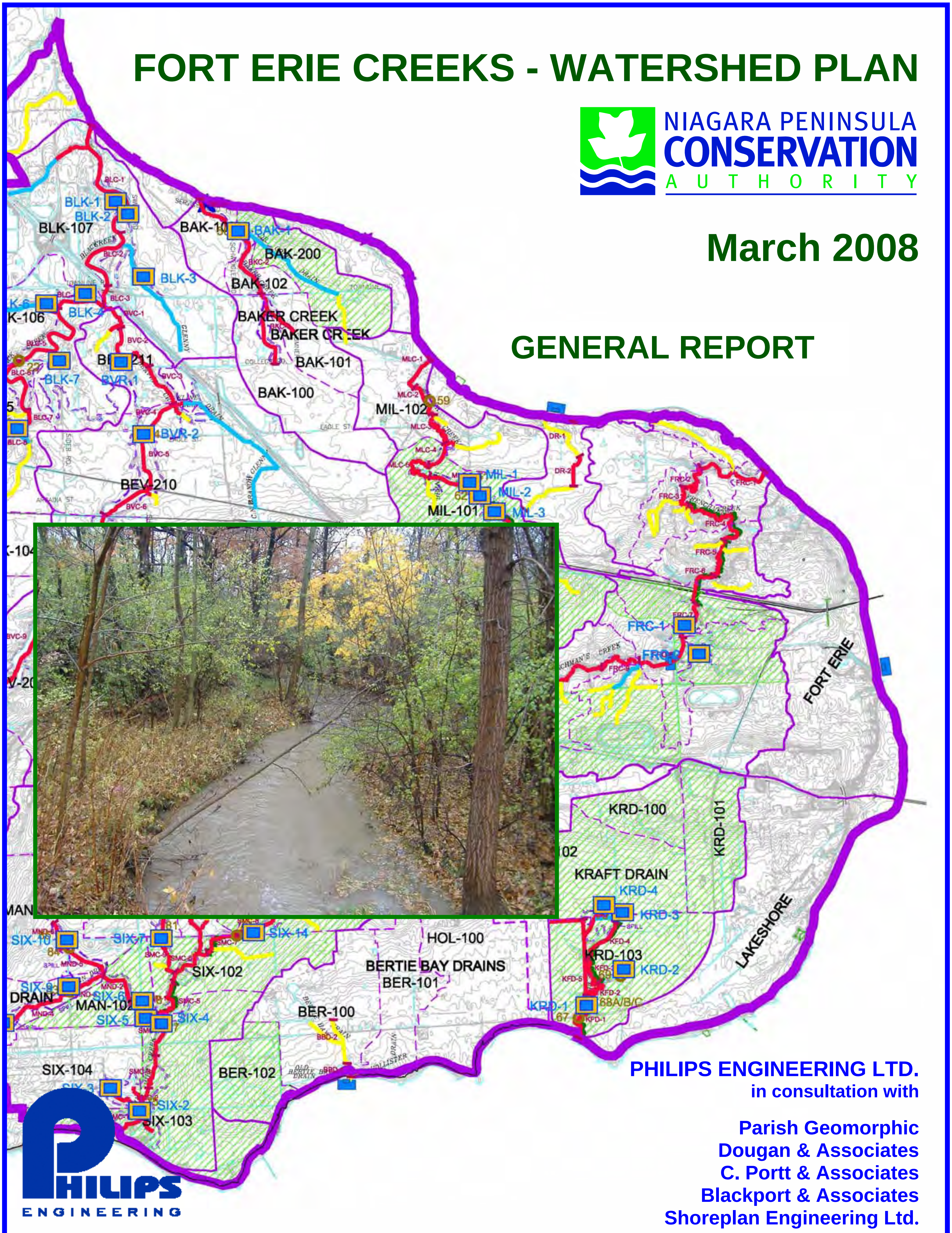
FORT ERIE CREEKS - WATERSHED PLAN

NIAGARA PENINSULA CONSERVATION AUTHORITY

March 2008

GENERAL REPORT



PHILIPS ENGINEERING LTD.
in consultation with

Parish Geomorphic
Dougan & Associates
C. Portt & Associates
Blackport & Associates
Shoreplan Engineering Ltd.

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FORT ERIE CREEKS - WATERSHED PLAN

GENERAL REPORT

NIAGARA PENINSULA CONSERVATION AUTHORITY

FORT ERIE

1. INTRODUCTION

The Niagara Peninsula Conservation Authority (NPCA) has commissioned the preparation of a Watershed Plan for the Fort Erie Creeks Watershed Planning Area (WSPA). The Fort Erie Creeks Watershed Plan provides strategies that will allow the community to care for water resources, natural heritage, settlement and agriculture in the context of land use planning documents (e.g., Official Plans). It also provides strategies for implementing specific watershed initiatives and specifies who is responsible for remedial actions outside of the land use planning process (e.g. restoration opportunities on public and private lands).

