING CREEK

Sections of Spring Creek in the upper reaches have been excavated and straightened as a drainage ditch. Flow in this creek is characterized as intermittent especially during the summer months. Draining 45 square kilometres, this subwatershed also contains the Spring Creek Woodlots located in the northwest portion of the system. Several regionally significant wetlands and numerous ESAs are also located in this subwatershed.

### NORTH CREEK

The North Creek subwatershed drains an area of 38 square kilometres and is predominately rural/agricultural in nature. Baseflow in North Creek drops to zero during the summer months. The Caistor Centre N.W. Woodlots ESA contains the headwaters of North Creek, which are classified as a regionally significant wetland.

### SINKHOLE CREEK

The Sinkhole Creek subwatershed is rural/agricultural in nature with encroaching urban development approaching from the northwest. The total drainage area for this subwatershed is 17 square kilometres. Stream flow is intermittent in this subwatershed, especially during the summer months. Field observations also suggest that this creek "disappears" underground in several locations only to "reappear" at another location in the watershed. This type of topography is known as karst. Karst areas are underlain by soluble rocks (e.g., limestone and dolomite), and are characterized by sinkholes, depressions, caves, and underground drainage.

### GAVORA DITCH

Gavora Ditch is unique because it is the only subwatershed in the Twenty Mile Creek watershed that flows through a quarry. Originating from a series of agricultural drains it also has the smallest drainage area in the Twenty Mile Creek watershed (14 square kilometres) (ESG International 1999). To accommodate quarry operations, Gavora Ditch has been realigned around the future quarry extraction area at the Vineland Quarry site. Base flow in Gavora Ditch is intermittent, and it generally only flows during the spring melt period and following significant precipitation events (Jagger Hims Limited 1999; ESG International 1999). Karst features are also found in the Gavora Ditch subwatershed.

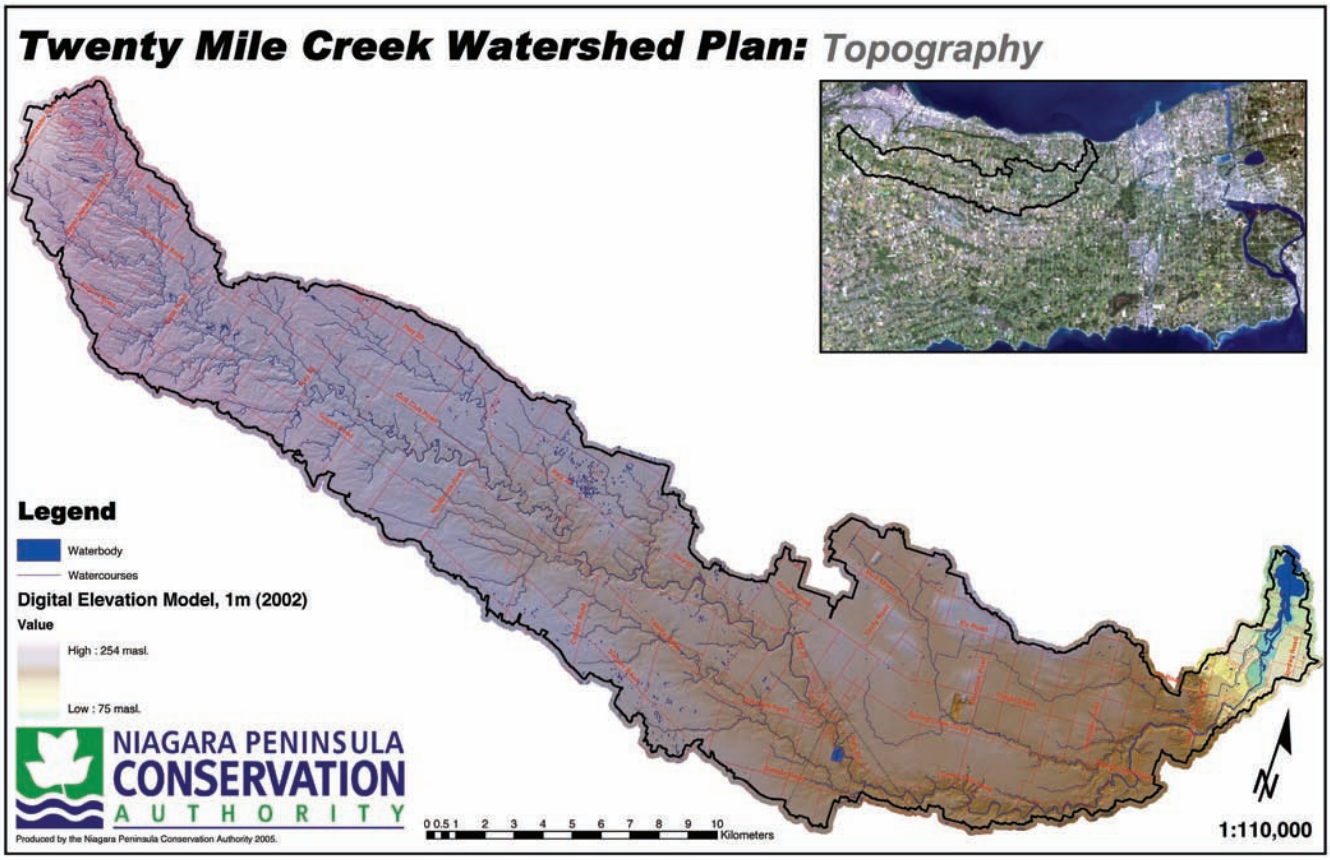


FIGURE 2: TOPOGRAPHY OF THE TWENTY MILE CREEK WATERSHED

## TOPOGRAPHY

The upper reaches of the Twenty Mile Creek watershed are characterized by rolling topography with fairly steep slopes in the headwaters. The middle and lower portions of the watershed area have a gently rolling to flat topography before the creek flows over the Niagara Escarpment at Ball's Falls Conservation Area. Twenty Mile Creek outlets to Lake Ontario through Jordan Marsh, which was created by lake waters flooding the lower reaches of the river valley as a result of isostatic tilting across the Ontario Basin (Harrington and Hoyle, *et al.* 1999) **(Figure 2).**

The isostatic rebound of the Niagara Peninsula is the first post-glacial event that altered the Twenty Mile Creek watershed. This event raised the downstream portion of the watershed, reducing the overall slope of the stream by approximately 10 meters over the length of the watershed. Most of Twenty Mile Creek flows over bedrock or is controlled by bedrock ridges. The creek has not been able to adjust vertically to compensate for the change. The second post-glacial event, which occurred approximately 2,500 years ago, was a divide breaching event that caused the upper half of Sixteen Mile Creek to be diverted into Twenty Mile Creek east of Smithville. This increased the watershed's size by approximately 10 percent with the addition of approximately 40 square kilometres around the North Creek tributary (Harrington and Hoyle, *et al.* 1999).

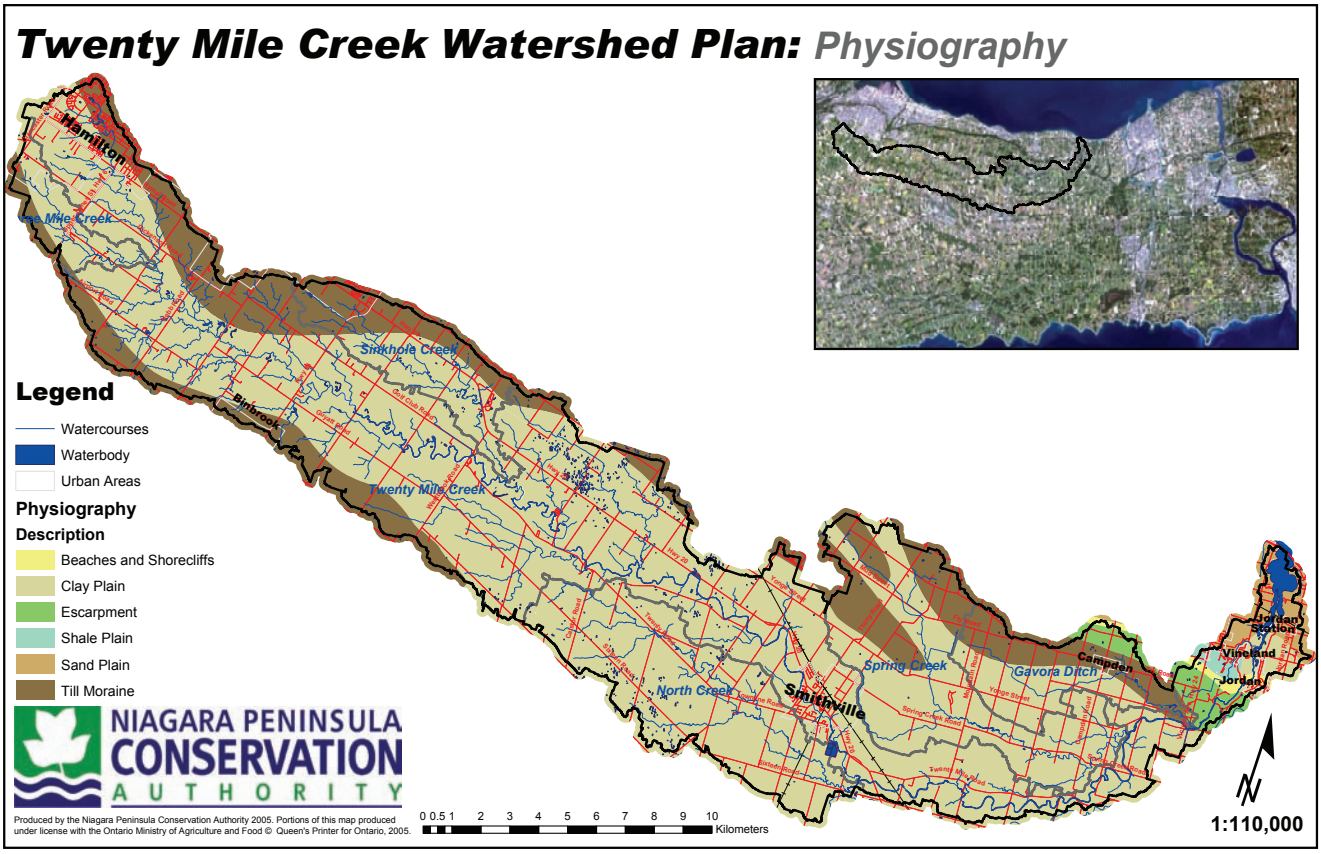


FIGURE 3: PHYSIOGRAPHY OF THE TWENTY MILE CREEK WATERSHED

## PHYSIOGRAPHY

Above the Niagara Escarpment, most of the watershed lies at the northern margin of the Haldimand Clay Plain physiographic region. This portion of the watershed is characterized by a broad flat clay plain with the exception of the sandy headwaters area. Drainage for Twenty Mile Creek originates in Ancaster and flows easterly between the Fort Erie Moraine to the south, and the Niagara Falls Moraine to the north. Covered by glacio-lacustrine clay deposits, the Fort Erie Moraine and the Niagara Falls Moraine are a set of moraines that parallel the brow of the Niagara Escarpment through the Niagara Peninsula. The predominant physiography of the Twenty Mile Creek watershed is the level to gently undulating clay plains (Hamilton Naturalists Club 1995) **(Figure 3).**

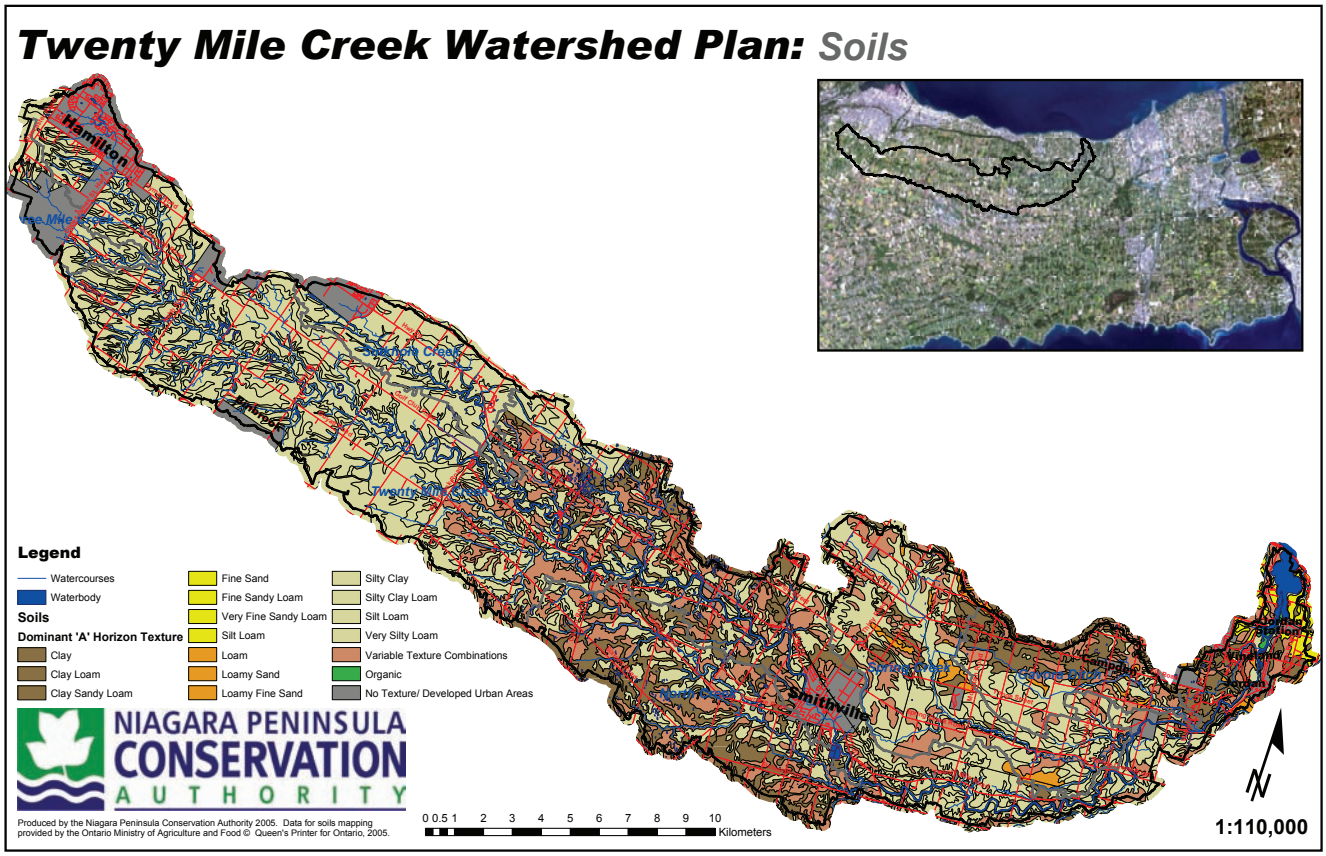


FIGURE 4: SOILS OF THE TWENTY MILE CREEK WATERSHED

## 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 for the portion of the watershed that falls within the Niagara Region. Soil data is less extensive for the section of the watershed that is located in the City of Hamilton. However, general soil data for this area is also included on **Figure 4.**

In the upper portion of the watershed, located above the Niagara Escarpment, the soils are representative of the Haldimand and Lincoln soil groups. Haldimand soils are imperfectly drained and slowly permeable soils with a medium to high water-holding capacity. These clay soils generally have a rapid surface runoff. This area is interspersed with sandy sediments in the headwaters area and loamy sediments over clay soils. Haldimand soils are suitable for growing common field crops if drainage systems (e.g., tile drainage) are used.

Lincoln soils, also found throughout the upper portion of the watershed, are closely related to the Haldimand soil group. Lincoln soils are poorly drained and usually slowly permeable. Due to the nature of this soil group, groundwater tends to occupy the upper surface and upper subsoil horizons for long periods each year. Surface runoff can be slow to rapid depending on the occurrence of cracks in the soil. Lincoln soils are suitable for field crops. However, like the Haldimand soil group these clay soils must be properly drained.

The Oneida and Smithville soil groups are most common in the watershed between Ball's Falls and Smithville. Oneida soils are moderately well-drained and moderately to slowly permeable. This soil group has a relatively high water-holding capacity, but fairly rapid surface runoff can occur on slopes. Soil textures are usually clay loam, with some silty clay loam. Smithville soils are moderately well-drained and slowly permeable unless cracks develop during dry conditions making these soils moderately permeable. Surface runoff is rapid and increases with slope. The loamy soils of the Smithville soil group are common in this portion of the watershed. However, inclusions of Haldimand and Lincoln soils are also found here. Due to the heavy clay content of these soils, the Smithville soil group is used for common field crops.

The Vineland soils group is common below the Niagara Escarpment. Vineland soils are imperfectly drained and moderately to rapidly permeable. The water-holding capacity of these soils is moderately low and surface runoff is slow to moderate. The predominant texture in this part of the watershed is characterized by very fine sandy loam. Vineland soils are highly rated for most agricultural crops, but in the Niagara Region they are commonly used for growing fruit crops.

## LAND USE

In general, the western portions of the watershed are characterized by rolling topography with urban, estate and strip rural residential development, together with livestock and poultry operations. The mid to eastern reaches of the watershed are characterized by gently rolling to flat topography and land uses tend more toward intensive crop and grape operations, some cattle operations, and nodal residential development. Golf course and aggregate operations are also located within the watershed **(Figure 5).**

The Town of Lincoln occupies approximately 20 percent of the watershed. Forty-two percent of the watershed lies within the Township of West Lincoln, and 36 percent of the watershed lies in the City of Hamilton, which contains the headwaters of Twenty Mile Creek. Only a small portion (2 percent) of the watershed is located in the Town of Grimsby. It is important to note that the portion of Grimsby that falls within the watershed is rural. Most of the urban development in Grimsby is located outside of the watershed boundary along Lake Ontario.

Agriculture is the predominant land use in the Twenty Mile Creek watershed. Agriculture in the watershed consists mostly of corn/wheat, cereal hay, vineyards and orchards, greenhouse operations, and pasture. Poultry, dairy and cattle are the dominant livestock operations in the watershed. For example, 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 livestock operations including, dairy, cattle, hog, and poultry and egg operations are concentrated in West Lincoln. Fruit and speciality crops (e.g., sheep and lamb, horse and pony, greenhouse, nursery product, and sod) are the main commodities in Lincoln. Only a small portion of the Twenty Mile Creek watershed falls within the Town of Grimsby. However, the agricultural data for Grimsby is included here, and it indicates a very small number of livestock operations and a concentration of fruit and speciality crops within its borders.