1.1 Process

As part of the Niagara Water Quality Protection Strategy (NWQPS), completed in 2003, the Fort Erie Creeks Watershed Planning Area was recommended for further study. The NWQPS identified three Local Management Areas (LMA's) 2.13, 2.18, and 3.4 (ref. Appendix 'H'), which cover almost all of the Town of Fort Erie, a portion of the easterly limits of the City of Port Colborne, and a small area in the southern part of the City of Niagara Falls. The subwatersheds, which are encompassed by this Watershed Plan include: Black Creek, Beaver Creek, Baker Creek, Miller Creek, Niagara River Shore (Niagara River #16, 19, 20, 21, & 22), Frenchman's Creek, Fort Erie, Lakeshore, Kraft Drain, Bertie Bay Drains & Lake Erie 1, and Six Mile Creek.

1.2 Background and Study Area Overview

The Watershed Plan study was initiated in part due to the fact that the NWQPS recommended that additional technical and physical study would be required to address certain key issues and objectives within the local study areas.

The large watersheds from the list above include: Black Creek, Beaver Creek, Frenchman's Creek, Six Mile Creek, Miller Creek, Baker Creek and Kraft Drain. The study area of each LMA within the WSPA is large, with 106.7 km^2 (LMA 2.13), 35.8 km^2 (LMA 2.18) and 37.6 km^2 (LMA 3.4). Urban areas as follows: 6.2 km^2, 10.5 km^2 and 11.0 km^2 respectively.

1.3 Administration

This study has been prepared under the direction of a Technical Steering Committee comprised of the following members:

Niagara Peninsula Conservation Authority	***Suzanne McInnes, Tony D'Amario, Steve Miller, Jennifer Durley, Geoff Verkade, Jayne Campbell, Jocelyn Baker, Ian Barrett, Annie Michaud***
Town of Fort Erie	***David Heyworth, Brett Ruck, Ron Tripp***
Regional Municipality of Niagara	***Brian Dick***
Ministry of Natural Resources	***Mike Stone***
Niagara Parks Commission	***Debbie Whitehouse***

The foregoing committee members have provided comments and technical direction throughout the study process (ref. Appendices 'B' and 'C' for comments and meeting minutes).

1.4 Public/Stakeholder Process

This watershed planning process has included several points of contact with the Public and stakeholders. Five points of formal Public contact were initiated as follows (ref. Appendix 'A').

Date	Type	Description
September, 2005	*Notice of Study*	*Notice of Commencement of the Study and Field Inventories*
April 6, 2006	*Workshop #1*	*Watershed Characterization and Vision Statements*
October 10, 2006	*Workshop #2*	*General Watershed Management Opportunities*
February 6, 2007	*Workshop #3*	*Local Management Opportunities*
June 28, 2007	*Open House*	*Draft Final Watershed Plan*

The public will be provided with a final opportunity to review the plan after the final Open House.

In addition to the foregoing, the NPCA conducted a Rural Landowner Survey in late 2005/early 2006. The Study Team distributed three newsletters, and the NPCA posted the newsletters on its website. Several meetings were held with the area residents, as well as the Friends of Fort Erie Creeks, an active local interest group, whose objectives include the annual monitoring of the creeks for water quality, fisheries, and erosion, as well as managing local restoration programs.

1.5 Project Team

The Project Team responsible for producing this Watershed Plan has been comprised of the following firms and key personnel:

Firm	***Key Members***	***Discipline Responsibilities***
Philips Engineering Ltd.	*Ron Scheckenberger, Project Manager Brian Bishop, Rizwan Ul-Haq*	*Project Management – Water Resources Engineering, Water Quality*
Dougan and Associates	*Elizabeth Snell, Ken Ursic, Karl Konze*	*Terrestrial Resources*
C. Portt and Associates	*Cam Portt, George Coker*	*Fisheries, Benthic Resources, Water Quality*
Blackport and Associates	*Bill Blackport*	*Hydrogeology*
Parish Geomorphic	*John Parish, Susi Kostyniuk*	*Stream Morphology*
Shoreplan Engineering Inc.	*Milo Sturm*	*Shoreline Engineering*

1.6 Reporting Structure

This General Report provides detailed information related to the study process, analyses, assessment and recommendations. The General Report documents the following:

- Subwatershed Characterization
- Subwatershed Management Strategies
- Implementation and Monitoring Plan

There are two appendices included with the General Report: a General Appendix, containing all of the consultation documents, followed by a Technical Appendix (bound under separate cover) containing the three following sub-appendices:

- Natural Heritage System
- Watercourse Systems
- Stormwater Management

A Summary Report has also been prepared, which provides an overview of the Watershed Plan, and focuses on the implementation procedure.

2. WATERSHED AREA CHARACTERIZATION

A large number of reports, studies, field inventory records, and maps of varying vintage have been acquired for use in this study. A list of the information used in contained in the Bibliography.

The information providers include:

- Niagara Peninsula Conservation Authority (NPCA)
- Town of Fort Erie
- Ministry of Natural Resources (MNR)
- Regional Municipality of Niagara
- Ministry of the Environment (MOE)
- Department of Fisheries and Oceans (DFO)
- Friends of Fort Erie Creeks
- Atmosphere Environment Service, Environment Canada
- Water Survey of Canada
- Ontario Power Generation (OPG)

The NPCA, through an agreement with the Region, provided 1:2000 digital base mapping (based on 2002 aerial photography) for the study area.

The Study Team has examined the study area in greater detail, and has compiled a watershed characterization. Detailed field investigations were conducted from September 2005 through to November 2006, related to the physical environment. Specific areas of study included:

- hydrogeology
- hydrology
- hydraulics
- floodplain mapping
- stream morphology
- aquatic resources
- terrestrial resources
- water quality
- shorelines

Detailed information, including the field data and analytic procedures associated with the field investigations is documented in the three Sub-Technical Appendices (Watercourse Systems, Stormwater Management, and Natural Heritage System).

2.1 Hydrogeology

Importance:

The groundwater flow system, through recharge and discharge, maintains storage and transmittal of groundwater for:

- Domestic water supplies
- Terrestrial and aquatic resources

2.1.1 Background Information Collection

The main sources of information relevant to the hydrogeologic understanding of the study area have been reviewed from the following documents:

- Niagara Water Quality Protection Strategy (2003)
- Niagara Peninsula Conservation Authority Groundwater Study (Waterloo Hydrogeologic Inc., 2005).
- Water Resources of the Niagara Frontier and the Welland River Drainage Basin (Gartner Lee Limited, 1987)
- The Physiography of Southern Ontario (Chapman and Putnam, 1984)
- Flint, J.J., and Lolcama, J., 1985. Buried ancestral drainage between Lake Erie and Ontario. Geological Society of America Bulletin, 97, 75-84.

These studies utilize regional and subwatershed-scale geologic and hydrogeologic data with accompanying maps and discussion, including but not limited to:

- Quaternary geology
- Bedrock geology
- Bedrock topography
- Overburden thickness
- Water table surface
- Potentiometric surface
- Specific capacities of wells
- Shallow intrinsic susceptibility

2.1.2 Work Activities

The following was proposed for potential field work activities:

"It is not anticipated that field studies are within the current scope of this study. It is expected that this study will direct the need for, and the types of more localized field work. If specific issues do arise during the course of this study potentially related to groundwater discharge and baseflow then field techniques involving spot baseflow measurements, the installation of streambed piezometers and water quality sampling may be warranted."

The groundwater assessment relating to groundwater discharge was to rely to a greater extent on information from the aquatic and terrestrial components for potential zones of groundwater discharge.

Various stream reaches were inspected for groundwater discharge. Site reconnaissance was carried out on four occasions in 2005 and 2006 approximately a week subsequent to snow melt or precipitation runoff events. Areas inspected by the hydrogeologist included the upper reaches of Black Creek, the upper and middle reaches of Beaver Creek, Frenchman's Creek and Miller Creek; various reaches of Six Mile Creek, Bertie Bay Drain and Kraft Creek. Reaches were generally inspected at road crossings with a greater focus on areas of more permeable surficial sediment and topographic breaks. In addition, the field reconnaissance of the fisheries component was to note any potential areas for groundwater discharge.

2.1.3 Findings/Constraint Identification

Physiography

Chapman and Putnam, 1984 went so far as to say *'..that the south eastern part of the Niagara Peninsula, might almost be considered as a separate sub-region, characterized by levelness and poor drainage.'* This includes the Fort Erie study area and gives rise to the very subtle groundwater flow features which will be described later.

One of the major features of note within the study area is the Onondaga Escarpment which is shown on the Surficial Geology map **(**Figure 2**)**. The Paleozoic bedrock dips in a north to south direction from the Niagara Escarpment towards and underneath Lake Erie. A portion of the conceptual hydrogeologic cross-section prepared by Gartner Lee, 1987 is presented in Figure 4. This north-south trending cross-section extends from St Catharines to the north to Port Colborne to the south approximately 5 km west of the western portion of the study area. The conceptual cross section shows the bedrock formations and the dipping trends. The hard limestone caprock of the Onondaga Escarpment is more resistant then the underlying shale units to the north and, as such, a bedrock trough has been eroded between the Onondaga Escarpment and the Niagara Escarpment. This trough has been filled to varying depths with alternating units of silt and clay resulting from previous episodes of glaciation and deglaciation and is designated in the more regional extent as the Haldimand Clay Plain. The southern extent of this clay plain consists of the thicker deposits of fined grained material in the north part of the study area and a thin veneer of sediment over a large portion of the bedrock plain of the Onondaga Escarpment to the south. Beach deposits associated with glacial Lake Warren can be found in the vicinity of Ridgeway and Ridgemount. Additional features include the subtle ridges associated with the Fort Erie Moraine and the Crystal Beach Moraine. The relief associated with the Onondaga Escarpment ranges from a high of approximately 200 metres above sea level (masl) at Ridgemount to 175 masl at the Lake Erie shoreline. The Onondaga Escarpment provides enough relief to affect the south eastern surface water divide for Beaver Creek. These characteristics are also evident in the NPCA Groundwater Study Fort Erie cross-section (Figure 4a).