The agricultural resource sector for the Hamilton portion of the watershed was reported in *Hamilton's Agricultural Economic Impact and Development Study* (2003). The major commodity groups in the former municipality of Glanbrook include poultry and egg, wheat, grain and oilseed, nursery product and sod, greenhouse product, and hog. Only a small portion of the Twenty Mile Creek watershed falls within the former Town of Ancaster. However, the agricultural data for Ancaster is included here, and it indicates that dairy is the largest commodity. Despite a slight increase (3 percent) in the number of acres in production between 1996 and 2001 in Glanbrook, urban development is a potential concern in this part of the watershed.

Urban expansion is expected in the upper portion of the watershed in the City of Hamilton within the next 20 to 30 years. The Town of Smithville, located further east in the watershed is also expected to grow significantly over the next 30 years (*NWQPS* 2003). Other development near the watershed is the Aerotropolis or the lands surrounding Hamilton International Airport, which is located in the vicinity of the headwaters of Twenty Mile Creek.

Some small parks and conservation areas are distributed throughout the upper portion of the watershed. However, recreational land uses abound in the lower portion of the watershed including the Bruce Trail that runs along the Niagara Escarpment, the Waterfront Trail along Lake Ontario, and Jordan Harbour which is utilized for boating, hunting and fishing (*NWQPS* 2003). Ball's Falls Conservation Area is also located in the lower portion of the watershed. Owned and operated by the Niagara Peninsula Conservation Authority, Ball's Falls Conservation Area is a 128 hectare historical park and conservation area providing passive recreation and educational opportunities as well as wildlife habitat conservation and geologic feature conservation. The Glancaster Golf and County Club and the Twenty Valley Golf and Country Club are also located in the upper and lower portions of the watershed respectively **(Figure 5).**

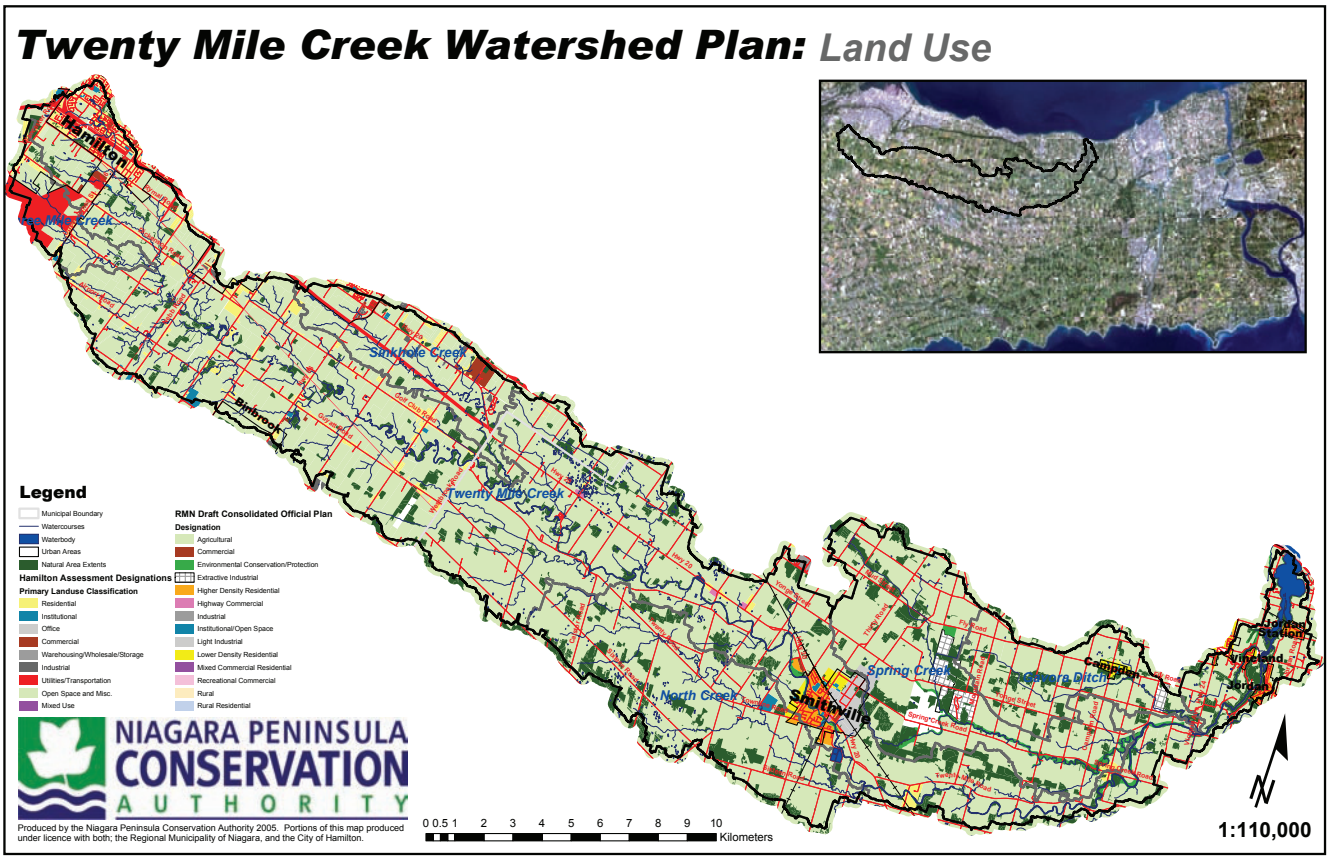


FIGURE 5: LAND USE IN THE TWENTY MILE CREEK WATERSHED

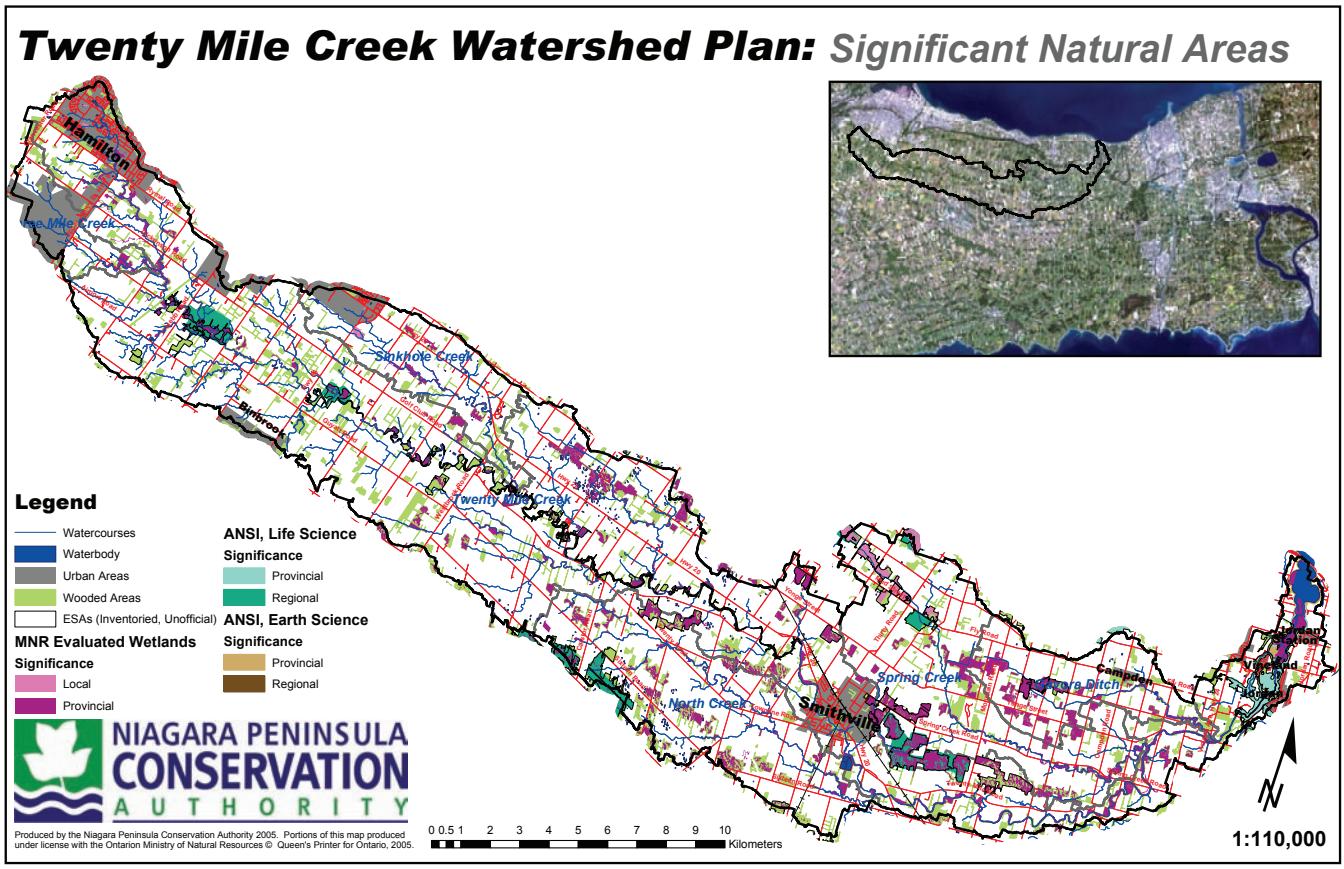


FIGURE 6: NATURAL HERITAGE AREAS IN THE TWENTY MILE CREEK WATERSHED

## 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 1.1 and 1.4 that make up the Twenty Mile Creek watershed indicate low to moderate total wetland and forest areas, with a greater proportion of the wetland and forested areas occurring in LMA 1.4 below the Niagara Escarpment. Protected land (parks and other natural areas) is at a minimum above the escarpment. However, below the escarpment approximately 20 percent of the land base is protected.

All of the natural heritage areas including wetlands, woodlots, Areas of Natural and Scientific Interest and Environmentally Significant Areas (ESAs) are illustrated on **Figure 6** and summarized in **Table 2** following the description of these areas.

| NATURAL HERITAGE | LMA 1.1 | LMA 1.4 |
|---|---|---|
| Open Wetland | 0.1 | 0.9 |
| Wetland Forest | 0.4 | 1.1 |
| Mixed Wetland/Lowland Forest | 4.1 | 6.3 |
| Moist/Dry Forest | 4.8 | 9.0 |
| Total Forest | 9.2 | 16.4 |
| Total Wetland | 2.5 | 5.0 |
| Protected Land | 4.7 | 20.4 |

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

## WETLANDS

The Ontario Wetland Classification system designates wetlands as "provincially significant" or "locally significant wetlands". Jordan Harbour Marsh has been classed as a provincially significant wetland in the watershed. In addition, the entire length of Twenty Mile Creek has been designated as a provincially significant wetland (Town of Lincoln 2000; Township of West Lincoln 1998). Numerous wetlands in the watershed are located in ESAs, which protects the wetlands from development including Jordan Harbour Marsh, Twenty Mile Creek Wetland, Caistor Centre Northwest Woodlots, Bismarck Northwest Woodlots, St. Ann's North Woodlots, and the Spring Creek Wetland. A description of each of these areas follows.

JORDAN HARBOUR MARSH is located in Jordan Harbour, which is a natural harbour formed by the drowning of Twenty Mile Creek in Lake Ontario. The Ministry of Natural Resources identified the Jordan Harbour wetland as a Provincially Significant Wetland for its species diversity, hydrology, social value and large size (135.22 hectares). The wetland marsh is regionally significant for providing fish spawning and rearing areas (M.M. Dillon Limited 1992; MNR 1992). It is also one of the largest remaining wetlands in the Niagara Region and it has been identified as an important coastal wetland in the Great Lakes system.

THE TWENTY MILE CREEK WETLAND runs the length of Twenty Mile Creek spanning the City of Hamilton, Town of Lincoln, Township of West Lincoln and Grimsby. The wetland types associated with Twenty Mile Creek are marsh (72 percent) and swamp (28 percent). This wetland is protected under the Greenbelt Act (2005) and it has been designated by the Ministry of Natural Resources as an area of high biodiversity for aquatic and related terrestrial functions.

THE CAISTOR CENTRE NORTHWEST WOODLOTS contain the headwaters of North Creek; a tributary of Twenty Mile Creek. The wetlands in this woodlot consist of 60 percent marsh and 40 percent swamp. This wetland contains mature trees occupying more than 51 percent of the wetland.

THE CAISTOR CENTRE NORTHEAST WOODLOTS is characterized by a combination of gently rolling terrain and imperfect drainage, which has resulted in swamp and marsh areas. This site has an unusually high diversity of biological communities and associated flora and fauna.

THE SMITHVILLE WEST WOODLOT AREAS 1 AND 2 consist of areas with marsh and swamp. Mature trees occupy more than 51 precent of these sites. Swamp White Oak, Balck Tupelo and Southern Arrowwood are all provincially significant plant species found at these sites.

THE BISMARK NORTHWEST WOODLOTS contains a wetland consisting of 74 percent swamp and 26 percent marsh in the North Creek subwatershed. This wetland contains mature trees occupying more than 51 percent of the wetland. Southern Arrowood, Pin Oak and Swamp White Oak, all provincially significant plant species, are located at this site.

THE ST. ANN'S NORTH WOODLOTS are located in the Township of West Lincoln. The wetlands at this site are comprised of a combination of 53.6 percent marsh and 46.4 percent swamp. Mature trees occupy 10 to 50 percent of the wetland area. Two provincially significant plants, Southern Arrowood and Swamp White Oak, are located at this site. The wetland is an active feeding area for the Great Blue Heron.

THE SPRING CREEK WETLAND is located along the northern border of the Twenty Mile Creek watershed within the Spring Creek subwatershed. This wetland is a combination of swamp and marsh. This wetland contains mature trees occupying more than 51 percent of the wetland.

| SITE | GEOGRAPHIC LOCATION | SIZE (HECTARES) |
|---|---|---|
| Twenty Mile Creek Wetland | West Lincoln/Lincoln | 100 |
| Spring Creek Bush/ Spring Creek Wetland | West Lincoln | 140 |
| Leyburn Bush | West Lincoln | 125 |
| Moore Woodlot | West Lincoln | 90 |
| Caistor Centre Northwest Woodlots/Wetland | West Lincoln | 14 |
| Caistor Centre Northeast Woodlots/Wetland | West Lincoln | 180 |
| Bismark Northwest Woodlots/Wetland | West Lincoln | 40 |
| Brouwer Bush | West Lincoln | 75 |
| Garber's Grove | West Lincoln | 105 |
| Smithville West Woodlot Areas 1 and 2 | West Lincoln | 8.5 |
| Durham Oak Grove | Grimsby | 40 |
| St. Ann's North Slough Woodlot/Wetland | Lincoln | 21 |
| Jordan Valley/ Jordan Harbour Marsh | Lincoln | 400 |

TABLE 2: NATURAL AREAS IN THE TWENTY MILE CREEK WATERSHED

## WOODLANDS

The Twenty Mile Creek watershed contains many isolated wooded areas and many areas of the creek and its tributaries are without riparian cover. Several areas have been identified as environmentally significant in the watershed and the Jordan Valley Area has been designated as an Area of Natural and Scientific Interest (ANSI). These woodlands have been evaluated by the MNR and mapped in partnership with the NPCA and Regional Niagara (Verkade Personal Communication).

THE JORDAN VALLEY ANSI consists of 400 hectares of Twenty Mile Creek in the Town of Lincoln. Spanning an area from the QEW at Lake Ontario south to Ball's Falls, the Jordan Valley ANSI includes a 2.9 kilometre portion of the Niagara Escarpment. One of the few naturally vegetated corridors on the Niagara Peninsula, the Jordan Valley ANSI is also part of a 7 kilometre corridor along Twenty Mile Creek that links the Niagara Escarpment to Lake Ontario (Hough Woodland Naylor Dance Leinster, *et al.* 2001).

The Jordan Valley ANSI provides representation of Niagara Escarpment features and river valley features of the Iroquois Lake Plain such as plain, rim, cliff, slope, terrace, terrace valley and incised valley. These features occur on rock substrates and deeper soils throughout the ANSI. A 1.2 kilometre incised gorge is a noteworthy feature in the ANSI because it is one of the most diverse on the Niagara Peninsula (MNR 1992). Other features of the ANSI below the Niagara Escarpment include a large flooded river mouth lagoon, the largest lakeshore marsh on the southwest shore of Lake Ontario, good quality oak valley slope forests, and some of the largest bottomland forests on the Iroquois Lake Plain (MNR 1992).

THE MOORE WOODLOT is located in the Spring Creek subwatershed and it serves as the headwaters area for 4 tributaries of Twenty Mile Creek as well as a catchment basin for agricultural runoff. This site is characterized by high species diversity and it provides forest, successional meadow and aquatic habitat.

SPRING CREEK BUSH is located in the Spring Creek subwatershed and it acts as a flow regulator for a tributary of Spring Creek. This site contains a high diversity of biological communities with forest succession from Oak/Pine to Maple/Beech forest.

LEYBRUN BUSH is located in the Spring Creek subwatershed. The wetland located at this site serves as the headwaters for Spring Creek, and it provides an excellent example of a mature, diverse, deciduous forest.

BROUWER BUSH is located between Twenty Mile and North Creeks. This natural area is important for augmenting flow for tributaries of both Twenty Mile Creek and North Creek.

GARBER'S GROVE is a privately owned woodlot with several small open swamps and intermittent streams that drain into both Twenty Mile Creek and the Welland River. The Haldimand Slough Forest of this site is biologically diverse due to the variation in the moisture regime found here.

DURHAM OAK GROVE acts as a flow regulator for Spring Creek and a catch basin for agricultural runoff, and it may provide a source of deep groundwater discharge.

## WATER QUALITY

Surface water quality is monitored in the Twenty Mile Creek through the NPCA Water Quality Program. Monthly grab samples are collected during the ice-free season at 5 monitoring stations in Twenty Mile Creek **(Table 3).** In addition to the 5 stations monitored on the main branch of Twenty Mile Creek, additional grab samples are taken during the ice-free season at 4 monitoring stations in Twenty Mile Creek tributaries including Gavora Ditch, Spring Creek, North Creek and Sinkhole Creek **(Table 3)**. All grab samples are analyzed for nutrients, metals and general chemistry. NPCA grab sampling stations are operated in partnership with the City of Hamilton, Regional Municipality of Niagara, and Ministry of the Environment. The locations of the water quality monitoring sites are illustrated on **Figure 7.**

Based on the data collected to date, water quality in Twenty Mile Creek is degraded primarily due to high nutrient concentrations. For example, concentrations of total phosphorus obtained from Twenty Mile Creek monitoring stations routinely exceed the Provincial Water Quality Objective of 0.03 mg/L. Sources of nutrient enrichment include rural and agricultural runoff, and faulty septic systems.