Bedrock Geology

The lower-most or oldest bedrock unit in the study area is the Salina Formation which can be found in the northern part of the study area (Figure 3 Unit 5) this unit consists of dolostone and shale with significant amounts of evaporites (i.e. gypsum, salt). This unit is up to 90 m thick.

Moving southward the resistant shaley dolostone of the Bertie Formation (Unit 6) overlies the Salina and provides the erosion contrast to form the Onondaga Escarpment. This unit is on the order of 10 m thick.

Along the brow of the escarpment the Bois Blanc Formation (Unit 7) is approximately 4 m thick and is composed of fossiliferous cherty limestone with some shale and sandstone layers.

The southern-most unit to the Lake Erie shoreline is the Onondaga Formation (Unit 8) consisting of fossiliferous cherty limestone. This unit can be on the order of 15 m thick.

The bedrock topography is presented on Figure 3, as well as in the NPCA Groundwater Study. Figure 3a, was enlarged from a more regional bedrock surface that was presented in Flint and Lolcama, 1985. This shows the bedrock surface in the study area and was chosen because it utilizes more data points and was field verified and interpreted to an extent by the authors. The Onondaga Escarpment is readily seen within the bedrock surface with the bedrock dipping south towards Lake Erie. The Crystal Beach paleo-drainage channel is outlined on the bedrock surface. This represents paleo-drainage from Lake Erie to Lake Ontario. The authors interpret the closed bedrock depression below the escarpment as the possible remains of a plunge pool. This depression also correlates with the thickest deposit of overburden within the study area. The bedrock topography also shows the lower elevations of the erosional trough, as described in the physiography discussion, within the northern part of the study area. Figure 4 demonstrates the general north south bedrock trend and the erosional bedrock trough previously described.

The drift thickness varies from slightly greater than 30 m at the depressional bedrock low to zero at the various bedrock outcrops (Figure 2). The drift thickness is presented in Figure 5.

Quaternary Geology

An excellent summary of the Quaternary stratigraphy is provided by Gartner Lee 1987 and is edited from the report and presented below.

A major ice advance covered the Niagara Peninsula approximately 22,000 to 14,000 years ago, during Late Wisconsinan time. This advance laid down the ground moraine characterized by the lower (Wentworth) till and associated sediments. As the ice retreated from the Peninsula into the Lake Ontario basin meltwater formed a large proglacial lake. The lower glaciolacustrine unit was deposited in this lake, covering the Wentworth Till.

The ice re-advanced out of the Lake Ontario basin approximately 13,000 years ago. It moved south-westward into the proglacial lake, covered most of the Niagara Peninsula, and deposited the Halton Till as ground and end moraines (Fort Erie Moraine and Crystal Beach Moraine). The ice then retreated northward and a series of proglacial lakes were re-established from the meltwater in the area resulting in the upper glaciolacustrine unit and various small shoreline features includes glaciolacustrine beach nearshore sand and gravel, and glaciolacustrine nearshore and deltaic sand and silt (ref. Figure 2).

Subsequent to the drainage of proglacial Lake Warren modern coastal dune sand and beach sand and gravel have been deposited along the Lake Erie shoreline. Bog deposits can be found particularly around Point Abino and modern alluvium can be found within a variety of the creek corridors particularly Beaver Creek.

The lower Wentworth Till is a dense silt to sand silt till with some sand inclusions. Locally there may be a significant component of gravel which was likely derived from the bedrock. Locally and definitely more regionally the bedrock/till contact can contain a discrete layer of granular sand and gravel. The extent of this deposit is usually limited.

The make up of the Halton Till and lower and upper glaciolacustrine units is a relatively consistent mixture of clayey silt to silty clay.

Conceptual Groundwater Flow System

Hydrogeology is the study of the movement of water through the ground and the interaction of this groundwater with surface water. It is important to understand the inter-relationship between the hydrogeologic conditions and the subwatershed ecosystem in order to assess and develop targets and controls for potential land use changes.

It is important to understand how hydrogeologic conditions influence the water movement and the hydrologic cycle. Water from precipitation percolates or infiltrates into the ground until it reaches the water table. Areas where water moves downward from the water table are known as recharge areas. These areas are generally in areas of topographically high relief. Areas where groundwater moves upward to the water table are known as discharge areas. These generally occur in areas of topographically low relief, such as stream valleys. Groundwater that discharges to streams is the water that maintains the baseflow of the stream. Wetlands are often fed by groundwater discharge.

There are different types and rates of recharge and discharge. Water percolating into the ground at a specific location may discharge to a small stream a short distance away. This is local recharge and local discharge. Some water may recharge a certain area and discharge to a larger river basin a long way from the source of recharge. This is known as regional recharge and regional discharge.