Benthic macroinvertebrate sampling has been completed at surface water quality monitoring stations TN001, TN002, TN006, GV001, NC001 and Twenty Mile Creek at Smithville using the BioMAP (Biological Monitoring and Assessment Program) protocol. Benthic macroinvertebrates are defined as the larger organisms inhabiting the substrate of waterways for at least part of their life cycle. Benthic macroinvertebrate species that are commonly found in the Niagara Peninsula include clams, snails, leeches, worms, and the larval stages of dragonflies, stoneflies, caddisflies, mayflies and beetles. At sites where water quality is impaired, the organisms found are less sensitive and therefore more tolerant to environmental stresses than organisms that would have historically occurred. The benthic population at an impaired site would typically be dominated by these more tolerant species, and as a result, biodiversity at the site would be quite low. BioMAP assessments completed in the watershed indicate that water quality in the watershed is impaired due to nutrient enrichment.

Results from all Twenty Mile Creek surface water quality monitoring stations are recorded in **Table 3.**

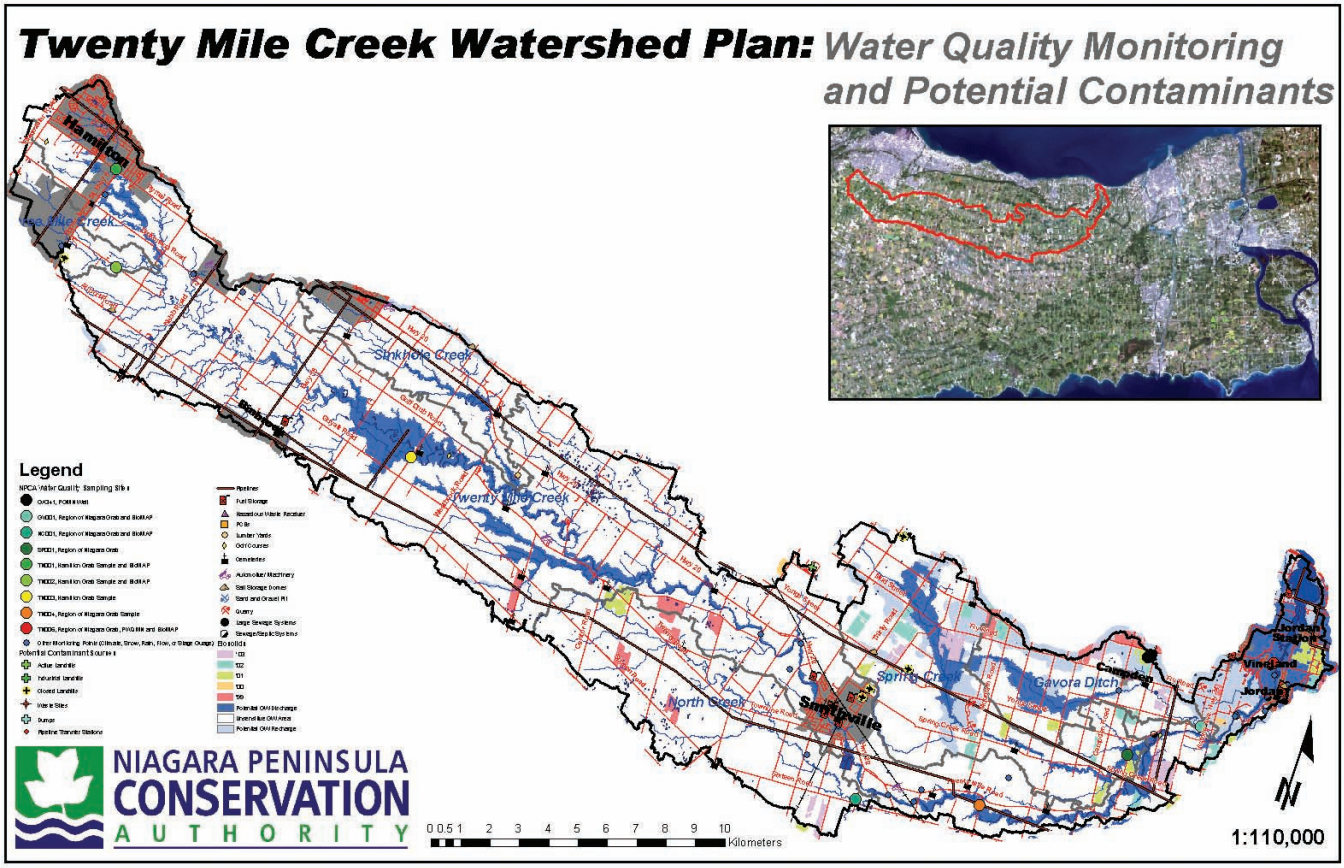


FIGURE 7: WATER QUALITY MONITORING AND POTENTIAL CONTAMINANTS

| STATION ID | LOCATION | RATIONALE | WATER QUALITY SUMMARY |
|---|---|---|---|
| TN001 (Twenty Mile Creek) | City Of Hamilton | • Upper Headwater Tributary | • Nutrient Enrichment<br>• Impaired BioMAP Rating |
| TN002 (Twenty Mile Creek) | City Of Hamilton | • Upper Headwater Tributary | • Nutrient Enrichment<br>• Impaired BioMAP Rating |
| TN003 (Twenty Mile Creek) | City Of Hamilton | • Upstream Of Smithville | • Nutrient Enrichment |
| TN004 (Twenty Mile Creek) | Region Of Niagara | • Downstream Of Smithville | • Nutrient Enrichment |
| TN006 (Twenty Mile Creek) | Region Of Niagara | • Outlet To Jordan Marsh | • Nutrient Enrichment<br>• Below Potential BioMAP Rating |
| GV001 (Gavora Ditch) | Region Of Niagara | • Tributary To Twenty Mile Creek | • Nutrient Enrichment<br>• Impaired BioMAP Rating |
| SP001 (Spring Creek) | Region Of Niagara | • Tributary To Twenty Mile Creek | • Nutrient Enrichment<br>• Impaired BioMAP Rating |
| NC001 (North Creek) | Region Of Niagara | • Tributary To Twenty Mile Creek | • Nutrient Enrichment<br>• Impaired BioMAP Rating |
| SH001 (Sinkhole Creek) | Region Of Niagara | • Tributary To Twenty Mile Creek | • No Data (Creek Dry) |

TABLE 3: SUMMARY OF NPCA SURFACE WATER MONITORING STATIONS IN THE TWENTY MILE CREEK WATERSHED

## GROUNDWATER RESOURCES

The NPCA currently operates 2 groundwater monitoring stations located in the Twenty Mile Creek watershed as part of the Provincial Groundwater Monitoring Network (PGMN). Monitoring wells GA341 and GA288 contain dataloggers which record hourly groundwater levels in the bedrock of the Clinton Group and Guelph-Lockport Formation, respectively. The first round of water quality samples from these wells were collected in the winter of 2004, and preliminary data indicates that groundwater quality does not exceed the Ontario Drinking Water Objectives.

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 headwaters area of Twenty Mile Creek, in the former Township of Glanbrook along Twenty Mile Creek, and on and below the Niagara Escarpment. Groundwater discharge areas are identified in 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 potential recharge area is located in the headwaters and on and below the Niagara Escarpment. Water that infiltrates to the water table may carry contaminants with it. Therefore, these areas are considered groundwater sensitive.

**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.

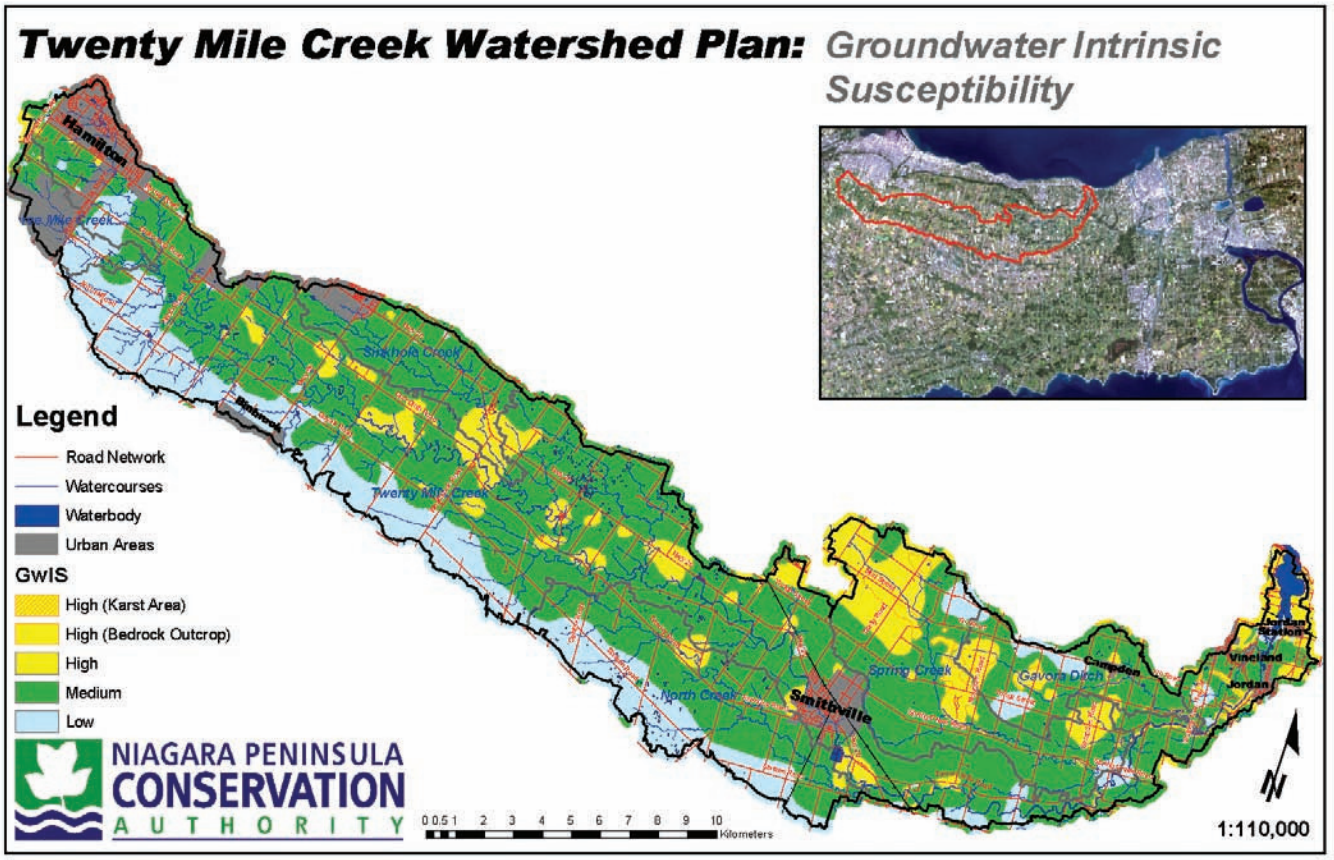


FIGURE 8: GROUNDWATER SUSCEPTIBILITY


## 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). 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 Twenty 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, the majority of Twenty Mile Creek and its tributaries that fall within the jurisdiction of the Niagara Region are classed as critical and important fish habitat.

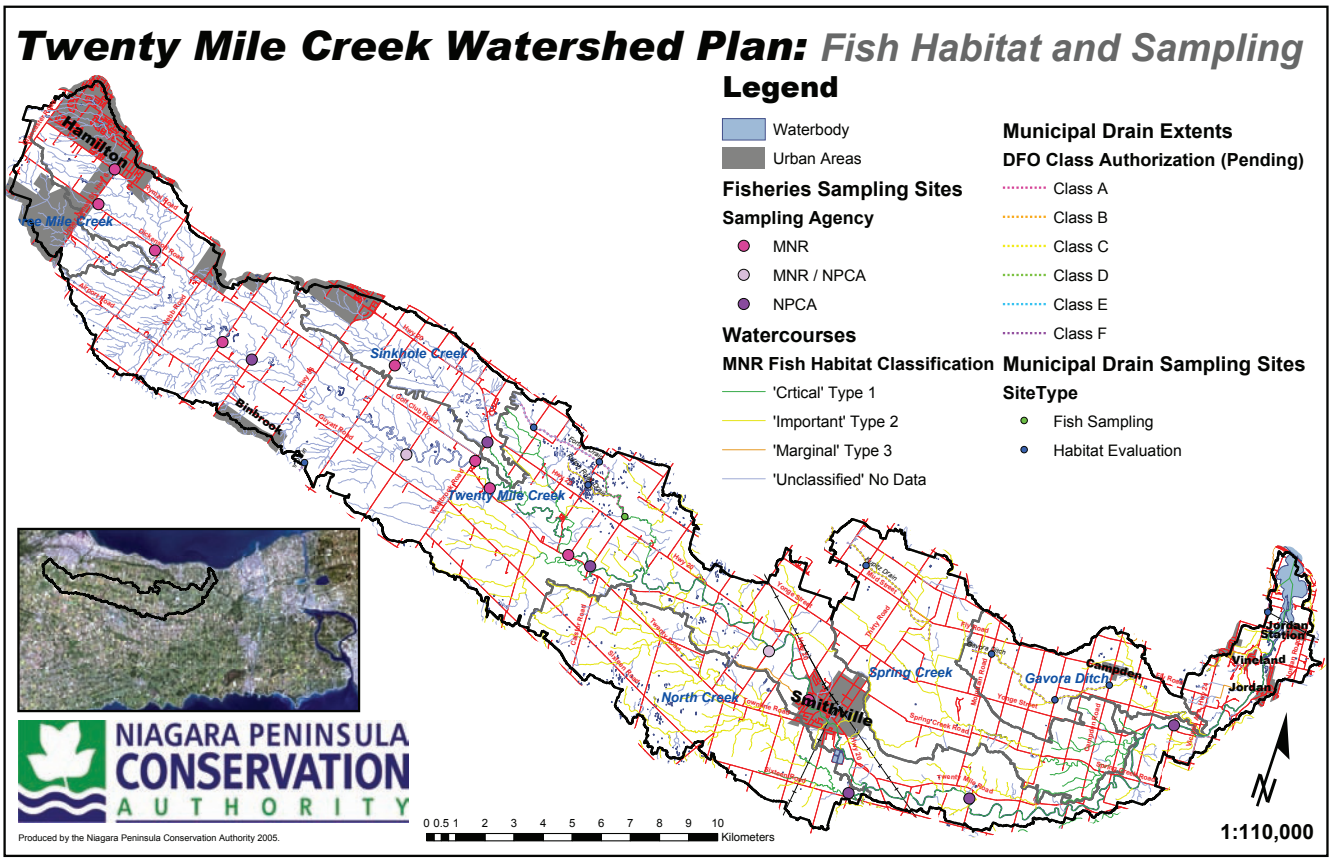


FIGURE 9: FISH HABITAT IN THE TWENTY MILE CREEK WATERSHED

## MUNICIPAL DRAINS

Several drains exist in the Twenty Mile Creek watershed. Even though their purpose is to remove excess water from the land, municipal and agricultural drains do contain fish habitat. To better manage these drains, Fisheries and Oceans Canada has developed a classification system which identifies municipal drains as Types A through F using variables such as flow conditions, temperature, fish species present, and the length of time since the last clean out (Fisheries and Oceans Canada No Date). For example, a Class A drain has permanent flow with cold or cool water temperature and no presence of trout or salmon present. A Type E drain also has a permanent flow with warm water temperatures and top predators (e.g., largemouth bass, northern pike, muskellunge and crappie) present in the drain. Type F drains are characterized by intermittent flow (Fisheries and Oceans Canada No Date).

As illustrated on **Figure 9** the drains in the Twenty Mile Creek watershed include the Fortino Drain (Class A) and the Fulton Road Drain (Class F) in the Twenty Mile Creek subwatershed. Kupitz Drain (Class F) is located in the Spring Creek subwatershed, and a portion of Gavora Ditch (Class F) is situated in the Gavora Ditch subwatershed.

## FISH SPECIES

The fish species found in 1974 (MNR) and 2004 (NPCA) are representative of an intermediately tolerant fish community. Given the results of both surveys, the fish community indicates that there has been little change in species diversity over the last 30 years in the watershed. Grass pickerel were captured in Twenty Mile Creek in 1974 and 2004. Grass pickerel are currently under review to be added as a Schedule 1 Species at Risk (Special Concern) either later this year or early next year. This will not give the species protection under the *Species at Risk Act*, but the Department of Fisheries and Oceans is starting to impose stricter management for grass pickerel.

## CHALLENGES AND OPPORTUNITIES IN THE TWENTY MILE CREEK WATERSHED

The *NWQPS* (2003) and the *Twenty Mile Creek Geomorphology Study* (1999) summarized a list of key water protection issues. Additional issues have been identified by residents living in the Twenty 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 Twenty Mile Creek watershed are reported here and specific management strategies are outlined in the watershed strategy included in this report.

### WATER RESOURCES

Summer base flow in Twenty Mile Creek and most of its tributaries is very low with no base flow upstream of the Niagara Escarpment during the summer months. Baseflow is low to non-existent in the summer due to a combination of factors related to land use such as loss of storage in forested areas, soil compaction, soil loss, and tile drainage. There may also be surface water losses via bedrock fractures and karst features.

Low base flow impacts water quality in the watershed because there is little water in the system to dilute known nutrient discharges of industrial waste, sewage effluent, agricultural runoff from fields, livestock operations, and runoff from urban areas and roads. The impact of the low base flows combined with nutrient discharges into the creek are evident in the summer when portions of the creek and its tributaries have severe odour problems and algae blooms (Harrington and Hoyle, *et al.* 1999).

Land use change is anticipated in the Twenty Mile Creek watershed. Future development is of utmost concern in the headwaters where water quality is threatened by the potential impacts of growth in the area around the Hamilton International Airport; also referred to as the Aerotropolis. Water quality and quantity can be negatively impacted when land is converted from natural areas and low-density use as in rural areas, to more intensive uses such as medium density residential or commercial use. A reduction in the size of natural areas leads to increased flow rates and velocities, and an increase in stormwater pollutants. This results in increased stormwater flows and flooding, erosion and sedimentation, and loss of natural features (e.g., wetlands), which are all problematic in the Twenty Mile Creek watershed. All of these issues will be addressed in the watershed strategy as part of this study. The specific impacts to water quality and quantity are discussed below.

### EROSION AND SEDIMENTATION

Increased erosion and sedimentation in watercourses is also a result of land use change in the 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.

An indicator of erosion potential along a stream boundary is the shear stress value for a given cross-section. Shear stress is the amount of stress exerted on the channel boundary by flowing water. Locations where significant shear stress values occurred for the 5 year storm return discharge were identified along Twenty Mile Creek. Since erosion of the channel bank is of concern for private and public properties it is important to know where high shear stress locations are to mitigate erosion potential.

Several sites that are subject to erosion have been identified through a computer modelling exercise **(Appendix C).** The first site is the Twenty Mile Creek headwaters, consisting of both the main channel and Three Mile Creek. The second site is located in Smithville just upstream and downstream of Canborough Street. Shear stress was also identified above the Niagara Escarpment around Victoria Avenue in Vineland (between High Road and Sixth Avenue), and the final location is near the mouth of the creek downstream from King Street in Vineland below the Escarpment. The shear stress values and the type of soil found at these sites indicate a vulnerability to erosion (NPCA 2005b). Recommendations for these sites are included in the following restoration strategy.

## WATER RESOURCES - WATER QUALITY

- Poor Surface And Ground Water Quality
- Groundwater Susceptibility Due To Fractured Overburden (Karst)
- Impacts Of Road Salt
- Sediment And Nutrient Inputs Including Septic Systems
- Impact Of Landfill Site On Regional Road 12
- Log Jams In Creeks And Subsequent Erosion
- Lack Of Tributary Buffers Through Intensive Cropland Causing Non-point Source Loading
- Manure And Nutrient Management
- Stormwater Management Facilities To Treat Urban Runoff

## WATER RESOURCES – WATER QUANTITY

- High Flooding Risk In Smithville
- Lack Of Year-round Flow (Shortages During Dry Years For Irrigation)

## 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 And Log Jams

## NATURAL HERITAGE AND RESOURCES

- Lack Of Forest Cover And Wetlands For Water Protection And For Wildlife Habitat And Population Protection
- Soil Erosion
- Impact Of Invasive Species
- Preserve Exiting Wetlands In The Watershed
- Preserve Species Diversity And Species At Risk Through Habitat And Corridor Protection

## URBAN DEVELOPMENT

- Investigate Potential Impacts From Future Urban Development In The Headwaters Area Of Twenty Mile Creek
- Investigate Potential Impacts Of The Proposed Niagara To Gta Corridor
- Urban Encroachment On Agricultural Land
- Loss Of Habitat And Biodiversity

## 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
- Partnership Creation With Organizations And Creation Of A "Friends" Group For Twenty Mile Creek
- Compensation Programs For Fragile And Valley Lands Put In Retirement
- Compensation Programs For Conservation Easements

BOX 1: TWENTY MILE CREEK WATERSHED CHALLENGES AND ISSUES

## PEAK FLOWS AND FLOODING

High stormwater flows in the upper portion of the watershed create flooding concerns downstream in the rural community of Smithville (NPCA 2005c). 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 are designed to include stormwater detention controls such as wet detention ponds, or on a smaller scale, residential rain barrels. Stormwater detention controls have been mandatory for water quantity issues since 1988 and in 1994 water quality was also included in stormwater pond design. Several municipalities, such as the City of Hamilton, are currently investigating methods to retrofit ponds created prior to 1994 to include water quantity protection (MOE 2003). The NPCA is currently developing a set of stormwater policies for its jurisdiction. These policies will also address stormwater pond retrofitting for water quality.

The downtown core of the Town of Smithville has been identified as flood prone only under the Regional Storm event (Hurrican Hazel) (Cumming Cockburn Ltd. 1988). However, ice jam conditions also pose a flooding concern for the downtown core. In 1988, a series of concrete dykes was recommended to increase the level of flooding protection for the downtown core. In addition, downstream of Griffin Street in Smithville, a number of residential structures were found to be flood susceptible under smaller storm events. The construction of an earth dyke was recommended at this site (Cumming Cockburn Ltd. 1988).

The floodplain mapping for the main branch of Twenty Mile Creek was completed in 2005 based on the 100 year storm event. This study identified 21 crossings that aggravate flooding along the main channel. These include:

- Flooding along the Three Mile Creek Tributary is aggravated by crossings at Upper James Street, the entranceway of Willow Park Golf Course, English Church Road, and Miles Road;
- Structures on the headwaters of Twenty Mile Creek at Christopher Road, Dickenson Road and Miles Road, all raise the 100 year flood profile; and
- Crossings at the rail (former railway) near English Church Road, Nebo Road, Blackhealth Road, Hendershot Road, Woodburn Road, South Grimsby Road 18, a driveway along Regional Road 20, Barters Drive, Saint Ann's Railway, Cerry Road, Sixth Street, King Street, and Twenty-First Street Louth all impact the 100 year flood profile of the main channel of Twenty Mile Creek (NPCA 2005c).

In addition, air photo interpretation has identified approximately 40 buildings in the 100 year event floodplain in the Town of Smithville.

## 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 later in this report.

## WEST LINCOLN SEWAGE LAGOON

A water treatment lagoon is a human-made pond where sewage is stored and undergoes natural decomposition. The water at the surface of the lagoon is relatively clean and is released into receiving flowing watercourses (e.g., streams, rivers). However, during periods of high rainfall, there is the potential for raw sewage to be released into receiving waterbodies, which can have human and ecological heath implications.

A project to reduce pollution at the Smithville sewage lagoons will reduce sewage overflows, basement flooding and water pollution through the installation of a holding tank. In addition, the capacity of the pumping station will be expanded in an effort to reduce discharges into Twenty Mile Creek (Ministry of Finance 2003). The 2005 floodplain mapping indicates that the 100 year flood line does not surpass the berms of the sewage lagoons, thus reducing the likelihood of direct contamination between the lagoons and the creek during a high flood event (NPCA 2005c).

## 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 Twenty 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. The study identified vulnerable areas for land use, groundwater, surface water, and natural areas. In the Twenty Mile Creek watershed, the Regional Road 20 corridor has been ranked as having high surface water vulnerability due to the high potential for runoff (Ecoplans Ltd. 2005).

## LANDFILL SITES

The Niagara Road 12 Landfill is located in the Twenty Mile Creek watershed. Several residents are concerned about the location of this landfill and its impact on Twenty Mile Creek. The Niagara Road 12 Landfill is located on Concession Road 7 in the Township of West Lincoln in the Gavora Ditch subwatershed; and it opened in October 1995. Residential, commercial and non-hazardous wastes are accepted at this landfill, and a household hazardous waste depot is located on site. The "Niagara Road 12 Landfill Site Citizen's Liaison Committee" was created to assist the Region in its efforts to operate the Niagara Road 12 Landfill Site (Regional Municipality of Niagara 1994). The locations of operating and non-operating landfill sites are on **Figure 7.**

## KARST ENVIRONMENTS

A karst environment is defined as a terrain typically underlain by limestone or dolomite whereby the topography is primarily formed by the dissolving of rock which may be characterized by sinkholes, sinking streams, closed depressions, subterranean drainage and caves (Monroe 1970). Conservation Authorities are in the process of identifying karst environments as hazard lands due to the potential problems related to flooding, surface collapse, and water quality.

The *Niagara Escarpment Planning and Development Act* (R.S.O. 1990, Chapter N.2) has eliminated the potential for serious problems to occur within the area designated as the "Plan Area" along the Niagara Escarpment including the portion that falls within the Twenty Mile Creek watershed. However, not all karst areas fall within the Plan Area. Cowell (2004) has noted that recent proposals for development along the Niagara Escarpment have encountered serious issues relating to: "the protection of adjacent designated areas; impacts associated with water withdrawal in karst terrain; impacts of nutrient and other contamination in karst terrains; surface flooding problems; and the potential for surface collapse". Karst areas have been identified for the Twenty Mile Creek watershed (Terra-Dynamics Consulting Ltd. 2005) and they are addressed in the watershed strategy later in this report.

## 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 a farm. In order to maintain soil and water quality, the Ontario government introduced the *Nutrient Management Act* in 2002. Under this act, farms must develop and implement a nutrient management strategy or a nutrient management plan. A nutrient management strategy is completed by non-agricultural and manure generators to manage the production, storage and use of manure and other nutrients produced and used on a farm. Nutrient management plans are completed for agricultural operations that apply nutrients to the land (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination.

## IRRIGATION WATER

Irrigation water shortages have been reported 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 Twenty 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. 2005a). This study investigated 4 districts in Regional Niagara requiring additional irrigation water. Two of these sites are located in the Twenty Mile Creek watershed.

The West District is comprised of lands below the Niagara Escarpment and above the Niagara Escarpment. Several options for this district have been presented based on cost. The most costly alternative for the Twenty Mile Creek watershed recommends

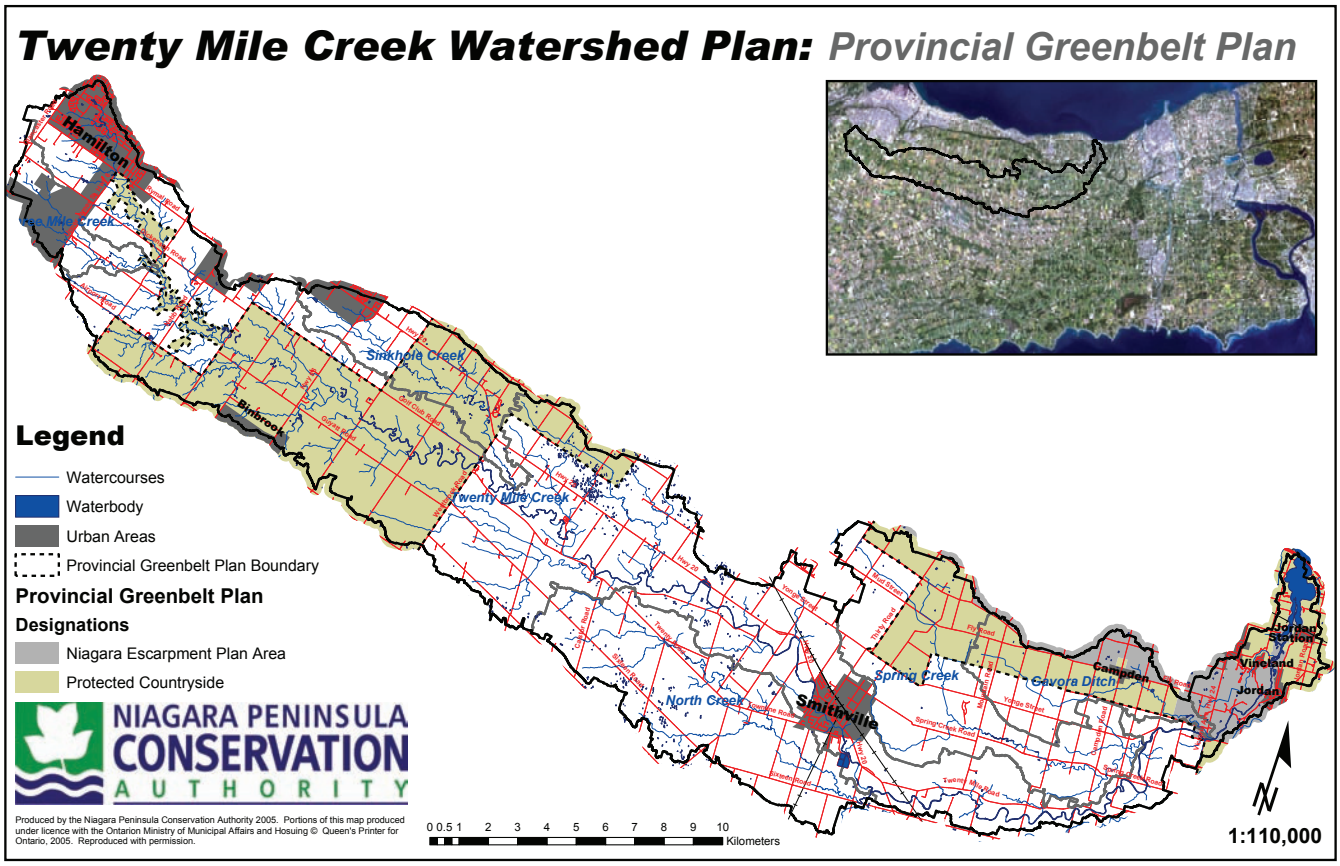


FIGURE 10: GREENBELT AND NIAGARA ESCARPMENT PLAN AREAS

taking water from Lake Ontario and/or Jordan Harbour. A pipeline distribution system with an intake from Lake Ontario has also been presented as an option. A third and least costly alternative is to create off-stream reservoirs close to major water sources (Lake Ontario). In addition, for the lands above the Niagara Escarpment groundwater wells have been identified as an option depending on available sources. If groundwater sources are limited, off-stream reservoirs are recommended in combination with groundwater supplies.

The recommendations presented in the feasibility study will impact surface and ground water resources and ecological systems in the Twenty 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.

## 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 Twenty 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* (1990), 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 Twenty Mile Creek Watershed.

## FISH AND AQUATIC HABITAT

The fish community in the Twenty Mile Creek watershed is representative of a tolerant warm water fishery. Different species of fish have varying tolerances to environmental change; therefore, they are considered valuable indicators of environmental and ecosystem health (Nottawasaga Valley Conservation Authority 1995).

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

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

Many residents in the Twenty Mile Creek watershed have commented on tumours on fish, smaller fish, and much fewer fish in Twenty Mile Creek. 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.

## 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 Twenty Mile Creek watershed in terms of protecting water quality, moderating water quantity and providing habitat. In natural areas stormwater is more or less infiltrated where it falls, allowing most of the pollutants to be filtered through soils. When these areas are lost, and their functions 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 Twenty 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
- augment low-flow by raising local water tables, which helps to maintain base flows

### FOREST HABITAT AND MEADOWS

The amount of forest cover in a watershed determines its ability to support species diversity. Although the Niagara Escarpment portion of the Twenty Mile Creek watershed contains considerable 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 and shading water courses,
- improves groundwater quality by increasing the amount of rainfall that percolates to the groundwater table,
- reduces soil erosion, and
- preserves and increases flora and fauna diversity.

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

## 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 Twenty Mile Creek watershed includes proposed large-scale land use changes associated with the Hamilton Aerotropolis and the Niagara to GTA Corridor.

### HAMILTON AEROTROPOLIS

Aerotropolis is defined as development surrounding the Hamilton International Airport. Aerotropolis Master Planned communities include services such as an airport, major highways, rail, port connections, mass transit service, airport industrial development, commercial/office spin-off development, and residential areas with schools and retail services (City of Hamilton 2005).

The John C. Munro Hamilton International Airport is located in the south end of Hamilton, within one day's drive to 150 million consumers, and it has been targeted as a proposed site for an Aerotropolis Master Planned Community. The vision for Hamilton's Aerotropolis is "to create an industrial, commercial and residential community around the Hamilton International Airport, that exists and grows in support of the airport's and the City's economic development objectives" (City of Hamilton 2005). The Airport Master Plan sets out objectives and recommendations to guide sustainable development decisions for the airport's operation and future development over the next 20 years (City of Hamilton 2004). The Hamilton Aerotropolis is currently being appealed to the Ontario Municipal Board (McGuinness 2005; Nolan 2005). However, if the Aerotropolis does move forward special attention will have to be given to Twenty Mile Creek because the headwaters are located within the proposed Aerotropolis development area. The lands surrounding the Hamilton International Airport are not considered prime agricultural lands (Soil Resource Group 2005).

### NIAGARA TO GTA CORRIDOR

The Niagara to Greater Toronto Area Corridor project is still in its infancy with the launch of a *Terms of Reference* in the Fall of 2005. The project was recognized after the existing transportation network was deemed incapable of supporting projected growth based on the province's *Growth Plan for the Greater Golden Horseshoe* (2005). Accordingly, the *Terms of Reference* identifies the need for the study based on transportation problems and opportunities within the Niagara to GTA region, current and future transportation needs, and it addresses a full range of reasonable solutions. The draft Growth Plan for the Greater Golden Horseshoe estimates that the Greater Golden Horseshoe area is expected to grow by almost 4 million people, which will bring the region's population to over 11 million by 2031. To accommodate this projected population the proposed environmental assessment for the projects will consider the need for the Niagara to GTA Corridor, alternatives such as roads, transit, rail, marine and other modes of transportation, alternative methods, and recommendations for specific infrastructure including mitigation measures.

The study area is still vague in its description **(Figure 11).** However, the Niagara to GTA Corridor has the potential to traverse portions or the entire Twenty Mile Creek watershed. It is difficult to determine the environmental impacts from the project until an alternative has been identified and assessed.


FIGURE 11: STUDY AREA FOR THE NIAGARA TO GTA CORRIDOR (MODIFIED FROM URS, *ET AL.* 2005)

## 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 Twenty Mile Creek watershed strategy. To facilitate communication between citizens and agencies in the Twenty 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 encourages the development of subdivisions whereby houses are clustered and open space is protected. Conventional subdivisions spread development evenly throughout a parcel of land. However, conservation subdivisions are considered "density neutral", which means that the same number of lots can fit on a parcel of land, but the arrangement of the houses are clustered. The clustered arrangement helps to protect water quality.

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

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

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

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

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

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

## WATERSHED BEST MANAGEMENT PRACTICES

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

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

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

- Managerial BMPs involve policy changes or operating procedures at a site (Brown, *et. al.* 2000).

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

| 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

### 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, stormwater 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 in 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 serve as the basis for the Twenty Mile Creek watershed strategy.
A summary of the wetland, riparian and forest habitat restoration guidelines have been reproduced in **Appendix E** and are discussed in greater detail following the watershed restoration strategy.

## WATERSHED STRATEGY

The Twenty Mile Creek watershed is the second largest watershed within the jurisdiction of the NPCA. For convenience, and to make restoration recommendations more manageable and easier to implement, the watershed planning strategy has been divided into separate regeneration plans for each of the 5 subwatersheds. The 5 subwatersheds are: Twenty Mile Creek, Sinkhole Creek, North Creek, Spring Creek and Gavora Ditch.