Permeable geologic materials through which groundwater moves are known as aquifers. Aquifers are "water bearing" formations meaning that water can be easily extracted from these units. Within the study area the major aquifer(s) occur within the bedrock units. Water is transmitted by bedding planes, joints, fractures and dissolution channels. The weathered component of the surficial bedrock is much more fractured and generally quite permeable. The permeability within the bedrock units can be quite variable over relatively small distances. Areas of sand and gravel act as more local aquifers and these occur primarily along the Lake Erie shoreline and to a limited extent within some of the glaciolacustrine sand and gravel deposits. How these aquifers are connected within a hydrogeologic setting is what controls much of the movement of groundwater. The less permeable units are known as aquitards, and although water can move through these units, it moves slowly and it is difficult to extract water from these units. The clayey silt and silty clay composition of the till units and glaciolacustrine lake bottom layers will act as aquitards.

Within the study area much of the surficial overburden consists of clay material, which typically is of a low permeability, that is, it does not transmit water readily. The horizontal component of groundwater flow, particularly within the overburden, will be weak due to low permeability of the silt/clay sediments. Fracturing within these types of clay deposits is known to occur to depths of 8-10 metres and likely allows for more infiltration and movement of groundwater vertically. The horizontal hydraulic connection of the clay fractures is variable with a more hydraulically active zone in the top 2-3 metres.

Groundwater flow is expected to be greater in the upper fracture bedrock and where there is contact to overlying permeable sand and gravel lenses due to the contrast between the higher permeability of this unit and the lower permeability of the overlying silt/clay unit and the underlying more competent bedrock units. Groundwater is usually directed more locally to the stream reaches that are in contact with the bedrock and more permeable alluvial sediments.

It cannot always be assumed that groundwater discharges to all wetlands. A large percentage of the wetlands are perennial or intermittent recharge areas and as such provide a significant linkage to groundwater particularly in the form of filtering out contaminants in the surface water entering them prior to the water infiltrating into the groundwater flow system. It cannot also be assumed that because of the predominance of clay that minor groundwater flow in the upper fractured clay does not provide local linkages. It is noted that there is an intricate pattern of countless small, shallow sloughs or seasonal pools connected by swales, resulting in complexes of swamp forest sloughs within a network of slightly drier forest. Minor horizontal groundwater flow through the shallow fractures in the clay may provide some level of local functional linkage.

The overburden and bedrock potentiometric (water level) maps presented in both the NPCA Groundwater Study and the Water Resources of the Niagara Frontier and the Welland River Drainage Basin study demonstrate only slight hydraulic gradients to the north and south and are a more subtle reflection of the surficial and bedrock topography. This lack of gradient also reflects the relatively lower permeability of the majority of surficial sediments. The Overburden Potentiometric Surface and Bedrock Potentiometric Surface can be found in Figures 6 and 7 as revised maps from Gartner Lee Limited, 1987.

The water level data utilized to construct overburden and bedrock potentiometric surfaces is primarily derived from the MOE water well database. Bedrock and overburden wells in and around the study area are shown in Figure 5a. The predominance of bedrock wells reflects the low potential to develop water supplies in the low permeability overburden. It is important to note the relative spatial and temporal limitations of the water well data. Spatially there a relatively small number of wells particularly in the northwest portion of the study area. Interpolation of water levels from point to point can be rather misleading and any subsequent use of the water level maps (i.e. Groundwater Discharge, Upward Gradients) can be limited. In a temporal sense the water level data reflects static levels at the time of the well installation and is not therefore a snap shop of water levels. Generally these data are useful within an averaging context but given the lack of hydraulic gradient and in some cases the lack of spatial data determination of specific groundwater flow directions, particularly within the intermediate and local scale flow systems, cannot be quantified. A dedicated groundwater monitoring well has been installed in the study area by the NPCA for the Provincial Groundwater Monitoring Network. This shallow bedrock well was installed by Jagger Hims Limited in 2003 within the upper Onondaga Formation at the corner of Hollow Bay Road North and Old Garrison Road. Details of the well installation, a local hydrogeologic cross-section, water level and water quality data are provided in Appendix 'SW-D'. The water level hydrograph shows seasonal variations of up to two metres. It can be seen that the lowest water levels occur later on in the summer with recovery through the fall and early winter. The two metre seasonal variation would be greater than the majority of hydraulic gradients within the local to intermediate flow system setting.

Any modest level of additional groundwater level data at a regional scale will not greatly add to the potentiometric surfaces but this does not preclude utilizing data from future site specific studies (Appendix 'SW-E') in refining the larger picture.

The general direction of horizontal groundwater flow within the shallow overburden/bedrock system will be north from the Onondaga Escarpment and then generally to the east and northeast. There may be more local components following the bedrock topography to the west and along the Crystal Beach paleo-drainage channel. Groundwater flow will also move to the south from the Onondaga Escarpment to the Lake Erie shoreline (Figure 7).