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 (2004c) 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 habitat 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 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 12-14).** In addition to the identification of areas suitable for riparian, wetland and upland restoration, areas where ecological linkages could be enhanced have also been provided, which have been derived through air photo analysis and the *Big Picture* (Riley and others 2003) **(Figure 15).**

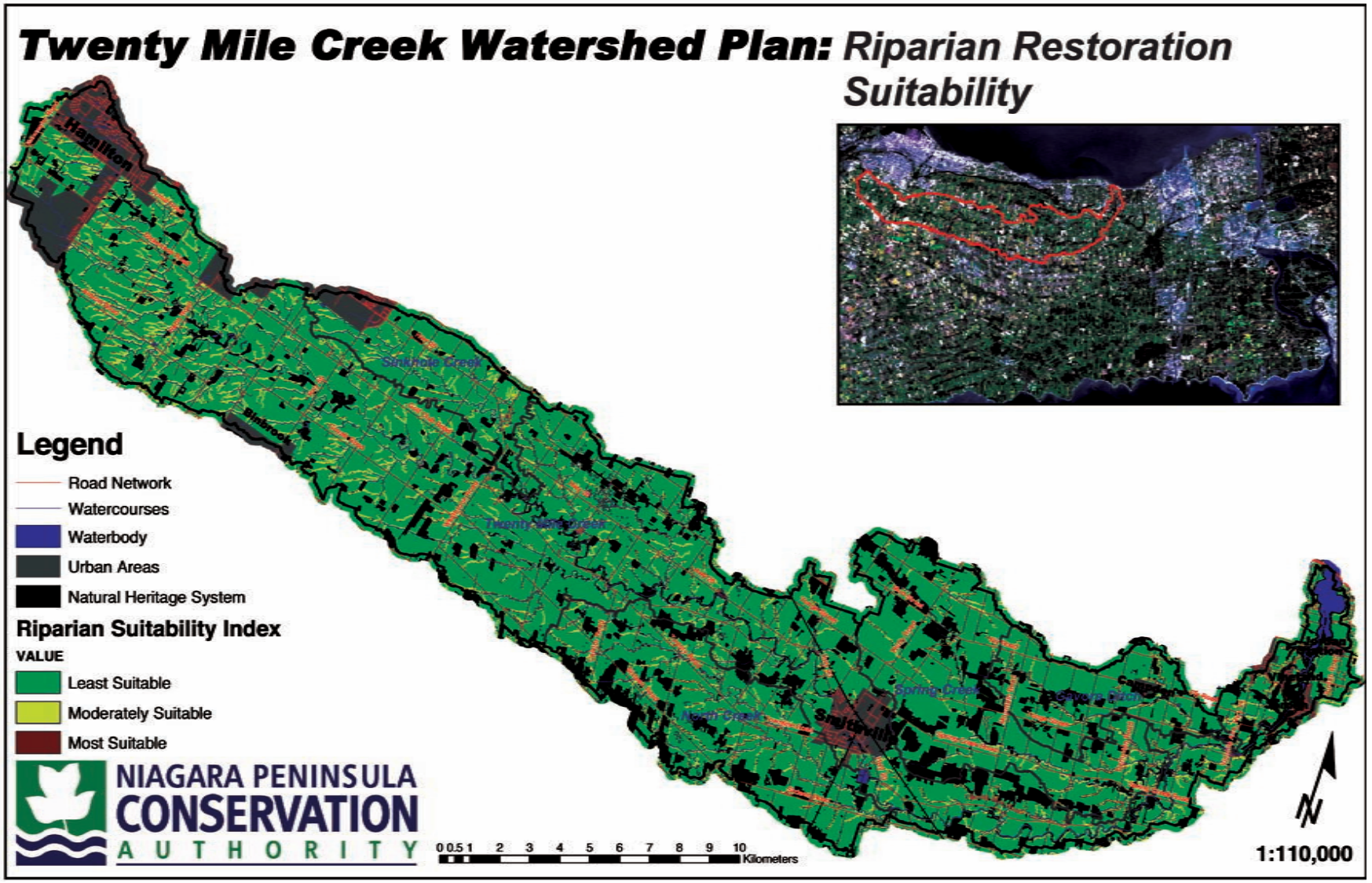


FIGURE 12: RIPARIAN RESTORATION SUITABILITY

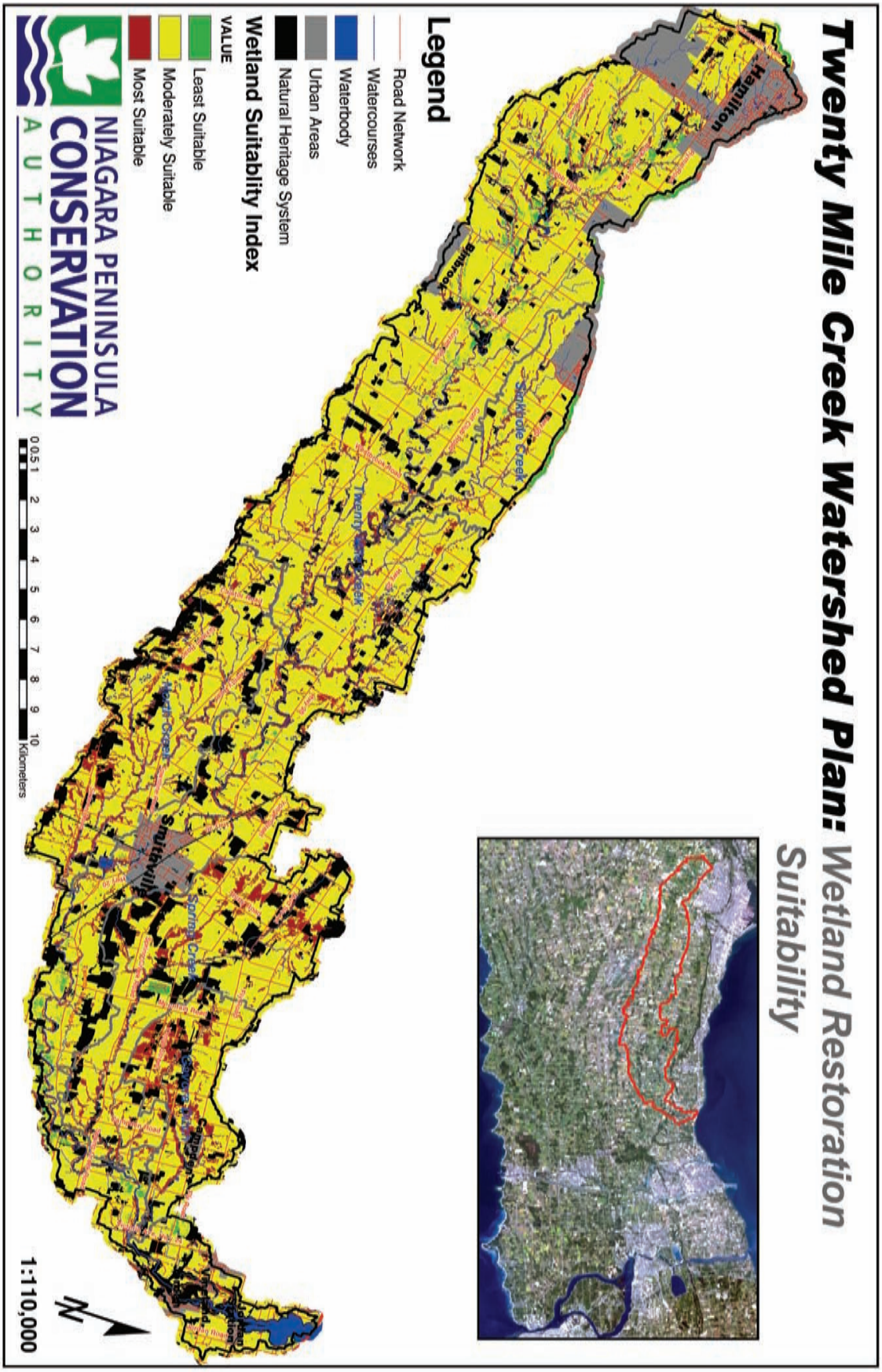


FIGURE 13: WETLAND RESTORATION SUITABILITY

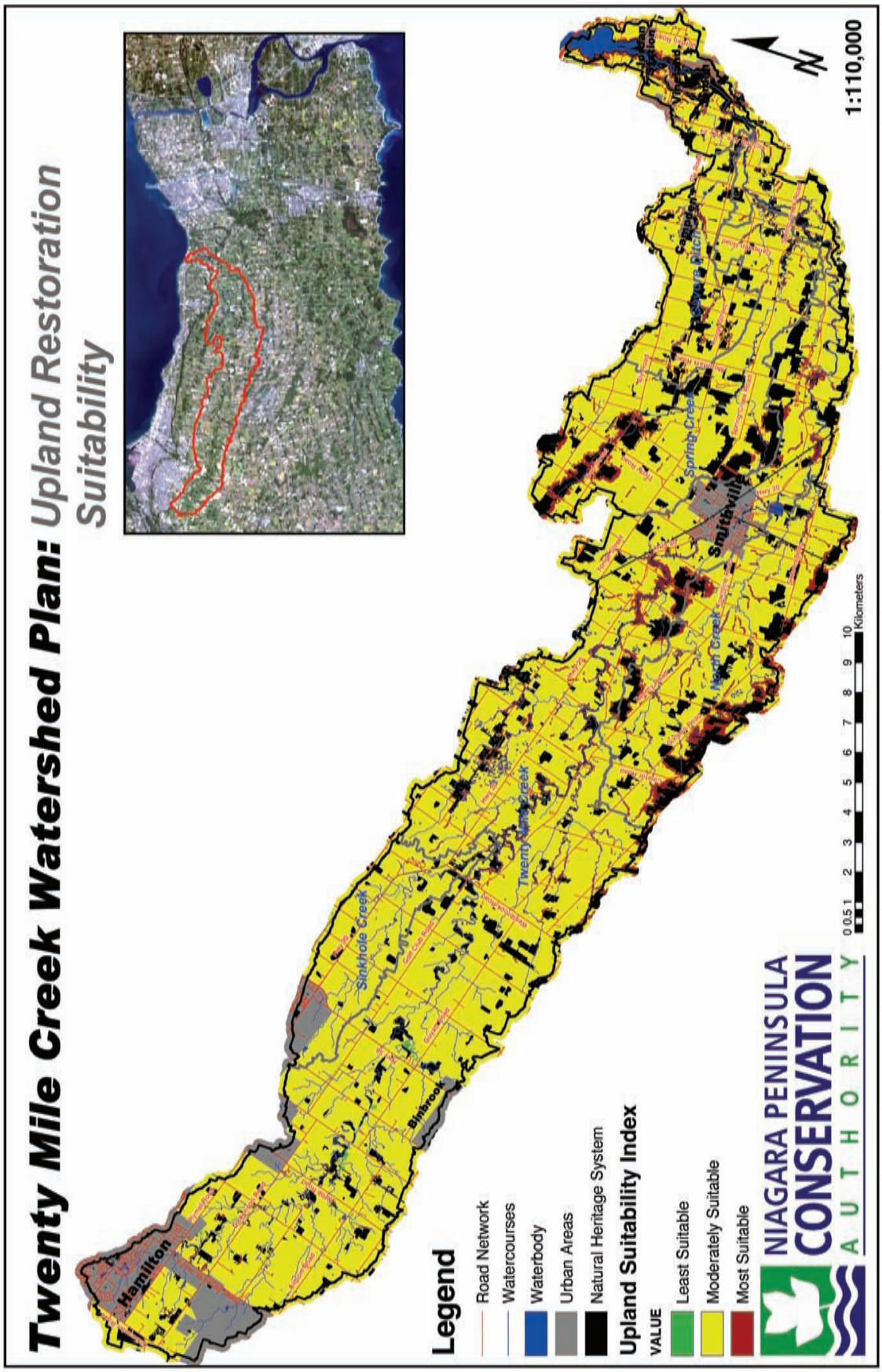


FIGURE 14: UPLAND RESTORATION SUITABILITY

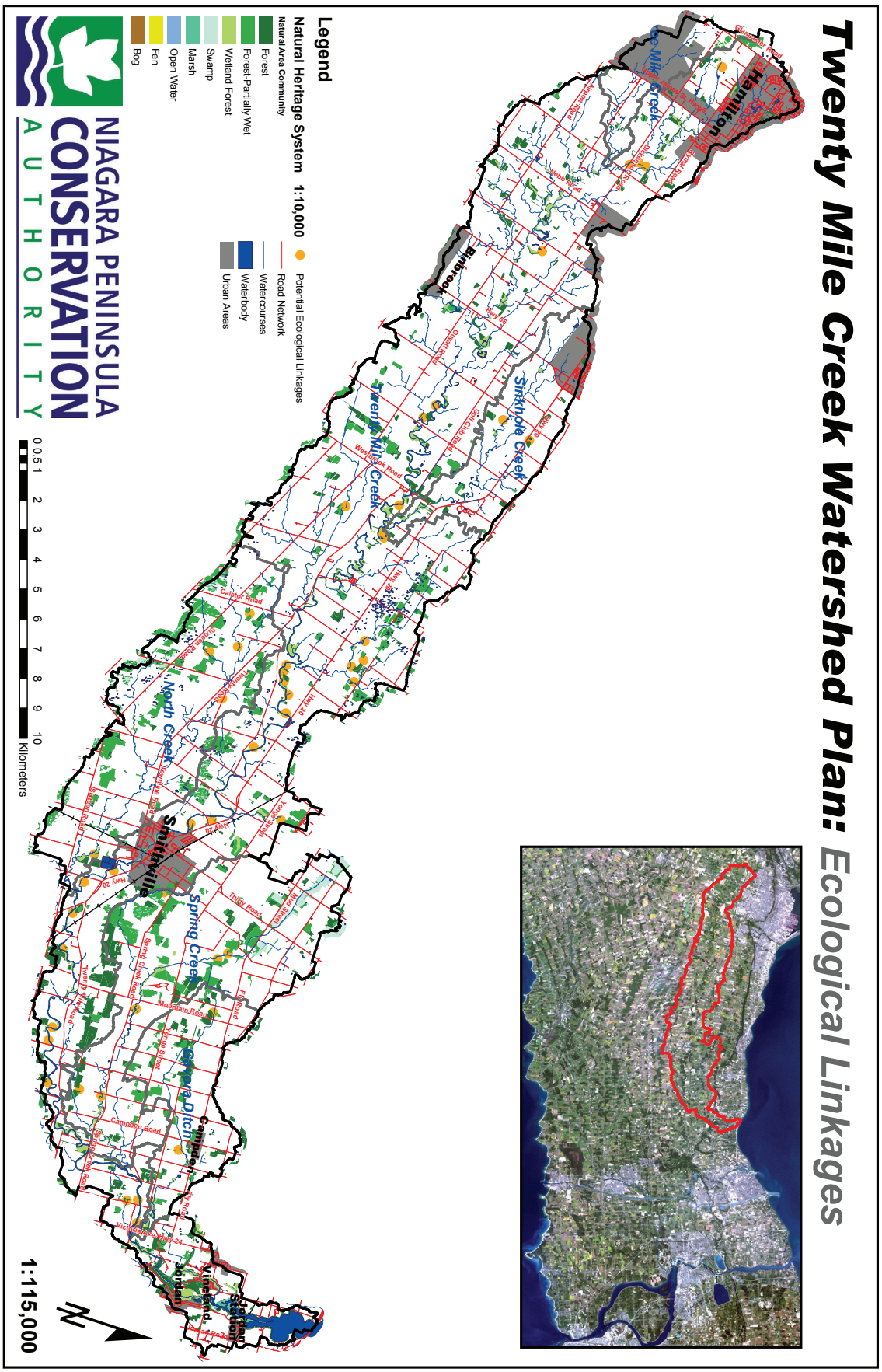


FIGURE 15: ECOLOGICAL LINKAGES

## TWENTY MILE CREEK MAIN BRANCH RESTORATION STRATEGY

The main branch of Twenty Mile Creek contains both the headwaters in Hamilton and the outlet of the creek to Lake Ontario through the provincially significant Jordan Harbour Marsh. Thus, several challenges exist for this subwatershed. For example, the Twenty Mile Creek headwaters contain a large forested area surrounded by provincially significant wetlands, located in an urban area in the City of Hamilton. The area surrounding these natural features are either already developed or are currently being developed (NPCA 2005b). It will be a challenge to minimize the impacts of urban development on the headwaters and provincially significant wetlands to preserve this natural area and protect the headwaters. At the outlet, environmental management of the Jordan Harbour Marsh and Niagara Escarpment is necessary to preserve and protect the provincially significant and coastal wetland, Niagara Escarpment features and Carolinian flora.

The Twenty Mile Creek Main Branch Restoration Strategy identifies 4 zones with specific stewardship and restoration recommendations **(Table 4).**

1) HEADWATERS INCLUDING THE HAMILTON URBAN AREA: The headwaters portion of the subwatershed would benefit from the protection and enhancement of the provincially significant wetlands and forested area from which the headwaters of Twenty Mile Creek originate. Opportunities for land acquisition of these lands should also be investigated to ensure their continued protection. A challenge for this portion of the subwatershed is to create buffers around the stormwater ponds and investigate the reported carp and goose problem (high numbers) at St. Elizabeth Village (private property).

There are also known karst areas in this subwatershed. Terra-Dynamics Consulting Inc. (2005) reported that surface water drainage that originates within the jurisdiction of the NPCA in the Twenty Mile Creek headwaters enters sinkholes and discharge to springs that are part of the Hamilton Conservation Authority's jurisdiction in the vicinity of Trinity Church Road. As part of their *Official Plan Review,* the City of Hamilton (2005b) suggests that the following issues be addressed when developing on karst:

- STORMWATER DRAINAGE: The rush of extra water gathered over an area can cause flooding when the amount of paved surface is increased in developments.
- UTILITIES: Buried utility lines can serve as a focus for sinkhole development because they provide a break in the bedrock for stormwater to enter and slowly dissolve the bedrock.
- GROUNDWATER CONTAMINATION: Water moves rapidly through karst and it undergoes little filtration. Therefore, groundwater in karst areas is easily polluted. If contaminants are introduced into a karst system they will spread quickly.
- FLOODING: Sinkholes and conduits may become blocked with debris and litter, resulting in water back-up and flooding. Sinkholes are often used as a convenient place to deposit trash.
- PROTECTION OF UNIQUE FEATURES AND THE DYNAMIC PROCESSES THAT CAUSE THE FORMATION OF KARST. Karst areas provide opportunities for education, research and recreation. They are also important hydrological systems, contributing to our ground and surface water supplies. For these reasons, policies must strive to protect the features and functions of karst systems.

These issues should be addressed for all development applications in karst areas throughout the Twenty Mile Creek watershed.

2) TOWN OF SMITHVILLE: The Town of Smithville has the potential to grow as a result of the limitations put on surrounding areas in the Greenbelt Plan (2005). Therefore, supplementary studies will be required to determine the ability of the Smithville Sewage Lagoons to accommodate additional development. Flooding has also been identified as an issue in this portion of the subwatershed.

A rain barrel program should be implemented to reduce rain water from entering the combined sewer system in the Town of Smithville, and to encourage water conservation. One combined sewer overflow has been identified in the Town of Smithville (*NWQPS* 2003).

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.

Floodplain mapping has been completed for the main branch of Twenty Mile Creek (NPCA 2005c), which will be used to regulate development in the floodplain as mandated by Ontario Regulation 97/04 (Development, Interference with Wetlands and Alterations to Shorelines and Watercourses). This regulation allows the NPCA to: prohibit, regulate or provide permission for straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream, watercourse, or changing or interfering with a wetland; and prohibit, regulate or provide permission for development for the control of flooding, erosion, dynamic beaches, pollution or the conservation of land that may be affected by the development (Conservation Ontario no date).

Karst topography has also been identified in the Town of Smithville. Terra-Dynamics Consulting Inc. (2005) has identified that additional studies are required because these karst features may be within the existing urban area or areas the municipality may want to consider for development in the future.

3) NIAGARA ESCARPMENT TO LAKE ONTARIO: Natural heritage features are abundant in this portion of the subwatershed. Existing natural features should continue to be protected and enhanced where feasible. Where suitable, upland areas should be expanded and planted with native species. This portion of the subwatershed also presents numerous education opportunities at the Jordan Harbour Marsh and Ball's Falls Conservation Area.

4) REMAINING RURAL AREAS: In addition to the natural features found in the headwaters and at the outlet of this subwatershed, numerous natural heritage areas dot the rural/agricultural landscape. Areas suitable for riparian planting have been identified and should be given priority due to their role in improving water quality. Wetland and upland restoration should also be carried out in areas identified as suitable to create larger contiguous habitat and enhance linkages for the movement of flora and fauna.

| RESTORATION OPPORTUNITIES | RECOMMENDED RESTORATION STRATEGIES | | |
|---|---|---|---|
| | RIPARIAN | WETLAND | UPLAND |
| HEADWATERS INCLUDING THE HAMILTON URBAN AREA | Due to the high degree of urbanization in the headwaters area of the Twenty Mile Creek Main Branch subwatershed, few areas are suitable for riparian, wetland and upland restoration. However, as urban development continues in this area all watercourses should be protected with a buffer up to 30 metres on each side (NPCA 1993 as amended in 2003 and 2005). In addition, municipalities and agencies with jurisdiction over erosion control should enforce the use of erosion control measures to control the discharge of sediment. Opportunities to plant buffers in areas that have already been developed should also be a priority in this portion of the subwatershed to enhance water quality and aquatic habitat. | | |
| TOWN OF SMITHVILLE | New development is occurring in the Town of Smithville. Proper mitigation measures should be installed in construction areas adjacent to watercourses and ditches, and they should be monitored for effectiveness. Opportunities to expand natural heritage areas located within the boundary of the town should also be given priority in this portion of the subwatershed. | | |
| NIAGARA ESCARPMENT TO LAKE ONTARIO | • The main branch of Twenty Mile Creek is provided with a continuous buffer along its length in this portion on the subwatershed; therefore, priority should be placed on protecting and enhancing the riparian cover | • Create new wetlands in areas where the wetness index and soil drainage permit (priority should be placed on areas near existing wetlands and woodlands to enhance ecosystem function) | • Reforest areas adjacent to existing forested areas to increase interior forest<br>• Maintain and enhance ecological linkages with adjacent forested areas |
| REMAINING RURAL AREAS | • Many stretches of the main branch and its smaller tributaries are without riparian cover; therefore, priority should be placed on establishing vegetated buffers (minimum 15-30 metres) along watercourses to enhance water quality | • Create new wetlands in areas where the wetness index and soil drainage permit (priority should be placed on areas near existing wetlands and woodlands to enhance ecosystem function, and along the main branch of Twenty Mile Creek) | • Reforest areas adjacent to existing forested areas to increase interior forest<br>• Maintain and enhance ecological linkages with adjacent forested areas |

TABLE 4: TWENTY MILE CREEK MAIN BRANCH RESTORATION STRATEGY ACTIONS

| PROJECT OPPORTUNITIES | RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS |
|---|---|
| STORMWATER PONDS IN THE HEADWATERS | A unique project opportunity has presented itself in terms of creating fish habitat in stormwater ponds in the headwaters. Numerous detention ponds are located in the headwaters and they are online with Twenty Mile Creek. The ponds are currently mowed to the edge and carp has been reported as a problem. Additional study is required that addresses the carp problem and lack of riparian buffer around the online ponds. Opportunities to enhance fish habitat should also be considered. |
| GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES | *The Groundwater Study* (2005) has identified several areas with high intrinsic susceptibility due to bedrock outcrops. The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Areas with exposed bedrock increase the potential for the movement of contaminants into the groundwater system, thereby making them susceptible to contamination. Additional studies should be conducted in these areas 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*. |
| RIPARIAN BUFFER ALONG REGIONAL ROAD 20 | The Regional Road 20 corridor has been ranked as having high surface water vulnerability due to the high potential for runoff (Ecoplans Ltd. 2005). Riparian restoration should be targeted for watercourses in the Twenty Mile Creek watershed along Regional Road 20 to lessen the impacts from road salt on water quality and aquatic habitat. |
| EROSION STUDY AND RESTORATION | Several sites along the main branch are susceptible to high shear stress. High shear stress values are indicative of erosion potential. Several sites have been identified as having a high erosion potential and are addressed by the NPCA (2005b) and illustrated in Appendix C. |
| **SPECIAL PROJECTS** | **RECOMMENDATIONS FOR FURTHER STUDY** |
| KARST STUDIES | Two known karst areas exist in this subwatershed (Terra-Dynamics Consulting Inc. 2005). Additional study is required for both areas to ensure they are protected from future development. |
| SMITHVILLE MASTER DRAINAGE PLAN | The current Master Drainage Plan (1989) for the Town of Smithville is outdated. Development of a new plan, that emphasizes where growth in the Town is anticipated, should be undertaken. |
| URBAN RAIN BARREL PROGRAM | A rain barrel program should be researched, designed and implemented to encourage water conservation in the subwatershed. In addition, a downspout disconnection bylaw should be developed and implemented to encourage landowners to discontinue the practice of directing rainwater from rooftops to storm or combined sewers. |
| 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 $2,000 and $10,000. |
| 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. |
| 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. |
| ABANDONED WELL DECOMMISSIONING PROGRAM | Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. A well decommissioning program similar to the one available through the *Hamilton-Halton Watershed Stewardship Program* should be established for all residents in the Twenty Mile Creek watershed. For example, the *Stewardship Program* provides funds through the City of Hamilton to assist landowners with the cost of decommissioning their wells. Residents of Hamilton may be eligible to receive at least 50% of the cost (up to $500) to decommission their well(s) (maximum 2 wells per property). Landowners in the City of Hamilton portion of the Twenty Mile Creek watershed are currently eligible for this program through the City of Hamilton. |
| POLICY TOOLS | Policy tools such as stormwater management policies, and protection of karst areas should be developed and included in regional and municipal Official Plans to ensure unity in environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction and they are complete for the City of Hamilton. |

TABLE 4: TWENTY MILE CREEK MAIN BRANCH RESTORATION STRATEGY ACTIONS

## SINKHOLE CREEK SUBWATERSHED RESTORATION STRATEGY

Sinkhole Creek flows through rural and agricultural areas as well as some residential and commercial developments located in the western portion of the subwatershed. The Sinkhole Creek subwatershed is unique because the creek "disappears" in many locations due to the karst topography found throughout this subwatershed. However, the karst features appear to be restricted to the creek channel of Sinkhole Creek. Due to the location of the karst features, further study of the area from a hazards perspective is likely not necessary (Terra-Dynamic Consulting Inc. 2005) because they will not be threatened by development. The challenge for this subwatershed will be water quality protection and enhancement due to the karstic nature of the bedrock which allows for the rapid movement of surface water and any contaminants to groundwater resources. Rural/agricultural best management practices to enhance water quality are the focus for this subwatershed.

The Sinkhole Creek Subwatershed Restoration Strategy identifies 2 zones with specific stewardship and restoration recommendations **(Table 5).**

1) NORTH OF REGIONAL ROAD 20: 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 best management practices education program should be promoted to ensure the rural community is aware of land management options and sources of funding for environmental projects on their land.

2) SOUTH OF REGIONAL ROAD 20: The wetland suitability mapping indicates high wetland suitability along watercourses. However, in areas identified as karst, wetland creation may not be suitable due to the quick conveyance of surface water to groundwater. Additional studies may be required to determine wetland suitability for specific sites in the Sinkhole Creek subwatershed. In addition, the southeast portion of the subwatershed contains natural heritage areas that have the potential for expansion to create larger contiguous areas.

| RESTORATION OPPORTUNITIES | RECOMMENDED RESTORATION STRATEGIES | | |
|---|---|---|---|
| | RIPARIAN | WETLAND | UPLAND |
| NORTH OF REGIONAL ROAD 20 | • Buffer strip planting (minimum 15-30 metres) along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality | • Create new wetlands in areas where the wetness index and soil drainage permit | • Very few areas are highly suitable for upland restoration in this subwatershed; therefore priority should be placed on planting buffer strips and wetland creation |
| SOUTH OF REGIONAL ROAD 20 | • Buffer strip planting (minimum 15-30 metres) along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality | • High wetland suitability along watercourses; however, in areas identified as karst, wetland creation may not be suitable due to the quick conveyance of surface water to groundwater | • Very few areas are highly suitable for upland restoration in this subwatershed; therefore priority should be placed on planting buffer strips and wetland creation<br>• Natural heritage areas in the southeast portion of the subwatershed should be maintained and enhanced; where possible they should be expanded to create larger contiguous areas for the movement of flora and fauna |

TABLE 5: SINKHOLE CREEK SUBWATERSHED RESTORATION ACTIONS

| PROJECT OPPORTUNITIES | RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS |
|---|---|
| GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES | The *Groundwater Study* (2005) has identified several areas with high intrinsic susceptibility due to bedrock outcrops. The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Areas with exposed bedrock increase the potential for the movement of contaminants into the groundwater system, thereby making them susceptible to contamination. Additional studies should be conducted in these areas 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.* |
| SINKHOLE CREEK FISH HABITAT PROJECTS MONITORING | Continue to monitor fish habitat projects in the watershed (for example, the Swayze Road fish habitat project) to ensure they meet the intent of the Department of Fisheries and Ocean's compensation requirements. |
| KARST STUDIES | Karst areas exist in this subwatershed (Terra-Dynamics Consulting Inc. 2005). Additional study may be required prior to wetland creation projects in the watershed. |
| RIPARIAN BUFFER ALONG REGIONAL ROAD 20 | The Regional Road 20 corridor has been ranked as having high surface water vulnerability due to the high potential for runoff (Ecoplans Ltd. 2005). Riparian restoration should be targeted for watercourses in the Twenty Mile Creek watershed along Regional Road 20 to lessen the impacts from road salt on water quality and aquatic habitat. |
| **SPECIAL PROJECTS** | **RECOMMENDATIONS FOR FURTHER STUDY** |
| 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 $2,000 and $10,000. |
| 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. |
| 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. |
| ABANDONED WELL DECOMMISSIONING PROGRAM | Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. A well decommissioning program similar to the one available through the *Hamilton-Halton Watershed Stewardship Program* should be established for all residents in the Twenty Mile Creek watershed. For example, the *Stewardship Program* provides funds through the City of Hamilton to assist landowners with the cost of decommissioning their wells. Residents of Hamilton may be eligible to receive at least 50% of the cost (up to $500) to decommission their well(s) (maximum 2 wells per property). Landowners in the City of Hamilton portion of the Twenty Mile Creek watershed are currently eligible for this program through the City of Hamilton. |
| POLICY TOOLS | Policy tools such as stormwater management policies, and protection of karst areas should be developed and included in regional and municipal Official Plans to ensure unity in environmentally-based planning in the watershed. The NPCA is currently developing stormwater management policies for its jurisdiction and they are complete for the City of Hamilton. |

TABLE 5: SINKHOLE CREEK SUBWATERSHED RESTORATION ACTIONS

## NORTH CREEK SUBWATERSHED RESTORATION STRATEGY

Agriculture is the dominant land use in the North Creek subwatershed. However, several natural heritage areas are present in the subwatershed along its southern boundary. Water quality testing in the North Creek subwatershed indicates high phosphorus levels, which is likely a result of manure from livestock operations, sewage discharges, soil erosion, and fertilizers and pesticides (NPCA 2005d). A lack of riparian buffers may also be contributing to poor water quality in this subwatershed. The challenge for the North Creek subwatershed will be to improve water quality through a combination of riparian, wetland and upland restoration projects and landowner education and incentive programs.

The North Creek Subwatershed Restoration Strategy identifies 2 zones with specific stewardship and restoration recommendations **(Table 6).**

1) WEST OF CAISTER-GAINSBOROUGH TOWNLINE ROAD: This portion of the subwatershed contains segments of the Caister Centre Northwest and East Woodlots/Wetland, both regionally significant Life Science Areas of Natural and Scientific Interest (ANSI). These natural heritage areas have been deemed significant due to the unusually high diversity of biological communities and associated flora and fauna present (Brady 1980). Where suitable, natural heritage areas should be expanded to create larger contiguous areas and provide ecological linkages between the ANSIs and other natural heritage areas in the subwatershed.

Riparian restoration should also be a priority for this portion of the subwatershed due to the lack of stream cover and the concentration of agricultural operations found here. Planting buffers of at least 30 metres on each side of watercourses will aid in enhancing and protecting water quality, which has been identified as a problem in the North Creek subwatershed.

2) EAST OF CAISTER-GAINSBOROUGH TOWNLINE ROAD: In addition to protecting and enhancing natural heritage areas in this portion of the subwatershed, riparian planting is also a priority. A riparian planting program in this primarily rural watershed will aid in improving water quality and fish habitat as well as increase species diversity.

The entire North Creek subwatershed would also benefit from the promotion of the NPCA's education program pertaining to agricultural best management practices (BMPs) such as sediment control BMPs, water quality BMPs and nutrient management BMPs. The rural/agriculture BMP education program also includes information about sources of funding for environmental projects on private land to encourage adoption and implementation of BMPs.

| RESTORATION OPPORTUNITIES | RECOMMENDED RESTORATION STRATEGIES | | |
|---|---|---|---|
| | RIPARIAN | WETLAND | UPLAND |
| WEST OF CAISTER-GAINSBOROUGH TOWNLINE ROAD | • Buffer strip planting along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality<br>• Riparian planting could be used to create linkages between ANSIs and other natural heritage areas in this portion of the subwatershed | • 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; high suitability surrounding ANSIs<br>• Maintain and enhance ecological linkages with adjacent forested areas within the Welland River watershed |
| WEST OF CAISTER-GAINSBOROUGH TOWNLINE ROAD | • Buffer strip planting along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality | • 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 forests; high suitability near existing forested areas<br>• Maintain and enhance ecological linkages with adjacent forested areas within the Welland River watershed |

TABLE 6: NORTH CREEK RESTORATION ACTIONS

| PROJECT OPPORTUNITIES | RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS |
|---|---|
| ECOLOGICAL LINKAGES BETWEEN NATURAL AREAS | The potential to create ecological corridors between the ANSIs and other natural areas in North Creek subwatershed should be studied to enhance the movement of flora and fauna in the subwatershed and adjacent Welland River watershed. The study should include an investigation into any impediments to the movement that wildlife may encounter. |
| **SPECIAL PROJECTS** | **RECOMMENDATIONS FOR FURTHER STUDY** |
| SMITHVILLE URBAN DEVELOPMENT ENCROACHMENT | There is the potential for urban development in the Town of Smithville to expand into the northern portion of this subwatershed near an existing wooded area. Due to the limited amount of natural heritage areas in the Twenty Mile Creek watershed, a comprehensive land use study should be completed by the municipality to determine the most appropriate place to expand the urban area boundary. |
| 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 $2,000 and $10,000. |
| 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. |
| 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. |
| ABANDONED WELL DECOMMISSIONING PROGRAM | Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. A well decommissioning program similar to the one available through the Hamilton-Halton Watershed Stewardship Program should be established for all residents in the Twenty Mile Creek watershed. For example, the Stewardship Program provides funds through the City of Hamilton to assist landowners with the cost of decommissioning their wells. Residents of Hamilton may be eligible to receive at least 50% of the cost (up to $500) to decommission their well(s) (maximum 2 wells per property). |
| POLICY TOOLS | Policy tools such as stormwater management policies, and protection of karst areas 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: NORTH CREEK RESTORATION ACTIONS

## SPRING CREEK SUBWATERSHED RESTORATION STRATEGY

The rural landscape of the Spring Creek subwatershed offers many opportunities to enhance and restore natural heritage areas. Many natural heritage areas already exist in this subwatershed. Therefore, restoration efforts should focus on enhancing existing natural areas and creating and improving ecological linkages between existing natural areas. Two aggregate operations are also present in the Spring Creek subwatershed. Several sites in this subwatershed have been identified as having high groundwater intrinsic susceptibility due to bedrock outcrops. A challenge in this subwatershed will be to protect groundwater resources in this primarily agricultural area.

The Spring Creek Subwatershed Restoration Strategy identifies 2 zones with specific stewardship and restoration recommendations **(Table 7).**

| RESTORATION OPPORTUNITIES | RECOMMENDED RESTORATION STRATEGIES | | |
|---|---|---|---|
| | RIPARIAN | WETLAND | UPLAND |
| NORTH OF YONGE STREET | • Buffer strip planting along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality<br>• Protect and enhance existing buffer in this portion of the subwatershed; especially in headwater wetlands | • 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; high suitability surrounding locally significant evaluated wetlands<br>• Maintain and enhance ecological linkages between wetlands and forested areas |
| SOUTH OF YONGE STREET | • Buffer strip planting along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality | • 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 | • Few areas are deemed suitable for upland restoration; priority should be placed on protecting and enhancing existing forested areas |
| **PROJECT OPPORTUNITIES** | **RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS** | | |
| QUARRIES | Quarry operations significantly alter the landscape and hydrological system. Therefore, it is important to ensure that all quarry restoration plans and the Twenty Mile Creek Watershed Plan are congruent. Opportunities for the NPCA and quarry operators to partner on rehabilitation plans and implementation should also be developed. | | |
| GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES | *The Groundwater Study* (2005) has identified several areas with high intrinsic susceptibility due to bedrock outcrops. The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Areas with exposed bedrock increase the potential for the movement of contaminants into the groundwater system, thereby making them susceptible to contamination. Additional studies should be conducted in these areas 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 7: SPRING CREEK RESTORATION ACTIONS

1) NORTH OF YONGE STREET: This portion of the subwatershed contains locally significant wetlands and forested areas along the upper section of the creek, which should be maintained and enhanced to protect water quality (surface and ground water) and improve fish habitat. A tributary of Spring Creek, is highly to moderately suitable for riparian planting, which will also aid in protecting and enhancing water quality and fish habitat. The locally significant evaluated wetlands in the vicinity of Mud Street will benefit from upland planting along their perimeter. This will also increase habitat and species diversity in this portion of the subwatershed. Numerous areas are also suitable for wetland creation.