One can generally provide additional detail on potential groundwater flow systems by noting where significant groundwater discharge occurs. Field investigations for both the hydrogeologic component and the aquatic component were extensive and only turned up areas of more diffuse groundwater discharge in which flow could not be quantified. These areas coincided with the lower parts of the Onondaga Escarpment and the contact between the surficial sand units and the clays or at topographic breaks within the surficial sand units. Anecdotal reports of "quick conditions" at a building site at Thunder Bay Road and Prospect Point Road suggest strong upward hydraulic gradients within the surficial sands, possibly driven by the local bedrock topography. Groundwater discharge was also noted at Dominion Road in the Buffalo Heights area. This area corresponds to local bedrock outcrops and the water is likely locally derived recharge in the surficial bedrock. The NPCA Groundwater Study presented areas of Potential Groundwater Discharge (Appendix 'SW-D') by comparing water table elevations to the ground surface. Areas where the water table intersects a surficial geology unit that is more permeable, such as sand, bedrock outcrops or very thin clay overburden (2-3 metres), are more likely to result in potential discharge.

Infiltration rates, which have a direct relation to recharge to the water table, are governed to a large extent by the surficial geology and associated permeability. Other factors include vegetative cover, topography, spatial and temporal distribution of precipitation events and temperature. Another factor, which can influence the infiltration potential, is the extent of fracturing within the overburden. When the overburden has significant clay content fracturing may occur particularly in the zone where the media has been exposed to unsaturated conditions. The extent of fracturing can be dependent on the thickness of the surficial clay layer and the permeability of the underlying layer. In the study area the underlying bedrocks is generally more permeable in the upper zone as a result of more extensive fracturing. This can lead to a preferential under-draining of the overburden and the potential for enhanced fracturing in the Halton Till/glaciolacustrine clay. Areas of sand and gravel, exposed bedrock (Figure 2) and thin overburden will also provide for the more significant local recharge zones within the study area. These areas coincide quite well the Potential Groundwater Recharge Map in the NPCA Groundwater Study.

Ranges of hydraulic conductivities of the various hydrostratigraphic units were summarized by Gartner Lee Limited, 1987 and are provided in Appendix 'SW-D'.

Groundwater Quantity and Quality

Groundwater is utilized for domestic consumption through private wells within the more rural parts of the study area. The majority of the private domestic wells are drilled into the bedrock units (Figure 5a). Private drilled wells are also installed in the more permeable sand and gravel overburden and a small number of large diameter dug wells are constructed within the fracture clay overburden. A survey of the water well database to investigate individual water well depths was no within the scope of this study. The greatest well capacities are in the bedrock wells but most wells provide sufficient water for domestic purposes. The capacities of the domestic wells are noted in the NPCA Groundwater Study to be less than 25m^3/day/m.

The natural quality of water is dependent on chemical make up of the geologic unit and the residence time of the water within that unit. The water quality within the shallow overburden is typically high in major ions due to the dissolution minerals available to infiltrating groundwater within the weathered clay. As water moves deeper into the overburden there is a significant reduction in dissolved minerals due to diffusion processes and mixing with better quality water. Natural groundwater quality within the surficial permeable sand and gravel units is expected to be relatively fresh as there is less material available for mineral dissolution. The bedrock water quality is quite variable and can be highly mineralized in the bedrock formations that contain evaporites. High levels of sulphate are quite common in the bedrock wells within the study area. Bedrock water quality in the upper Onondaga Unit is presented in Appendix ‘SW-D’. The chemical results indicate slightly mineralized water.

Contaminant Susceptibility

With a delineation of the groundwater flow system which identifies where groundwater originates, where it discharges and the most prominent paths it travels one can assess the relative sensitivity of the aquifer(s) and the subsequent linkage from the groundwater system to the aquatic or terrestrial systems. Knowing the level of sensitivity of the receptor one can determine the impacts of particular types and scales of land uses or land use changes on the groundwater flow system and other linked ecosystem components.

By considering the permeability and thickness of hydrogeologic layers which may contact streams, wetlands or be the source of water for local domestic wells, one can provide a qualitative assessment of the groundwater flow system sensitivity. Within the study area these more sensitive localized areas are a result of local sand and gravel deposits, outcrops of bedrock, thin fractured surficial overburden clay (less than 10 metres) and the more recently deposited surficial sands and gravels associated with the Lake Erie shoreline. Both the NPCA Groundwater Study and the Water Resources of the Niagara Frontier and the Welland River Drainage Basin study provide contaminant susceptibility maps. Within the current mapping the Surficial Geology Map, Figure 2 and Overburden Thickness Figure 5 provides characteristics for the areas of greatest susceptibility. Permeability and overburden thickness are major criteria in the development of the NPCA Groundwater Study Shallow Intrinsic Susceptibility map (Figure 7a). A substantial portion of the southern part of the study area is considered more susceptible due to sand, exposed bedrock and thinner overburden. Alternatively underlying aquifers can be protected from surficial contaminants by thick sequences of less permeable clay and silt or upwards hydraulic gradients. The NPCA Groundwater Study Upward Gradient map can be found in Appendix ‘SW-D’.

Discussions with the Region of Niagara and data requests from the Technical Steering Committee did not provide for any studies or available data indicating local water quality problems relating to private septic systems and shallow wells or any other significant water quality problems but the

NPCA Groundwater Study did delineate an area in the southern part of Six Mile Creek and Bertie Bay Drains that are considered septic system problem areas.

2.1.4 Summary of Significant Features/Constraints

The majority of the study area is covered by relatively low permeability silt/clay overburden which will reduce infiltration but offer protection for contaminant migration to the lower bedrock aquifer.

Areas of thin fractured overburden, bedrock outcrops and surficial sand and gravel provide for greater infiltration but are more susceptible to contamination

The shallow fractured overburden provides recharge, although limited, which can be locally significant for baseflow or wetlands. Reworking the silt clay or till may reduce recharge. Efforts should be made to emulate or enhance the quality and quantity of recharge on local or site-specific basis.

Infiltration facilities for storm water management will not be effective through a majority of the study area.

The main aquifer(s) for private domestic wells are the limestone and dolostone bedrock units, which generally provide good quantity but poor quality of water. The limited surficial sand and gravel deposits are utilized for local domestic wells. Large diameter wells do exist within the clay silt till units.

The Onondaga Escarpment provides the relief for a subtle groundwater divide which directs groundwater flow in both the overburden and bedrock to the north and south.

Bringing water from outside subcatchment areas or the subwatershed can increase local recharge and potential baseflow (i.e. lake based domestic water supply).

Locations of services can short-circuit groundwater flow through the permeable underfill and may modify local groundwater flow systems. Opportunities exist to potentially enhance baseflow, however care must be taken not to intercept existing springs or local discharge.

2.2 Hydrology

Importance:

Hydrologic processes are integral to many of the natural functions and features within the subwatershed. Significant alterations to the hydrologic response within a subwatershed may increase flood potential, reduce baseflows, and alter channel-forming processes. It is therefore imperative that hydrologic processes be maintained in order to preserve existing resources.

2.2.1 Background Information Collection

The following is a list of the background reports reviewed for the Watershed Plan. A brief review of each report has been included in the Stormwater Management Technical Appendix.

- Floodplain Mapping Frenchman's Creek, Fort Erie, Niagara Peninsula Conservation Authority, May 2004.

- Niagara Water Quality Protection Strategy, Philips Engineering Ltd, CH2MHILL, MacViro Consultants, October 2003.

- Spears and High Pointe Neighbourhoods Master Servicing Plan, Earth Tech Canada Inc. December 2002

- Pollution Prevention and Control Program: Progress Report, Town of Fort Erie, September 2002

- Shoreline Management Plan, Lake Erie Shoreline, Philpott Associates Coastal Engineers Ltd. June 1992

- Town of Fort Erie, Sanitary Sewer System Master Plan Update, Totten Sims Hubicki Associates, June 1999

- Joint Evaluation of Upstream/Downstream, Niagara River Data 1996-97, March 1999

- Town of Fort Erie Storm Drainage Master Plan Update, Kerry T. Howe Engineering Limited, 1999

- Willoughby Marsh Project - Phase 1: background Report DRAFT. Contributors: Great Lakes Clean up Fund, NPCA, OMNR, Friends of Fort Erie Creeks, Ontario Hydro, Regional Municipality of Niagara, MOEE, 1996

- Town of Fort Erie Storm Drainage Master Plan, Kerry T. Howe Engineering Limited, 1994

- Town of Fort Erie Technical Appendix. Master Storm Drainage Plan Guidelines, Kerry T. Howe Engineering Limited, 1993

- Watershed Hydrology Study, Volumes 1-4, Marshall Macklin Monaghan Limited, December 1989.

In addition to the above reports, a large amount of mapping data has been supplied by the NPCA. The mapping has been checked against the other sources, e.g. the Regional Municipality of Niagara's NWQPS mapping that was produced in 2003. A comparison of the watershed boundary layers has been undertaken, and the differences have been resolved through this study, with the use of the 1 m contour DEM and through field verification.

The Town of Fort Erie has provided mapping of the Municipal Drains, as well as storm and sanitary sewer mapping.

A combination of digital and paper copies of the drainage areas has been received by the Town. It is noted that the Town records remain the standard for each of the various drains and watercourses. One example is the Kraft Drain, which has an officially delineated drainage boundary under the Drainage Act. There are however, potential spills during extreme events that have been documented in separate drainage studies.

Digital Data

- OBM mapping (MNR)
- NPCA Watershed boundary mapping, and subcatchment boundaries
- Local Management Area mapping (NWQPS 2003)
- Stormwater management facilities and flooding and erosion sites (NWQPS, 2003)
- Aerial Photography (Region 2002)
- Land use (Town of Fort Erie Official Plan)
- Municipal Drains and tile drain mapping (Town of Fort Erie)
- Black, Beaver, and Frenchman's Creeks 100 year Regulatory Floodlines (NPCA)

Soils Mapping

The Soils of The Regional Municipality of Niagara (1:25,000 mapping), Ministry of Agriculture and Food, 1989.