2) SOUTH OF YONGE STREET: Although some riparian cover is present along the main branch of Spring Creek, this primarily agricultural subwatershed would benefit from continuous riparian cover along all of its watercourses. Many areas in this section of the subwatershed are also suitable for wetland creation. Wetland creation in areas denoted as groundwater sensitive should be studied to determine the benefits of wetland creation in these areas for groundwater protection.

| SPECIAL PROJECTS | RECOMMENDATIONS FOR FURTHER STUDY |
|---|---|
| SMITHVILLE URBAN DEVELOPMENT ENCROACHMENT | There is the potential for urban development in the Town of Smithville to expand into this subwatershed. Due to the limited amount of natural heritage areas in the Twenty Mile Creek watershed, a comprehensive land use study should be completed by the municipality to determine the most appropriate place to expand the urban area boundary. |
| 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 $2,000 and $10,000. |
| 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. |
| 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. |
| ABANDONED WELL DECOMMISSIONING PROGRAM | Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. A well decommissioning program similar to the one available through the *Hamilton-Halton Watershed Stewardship Program* should be established for all residents in the Twenty Mile Creek watershed. For example, the *Stewardship Program* provides funds through the City of Hamilton to assist landowners with the cost of decommissioning their wells. Residents of Hamilton may be eligible to receive at least 50% of the cost (up to $500) to decommission their well(s) (maximum 2 wells per property). |
| POLICY TOOLS | Policy tools such as stormwater management policies, and protection of karst areas 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: SPRING CREEK RESTORATION ACTIONS

## GAVORA DITCH SUBWATERSHED RESTORATION STRATEGY

Gavora Ditch is in fact an intermittent stream that originates from a series of agricultural drains. This watercourse is a bedrock-bottom stream that runs through a pronounced bedrock ridge, which has resulted in the development of in-channel sinkpoints near the Bethesda Road overpass (Terra-Dynamics Consulting Inc. 2005). Since the karst features found in this subwatershed are primarily located within the channel, additional studies are not required from a hazards perspective. The creek has also been realigned around a future quarry extraction area. The remainder of the watershed is primarily agricultural, with the exception of a small hamlet (Campden).

The Gavora Ditch Subwatershed Restoration Strategy identifies 1 zone with specific stewardship and restoration recommendations **(Table 8).**

1) GAVORA DITCH SUBWATERSHED: This primarily rural subwatershed contains many sections of creek that do not have riparian cover. A challenge for this subwatershed will be to plant buffers along all sections of the creek to improve water quality (surface and ground water). The Gavora Ditch subwatershed has the greatest amount of suitable land for restoration in the Twenty Mile Creek watershed. These areas should be further investigated for wetland creation to increase total wetland area in the watershed. Additional studies should be conducted in karst areas to ensure suitability. Few upland areas have been identified as suitable for restoration. Therefore, priority should be placed on riparian and wetland creation. A small portion of the subwatershed in the vicinity of Campden also falls within the *Greenbelt* Tender Fruit and Grape Lands. Therefore, development is restricted in this area.

| RESTORATION OPPORTUNITIES | RECOMMENDED RESTORATION STRATEGIES | | |
|---|---|---|---|
| | RIPARIAN | WETLAND | UPLAND |
| GAVORA DITCH SUBWATERSHED | • Buffer strip planting along watercourses that currently have no buffer; priority should be placed on riparian creation to protect and enhance water quality | • 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<br>• Large areas of land are suitable for wetland creation in this subwatershed; therefore, priority should be place on wetland creation | • Very few areas are highly suitable for upland restoration in this subwatershed; therefore priority should be placed on planting buffer strips and wetland creation |
| **PROJECT OPPORTUNITIES** | **RECOMMENDED ACTIONS FOR PUBLIC AND PRIVATE LANDS** | | |
| GROUNDWATER INTRINSIC SUSCEPTIBILITY STUDIES | *The Groundwater Study* (2005) has identified several areas with high intrinsic susceptibility due to bedrock outcrops. The intrinsic susceptibility of groundwater considers only the physical factors affecting the flow of water to, and through, the groundwater resource. Areas with exposed bedrock increase the potential for the movement of contaminants into the groundwater system, thereby making them susceptible to contamination. Additional studies should be conducted in these areas 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*. | | |
| QUARRIES | Quarry operations significantly alter the landscape and hydrological system. Therefore, it is important to ensure that all quarry restoration plans and the Twenty Mile Creek Watershed Plan are congruent. Opportunities for the NPCA and quarry operators to partner on rehabilitation plans and implementation should also be developed. | | |
| KARST STUDIES | Karst areas exist in this subwatershed (Terra-Dynamics Consulting Inc. 2005) (Figure 15). Additional study may be required prior to wetland creation projects in the watershed. | | |

TABLE 8: GAVORA DITCH RESTORATION ACTIONS

| SPECIAL PROJECTS | RECOMMENDATION FOR FURTHER STUDY |
|---|---|
| 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 $2,000 and $10,000. |
| 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. |
| 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. |
| ABANDONED WELL DECOMMISSIONING PROGRAM | Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. A well decommissioning program similar to the one available through the *Hamilton-Halton Watershed Stewardship Program* should be established for all residents in the Twenty Mile Creek watershed. For example, the *Stewardship Program* provides funds through the City of Hamilton to assist landowners with the cost of decommissioning their wells. Residents of Hamilton may be eligible to receive at least 50% of the cost (up to $500) to decommission their well(s) (maximum 2 wells per property). |
| POLICY TOOLS | Policy tools such as stormwater management policies, and protection of karst areas 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: GAVORA DITCH RESTORATION ACTIONS

## RESTORATION TARGETS

Environment Canada (2004c) has created a set of guidelines for wetland, riparian and forest habitat restoration that identify targets for each habitat type in a watershed **(Appendix 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 (i.e., minimum 15 metres naturally vegetated buffer on both sides of a Type 2 and 3 fish habitat classed stream, and a minimum 30 metres on both sides of a Type 1 fish habitat classed stream).

The Twenty Mile Creek watershed currently contains approximately 2 percent wetland cover and approximately 13 percent forest cover. Based on the above guidelines, an additional 8 percent of wetland cover and 17 percent forest cover are required to create minimum desirable habitat proportions in the Twenty Mile Creek watershed. In addition, larger patches of forest are recommended for increased flora and fauna diversity, vegetation communities and habitat, and the establishment of more resilient nutrient cycles and food webs. For example, the Ministry of Natural Resources (1999) recommends creating forest patches at 4, 10 and 30 hectares to accommodate a variety of animals. Riparian cover in the watershed ranges between 20-25 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 50-55 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 features and areas in the watershed should be conserved and enhanced whenever possible. Implementation Responsibilities and Recommended Management Actions.

## IMPLEMENTATION RESPONSIBILITIES AND RECOMMENDED MANAGEMENT ACTIONS

The above Twenty 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 will 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 Twenty 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.

# TWENTY MILE CREEK WATERSHED PLAN OBJECTIVES SUMMARY TABLE

| WATERSHED PLAN OBJECTIVES | RESPONSIBLE AGENCIES AND GROUPS | | | | | | | | | | | | RECOMMENDED MANAGEMENT ACTIONS | IMPLEMENTATION | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WATER RESOURCES | NPCA | MUNICIPALITIES | CITY OF HAMILTON | REGIONAL NIAGARA | NEC | MNR | MOE | OMAFRA | DFO | 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 |
| | ▲ | ● | ● | | ● | ● | ● | | ● | | | | Monitor temperature in Twenty Mile Creek and storm water ponds in the headwaters and investigate measures to improve the water temperature regime (e.g., riparian cover) | | 2,000 (START UP COST) |
| | ▲ | ● | ● | ● | ● | ▲ | | | ▲ | | | | Where legislation permits, maintain stream flows by removing debris and sediment in water courses | | 25,000 yr* |
| | ▲ | ● | ● | ● | ▲ | ● | | | ● | | | | Continue to restrict new on-line pond construction | | ONGOING |
| | ▲ | ▲ | ▲ | ▲ | | | ● | ● | | | ● | ● | Monitor phosphorus levels to achieve below .03 mg/L | | 20,000/yr |
| Protect all municipal drinking water supplies and designated vulnerable areas.<br><br>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 (including karst environments). | ▲ | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | 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** |
| | ▲ | | | | ● | ● | ● | | | | | | Examine the ongoing effect of quarries on groundwater, the impacts when they cease dewatering, and the potential for long-term augmentation of base flows | | ONGOING |
| | ● | ▲ | ▲ | ▲ | | | | | | | | | Incorporate surface and ground water protection policies into municipal and 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 Twenty Mile Creek watershed water budget for 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

# TWENTY MILE CREEK WATERSHED PLAN OBJECTIVES SUMMARY TABLE

| WATERSHED PLAN OBJECTIVES | RESPONSIBLE AGENCIES AND GROUPS | | | | | | | | | | | | RECOMMENDED MANAGEMENT ACTIONS | IMPLEMENTATION | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WATER RESOURCES | NPCA | MUNICIPALITIES | CITY OF HAMILTON | REGIONAL NIAGARA | NEC | MNR | MOE | OMAFRA | DFO | 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 City of Hamilton, Town of Smithville, and settlement areas in the Town of Lincoln | | 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 *Twenty Mile Creek Headwaters and Erosion Study* (2005) | | 15,000-25,000/yr |
| FISH & AQUATIC HABITAT | | | | | | | | | | | | | | | |
| Protect, enhance, reforest and restore woodlands and wildlife habitata in the watershed for the long-term | ▲ | ● | ● | | | ● | | | ● | ▲ | ● | ● | Develop a Fish Barrier Program to remove barriers to fish movement | | 5,500 |
| | ▲ | ● | ● | | | ● | | | ● | ▲ | ● | ● | Develop a Fisheries Management Plan for Twenty Mile Creek and its tributaries | | 45,000 |
| | ● | | | | | ▲ | ▲ | | ● | ● | ● | ▲ | Where possible, remove, relocate or modify online ponds | | 10,000/yr* |
| | ▲ | ● | ● | | | | | | | ● | ● | ▲ | Plant buffer strips around watercourses and wetlands | | 25,000/yr (5,000/250m)* |
| | ▲ | | ● | | | ● | | | | | | ● | Investigate the reported carp problem in the stormwater ponds in the headwaters at St. Elizabeth Village | | EXISTING PROGRAM |

**LEGEND**

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

# TWENTY MILE CREEK WATERSHED PLAN OBJECTIVES SUMMARY TABLE

| WATERSHED PLAN OBJECTIVES | RESPONSIBLE AGENCIES AND GROUPS | | | | | | | | | | | | RECOMMENDED MANAGEMENT ACTIONS | IMPLEMENTATION | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NATURAL HERITAGE AND RESOURCES | NPCA | MUNICIPALITIES | CITY OF HAMILTON | REGIONAL NIAGARA | NEC | MNR | MOE | OMAFRA | DFO | CONSERVATION GROUPS | AGRICULATURAL COMMUNITY | PRIVATE LANDOWNERS | | | $ |
| Protect, enhance, reforest and restore 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 | | 30,000/yr* (1,500/acre) |
| | ▲ | ▲ | ▲ | ▲ | ● | | | | | ● | ● | ● | Utilize conservation easements, land dedication and acquisition to secure critical linkages as desired lands become available for purchase | | 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
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# TWENTY MILE CREEK WATERSHED PLAN OBJECTIVES SUMMARY TABLE

| WATERSHED PLAN OBJECTIVES | RESPONSIBLE AGENCIES AND GROUPS | | | | | | | | | | | | RECOMMENDED MANAGEMENT ACTIONS | IMPLEMENTATION | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMMUNICATION AND EDUCATION | NPCA | MUNICIPALITIES | CITY OF HAMILTON | REGIONAL NIAGARA | NEC | MNR | MOE | OMAFRA | DFO | CONSERVATION GROUPS | AGRICULATURAL COMMUNITY | PRIVATE LANDOWNERS | LEGEND<br>▲ LEAD STAKEHOLDER<br>● INVOLVED STAKEHOLDER<br>SHORT TERM<br>MEDIUM TERM<br>LONG TERM | | $ |
| 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 | | 110,000/yr*** |
| Encourage the creation of partnerships with agencies, organizations and landowners in the watershed. | ▲ | ▲ | ▲ | ▲ | | | | | | ▲ | ▲ | ● | Assemble and meet with a 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/annual REPORT CARD |

* Based on grant ceiling under the NPCA's *Water Quality Protection Program* for landowners
** Includes project costs and NPCA staff salaries
*** *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 and wetland 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 *Twenty Mile Creek Watershed Plan*. The Plan will be reviewed by the NPCA Restoration Team. 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 Twenty 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 include:

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

- 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 landowner's 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 Twenty 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 Twenty Mile Creek watershed is comprised of 5 subwatershed; 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 a restoration strategy for riparian, wetland and upland habitat in the watershed that has been derived from detailed restoration suitability mapping. In addition, project opportunities on private and public lands have been identified such as riparian planting to reduce erosion and enhance fish habitat. Special studies such as policy tools and agricultural best management practice education and incentive programs have been proposed. Recommended management actions for the watershed have also been identified and include riparian, wetland and upland restoration to enhance water quality, fish habitat and recreation; specific policy tools including municipal and regional official plan amendments; outreach and communication; and research and monitoring programs to obtain additional data from which the watershed plan can be updated and revised.

The Niagara Peninsula Conservation Authority will oversee the implementation of the Twenty Mile Creek watershed strategy and recommendations made in this report. Watershed plan progress will be communicated annually by means of a qualitative report card that details progress in the watershed. The *Twenty Mile Creek Watershed Plan* will be revisited and updated, normally every 5 years.

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 *Twenty 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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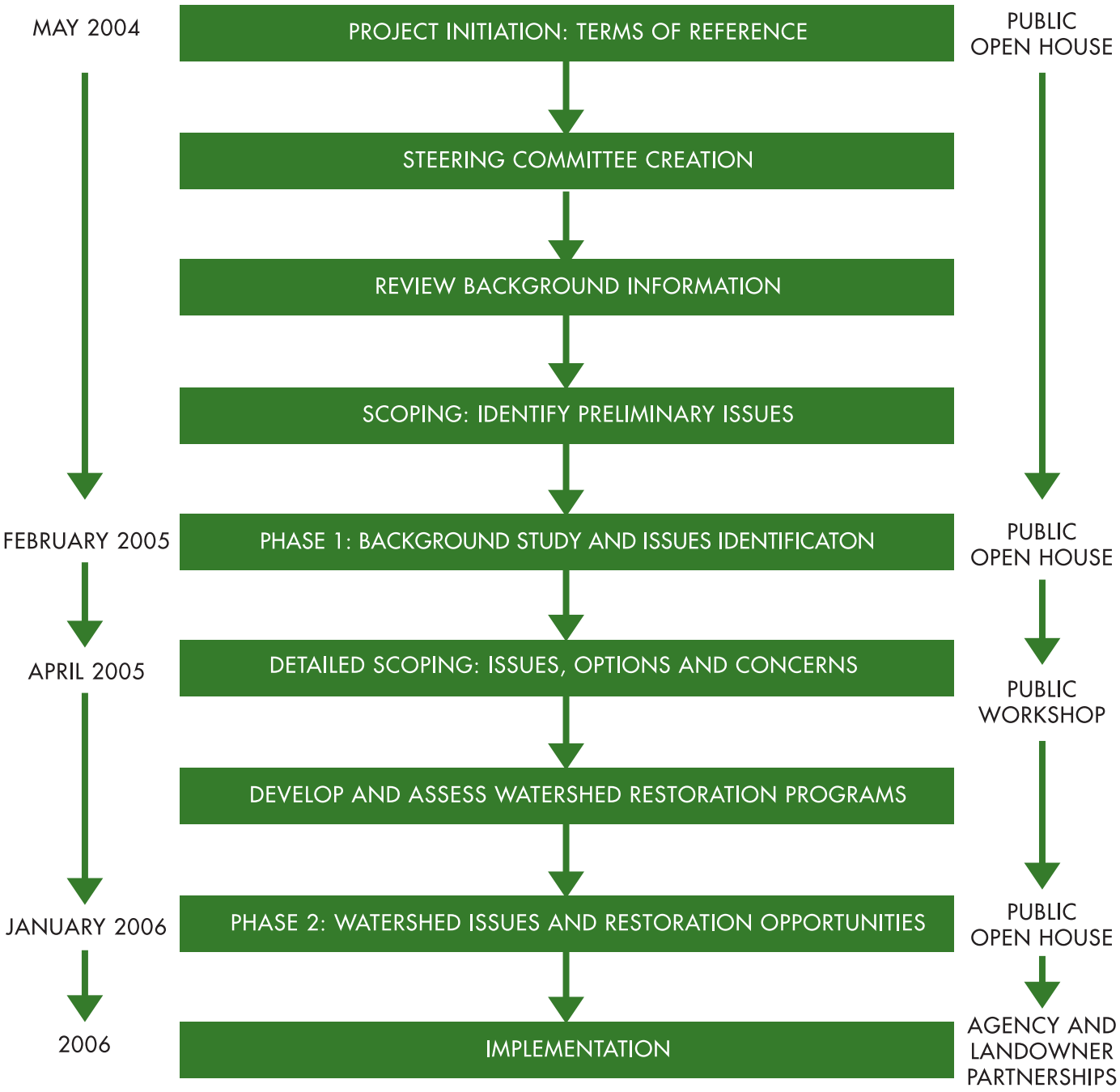
NIAGARA PENINSULA CONSERVATION AUTHORITY

# TWENTY 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 | ☐ | ☐ | ☐ | ☐ | ☐ |

## APPENDIX B

| 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): | ☐ | ☐ | ☐ | ☐ | ☐ |

_____

## APPENDIX B

### 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:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

THANK YOU

## APPENDIX C

# SUMMARY OF RECOMMENDATIONS AND ACCOMPANYING MAPS FROM THE *TWENTY MILE CREEK HEADWATERS AND EROSION STUDY* (NPCA 2005)

Several recommendations were put forth in the *Twenty Mile Creek Headwaters and Erosion Study,* which have been summarized under the broad categories of policy recommendations and restoration recommendations.

POLICY RECOMMENDATIONS: Municipal policies can be used to protect the quality of water and the ecosystems that depend on it. Stormwater management is designed to prevent downstream flooding and to protect water quality, it is therefore important that downstream ponds not be permitted to be on-line with main channels. Riparian buffers should be managed and adequately sized due to the role they play in water quality and aquatic habitat as recommended in the *Resources Planning Program, Plan Input and Review Policies and Guidelines* (NPCA 1993 with amendments in 2003 and 2005). It is important that stormwater ponds and streams within urban areas be surrounded by adequate buffer zones. Municipal Official Plans should be updated to reflect stormwater and riparian buffer ordinances.

Land acquisition programs can also help to protect water courses through the purchase of land by government associations, which will keep the land in a natural state. Educating property owners within the headwaters on the importance of water quality and riparian buffers will also benefit Twenty Mile Creek downstream.

RESTORATION RECOMMENDATIONS: Planting adequately sized riparian buffers around stormwater detention ponds and streams will help to limit contaminants from entering the water, help prevent erosion and siltation, and also provide shading for aquatic habitat. Native vegetation should also be used in riparian plantings.

APPENDIX C

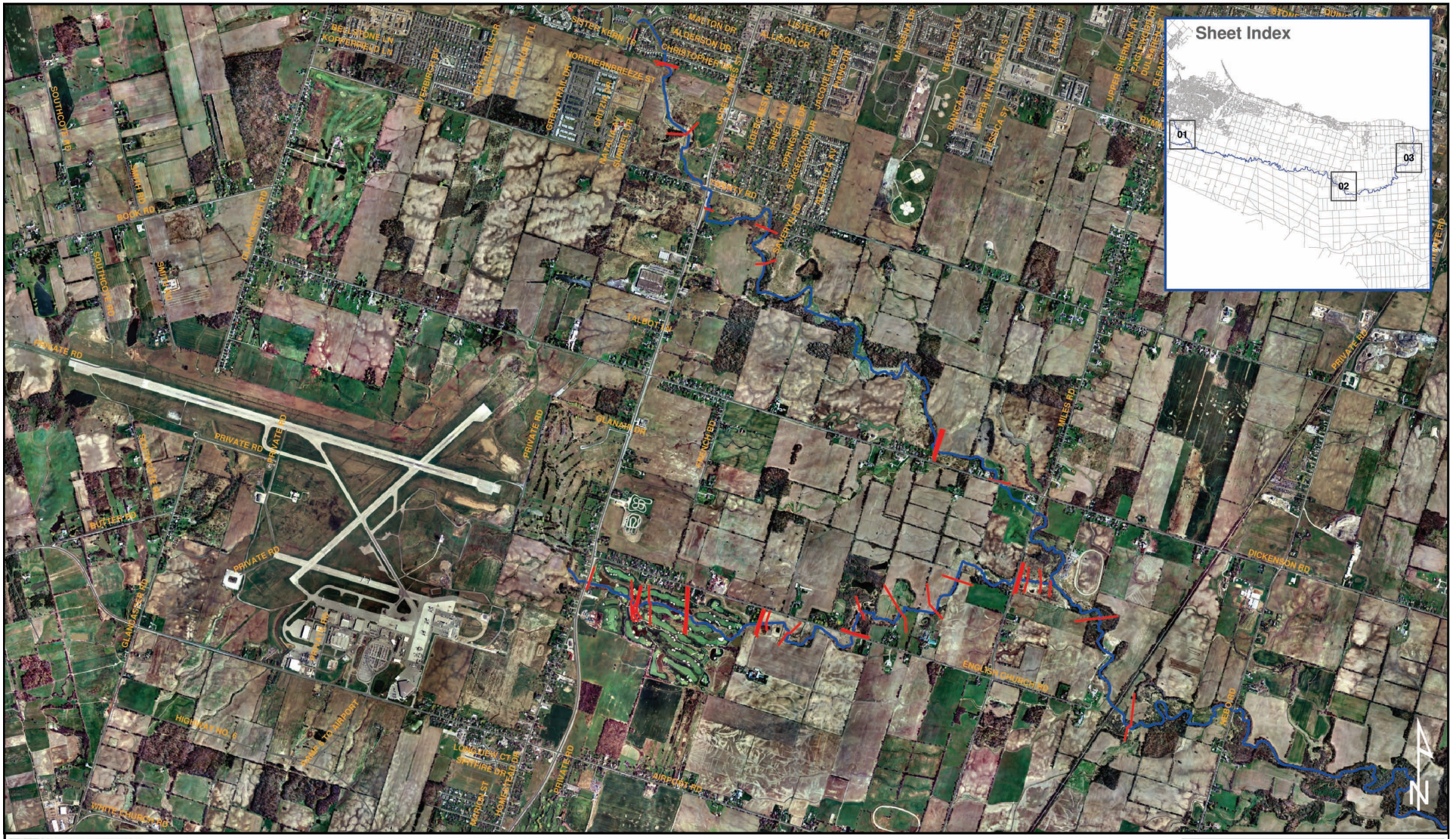
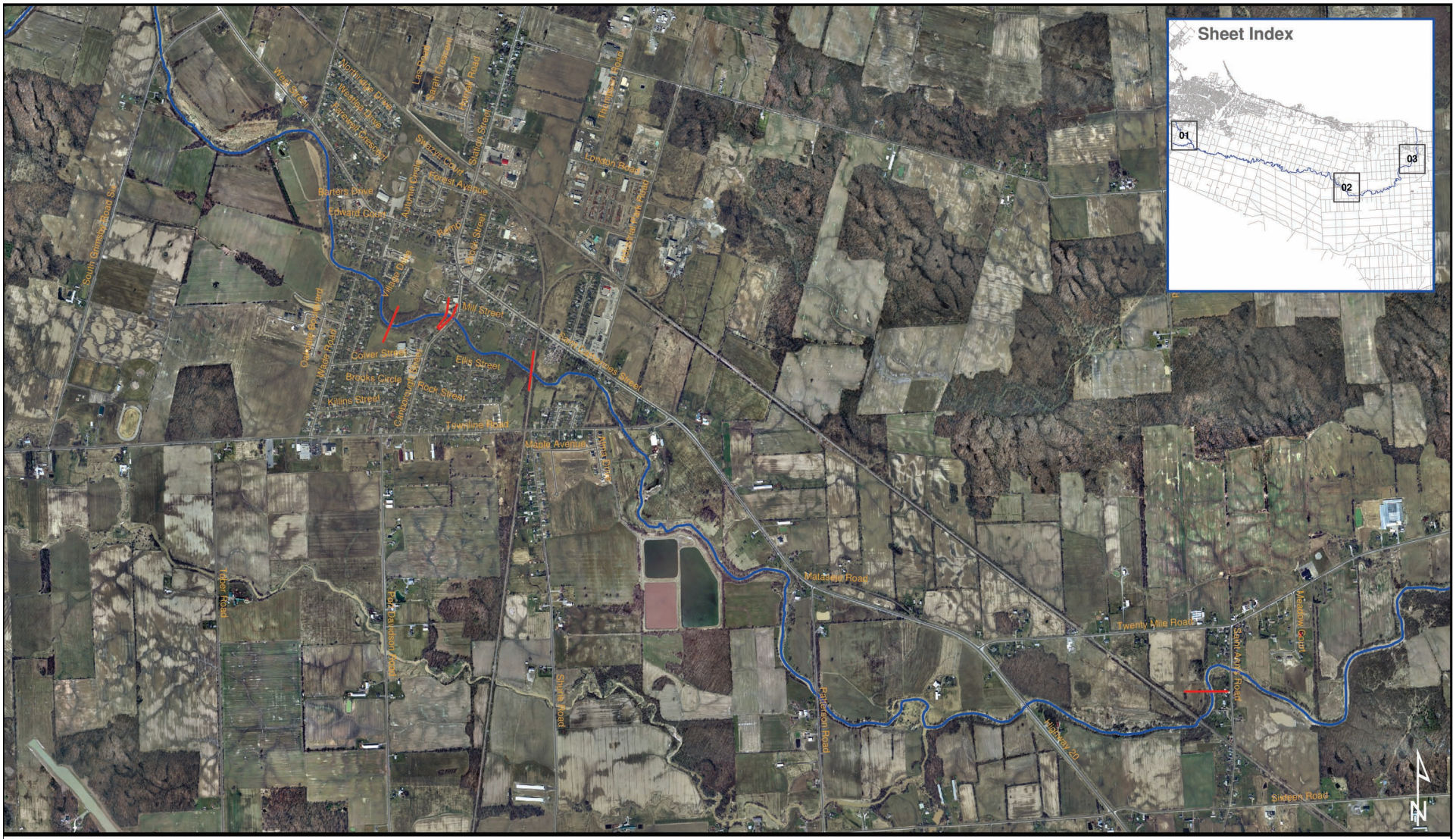



**Figure 17: Twenty Mile Creek - Sheet 1 of 3**

**Shear Stress Sites in the Twenty Mile Creek Watershed**




NIAGARA PENINSULA CONSERVATION AUTHORITY

Notes
North American Datum 1983
Universal Transverse Mercator
Zone 17
Orthoimage provided by First Base Solutions Inc. 2002.

## Figure 18: Twenty Mile Creek - Sheet 2 of 3

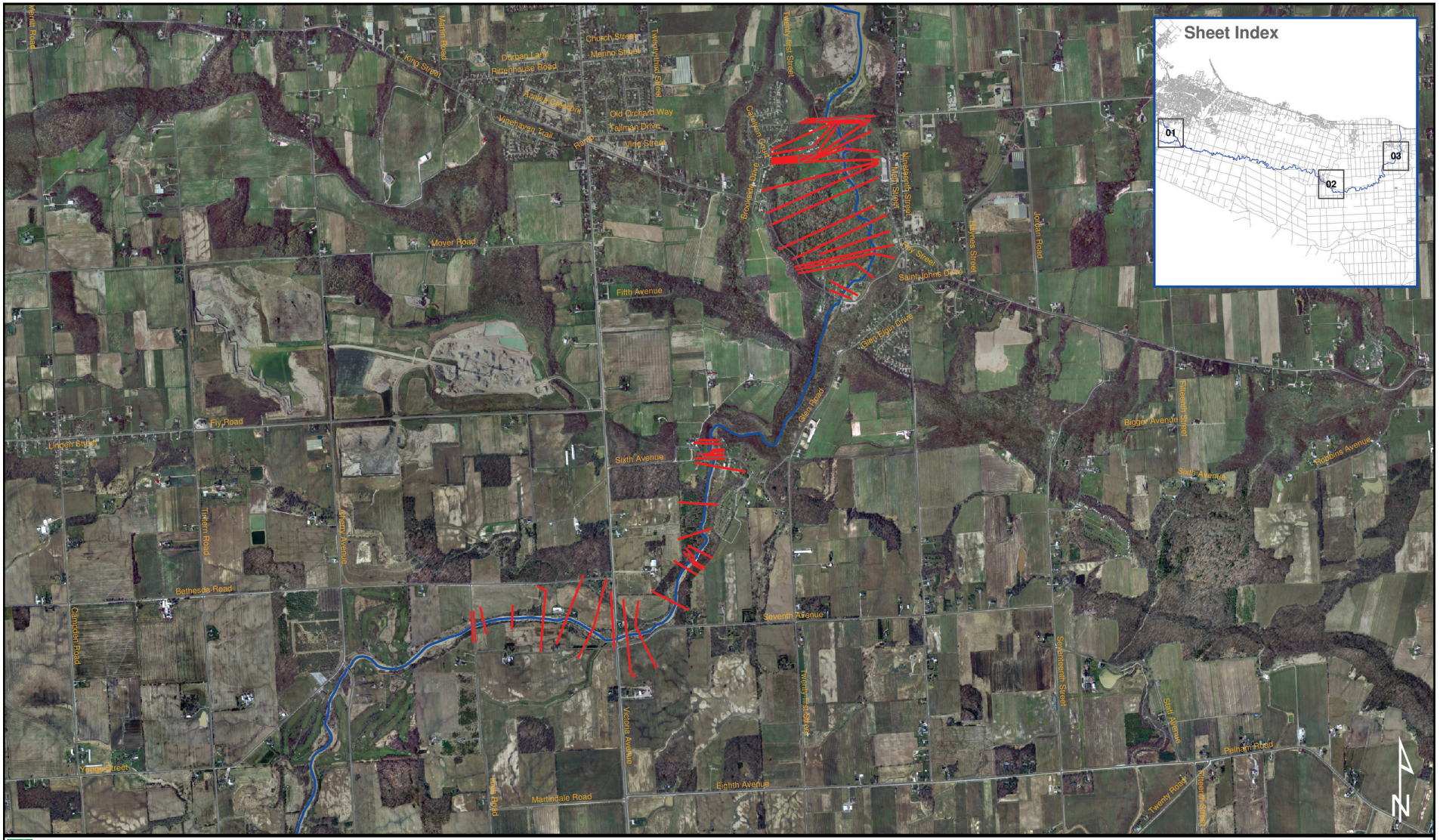
Shear Stress Sites in the Twenty Mile Creek Watershed

750 375 0 750 1,500 2,250 3,000 Meters

**Legend**

- Roads
- Shear Stress Cross Section Locations
- Main Channel

APPENDIX C




NIAGARA PENINSULA CONSERVATION AUTHORITY

Notes
North American Datum 1983
Universal Transverse Mercator
Zone 17
Orthoimage provided by First Base Solutions Inc. 2002.

# Figure 19: Twenty Mile Creek - Sheet 3 of 3

Shear Stress Sites in the Twenty Mile Creek Watershed

750 375 0 750 1,500 2,250 3,000 Meters

**Legend**

- Roads
- Shear Stress Cross Section Locations
- Main Channel

## 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. |

## APPENDIX D

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:<br>• limiting total bare soil exposed by phasing,<br>• protecting bare soil through mulching and revegetation,<br>• diversion of flow around disturbed areas, and<br>• 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. |

## APPENDIX D

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 Twenty 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 Twenty 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. |

## APPENDIX D

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. |

## APPENDIX E

| 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:<br>Bog – the total catchment area<br>Marsh – 100 metres<br>Fen – 100 metres or as determined by hydrogeological study<br>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. |

# RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

| HABITAT: RIPARIAN | RATIONALE | METHODOLOGY | REFERENCE |
|---|---|---|---|
| CRITERIA:<br>PROXIMITY TO WATERCOURSE/WATERBODY<br>*( edgedr )*<br>3 ≤ 30m<br>2 > 30m & < 50m<br>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<br>*( lurwood )*<br>3 Woodland, Wetland, Scrub, Low Intensity Agriculture<br>2 Recreational, Residential, High Intensity Agriculture<br>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<br>*( slopedr )*<br>3 ≥ 10 degrees<br>2 < 10 degrees<br>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<br>*( catchfhr )*<br>3 Critical<br>2 Important<br>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<br>*( catchsor )*<br>3 intermittent flow ( 1st & 2nd order)<br>2 intermittent / permanent flow (3rd order)<br>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<br>*( coverwor )*<br>3 woodland not present<br>2 planting site<br>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 |

APPENDIX F

# RESTORATION SUITABILITY CRITERIA: RIPARIAN HABITAT

| HABITAT: RIPARIAN | RATIONALE | METHODOLOGY | REFERENCE |
|---|---|---|---|
| CRITERIA: STREAMBANK EROSION RATES<br>*(Wetness Index)*<br>( ripwir )<br>3 High (10-21)<br>2 Mid (5-10)<br>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<br>*( careasdr )*<br>3 within conservation area boundary<br>2 ≤ 30m from conservation area boundary<br>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)<br>*( wecoredr )*<br>3 ≤ 50m<br>2 > 50m & < 100m<br>1 ≥ 100m | Areas within closest proximity to existing wetland patches of highest Natural Heritage Score (core size) will be most suitable to restoration of increased interior habitat. | Select existing patches with highest size significance value. Generate distance surface from selected patches. Reclassify surface values where lowest distances have highest suitability values. | Niagara River AOC RAP Wetland Extent Guidelines |
| CRITERIA: PROXIMITY TO SIGNIFICANT EXISTING PATCH<br>*( wenndr )*<br>3 ≤ 50m<br>2 > 50m & < 100m<br>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<br>*( edgedr )*<br>3 ≤ 30m<br>2 > 30m & < 50m<br>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<br>*( sdrainr )*<br>3 Alluvial Soil<br>2 Very Poorly and Poorly Drained<br>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<br>*( lurwood )*<br>3 Woodland, Wetland, Scrub, Low Intensity Agriculture<br>2 Recreational, Residential, High Intensity Agriculture<br>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<br>*( catchfr )*<br>3 Critical<br>2 Important<br>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 |

APPENDIX F

# RESTORATION SUITABILITY CRITERIA: WETLAND HABITAT

| HABITAT: WETLAND | RATIONALE | METHODOLOGY | REFERENCE |
|---|---|---|---|
| CRITERIA: STREAM ORDER OF CATCHMENT<br>*( catchsor )*<br>3 intermittent flow ( 1st & 2nd order)<br>2 intermittent / permanent flow (3rd order)<br>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)<br>*( wetindr )*<br>3 high (10-21)<br>2 mid (5-10)<br>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<br>*( coverwer )*<br>3 Forest cover present<br>2 Planting site present<br>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<br>*( careasdr )*<br>3 within conservation area boundary<br>2 ≤ 30m from conservation area boundary<br>1 > 30m from conservation area boundary | Areas within C.A. boundaries are protected from development pressure and destruction. Areas in close proximity to these boundaries are more suitable to restore in terms of establishing connectivity. | Generate straight line distance surface from Conservation Area boundary polygons. Reclassify surface values according to restoration suitability. | Niagara Peninsula Conservation Authority |

## RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

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

APPENDIX F

# RESTORATION SUITABILITY CRITERIA: UPLAND HABITAT

| HABITAT: UPLAND FOREST | RATIONALE | METHODOLOGY | REFERENCE |
|---|---|---|---|
| CRITERIA:FISH HABITAT CLASSIFICATION OF CATCHMENT<br>*( catchfhr )*<br>3 Critical<br>2 Important<br>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<br>*( catchsor )*<br>3 intermittent flow ( 1st & 2nd order)<br>2 intermittent / permanent flow (3rd order)<br>1 permanent flow (> 3rd order) | Catchments which drain to watercourses in headwater streams are considered more suitable for restoration than those that drain to higher ordered streams in terms of water quality improvement. | Generate surface from catchment polygons on stream order value. Reclassify values according to restoration suitability. | Niagara River AOC RAP Evaluation of Upland Habitat |
| CRITERIA:0-240M WETLAND BUFFER HABITAT THRESHOLDS<br>*( sigwetdr )*<br>3 < 50m<br>2 50m - 120m<br>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<br>*( careasdr )*<br>3 within conservation area boundary<br>2 ≤ 30m from conservation area boundary<br>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<br>*( slopedr )*<br>3 ≥ 10 degrees<br>2 < 10 degrees<br>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<br>*( coverwor )*<br>3 woodland not present<br>2 planting site<br>1 woodland present | The amount of forest cover must be increased in order to meet habitat targets. It is obviously more suitable to restore forest habitat where it does not presently exist, or where infilling may be necessary from a previous restoration site. | Generate surface from natural vegetation polygons based on vegetation type. Reclassify areas lacking forest cover as highest suitability values. | Niagara River AOC RAP Evaluation of Upland Habitat |

# RIPARIAN

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

## BACKGROUND INFORMATION

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

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

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

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

# RIPARIAN

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

## BACKGROUND INFORMATION

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

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

*Min. Value

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

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

# WETLANDS

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

## BACKGROUND INFORMATION

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

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

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

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

# WETLANDS

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

## BACKGROUND INFORMATION

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

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

* Min. Value

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

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

# WOODLANDS

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

## BACKGROUND INFORMATION

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

| | | | |
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| 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

APPENDIX G

# WOODLANDS

## NORMALIZED VALUES

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

## BACKGROUND INFORMATION

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|---|---|
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| Moderately More Important | 3.00 |
| Moderately To Strongly More Important | 4.00 |
| Strongly More Important | 5.00 |
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| 1 - 4 = X | 2 - 4 = X | 3 - 4 = X | 4 - 4 = 1 |

* Min Value

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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

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