Flow Data

Limited flow data is available for the flow gauge in Black Creek at Stevensville. Monthly flow record files show hourly data for the period between 1991 and 1994, for some of the months.

Rainfall Data

Two meteorological stations have been identified by the Region for their proximity to Stevensville: one in Fort Erie (industrial park) and one in Welland (Sewage Treatment Plant). A comparison of this rainfall data was made with the Environment Canada gauge data (EC6132470). The Region's data covered a comparable length of time, and offered greater spatial coverage of the study area.

2.2.2 Work Activities

Compilation of background information and review of available historical streamflow and rainfall data has been conducted. Three meetings were held with the Town of Fort Erie drainage superintendent and engineering staff. A full field survey of all of the watercourse crossings has been completed, with the culvert information documented in Appendices 'WS-E' and 'WS-F'.

The majority of the work has focused on the creation the subwatershed hydrologic models, and the subsequent calibration of the Black Creek model for use in verifying flow response in the other systems.

Hydrologic Model Development

The hydrologic model SWMHYMO has been selected for use in this study due to its wide-spread application for both urban and rural land uses. SWMHYMO is an event-based model for which both historical and design storms can be used to generate runoff response (peaks and volumes) to rainfall. Additionally, observed rainfall events can be used for model calibration.

Two hydrograph algorithms have been used in the watershed model: CALIB NASHYD has been used for the rural subcatchments and CALIB STANDHYD has been used for the urban subcatchments. Any subcatchment with an impervious coverage of less than 10 % has been considered to be rural, and a subcatchment with an impervious coverage of greater than 10 % has been assumed to be urban. The existing land use model parameters are listed in Table 2.2.4.

The hydrologic routing, (i.e. routing of flows through creeks and reaches), has been modeled using the ROUTE CHANNEL algorithm. This algorithm requires a typical cross-section, which represents the channel and floodplain of each reach. A total of 17 typical sections have been determined based on the digital topographic mapping and applied over similar reaches throughout the study area.

Subwatershed Delineation and Parameterization

Previous studies that defined the watershed boundaries and municipal drains have been used as the starting point for the delineation of the subwatersheds (e.g. the Marshall Macklin Monaghan NPCA Watershed Study in 1986, which used the MNR 1:10,000 OBM for base mapping).

All watershed boundaries provided by the Town were developed by Drainage Engineers and adopted by Town By-law, and therefore can only be changed using the process stipulated under the Drainage Act.

For this study, the updated digital base mapping (Region, 2002), with 0.5 m contours, has been used to delineate the subwatersheds. Sixteen subwatersheds have been identified within the study area (ref. Table 2.2.1). The total drainage area of the Fort Erie Creeks varies from 7 ha to 10656 ha. Within each watershed there are subwatersheds of smaller size. The subwatershed boundaries have been shown in Figure 8 and the schematics of subwatersheds are shown in Figure 9.

TABLE 2.2.1:
STUDY AREA SUBWATERSHEDS

Watershed Name	Drainage Area (ha)	Watershed Name	Drainage Area (ha)
Black Creek (Confluence with Beaver Creek)	6374	Fort Erie (urban Area)	397
Beaver Creek (Confluence with Black Creek)	3777	Lakeshore (urban Area)	364
(Black Creek at Outlet)	10656	Niagara River # 16	87
Six Mile Creek	1805	Niagara River # 19	159
Frenchman's Creek	1640	Niagara River # 20	7
Miller Creek	901	Niagara River # 21	36
Baker Creek	431	Niagara River # 22	60
Bertie Bay Drains	826	Lake Erie #1	41
Kraft Drain	555		

The Frenchman's Creek hydrologic model has not been updated as part of this study since the NPCA developed the hydrology and updated the floodplain mapping of the creek in May 2004. The previously defined Frenchman's Creek watershed boundary has been used as part of the watershed delineation results of this study.

The majority of the urban areas of the Town of Fort Erie drain to Lake Erie and the Niagara River via numerous outlets. For the purpose of this study, the urban area has been "lumped" into subwatersheds according to their location. The urban area draining to the Lake Erie has been delineated with two subwatersheds: namely Fort Erie and Lakeshore, divided by the QEW. Similarly, the Niagara River subwatersheds #16, 19, 20, 21, and 22 are small urban subwatersheds along the Niagara River, which drain directly or indirectly to the river.

Of the sixteen study subwatersheds, five subwatersheds drain to Lake Erie, namely: Six Mile Creek, Bertie Bay Drains, Kraft Drain, Lakeshore and Lake Erie-1; while the rest of the subwatersheds drain to the Niagara River.

Physiographic Data and Land Use

Overall, the topography of the land is relatively flat with average overland slopes of less than 1%. The floodplains slope towards the creeks are generally relatively steep, that is greater than 3%, towards the creeks, along major creek tributaries.

The hydrologic parameter "length of flow" has been estimated between the most remote areas of a subwatershed to the outlet of each watershed. Accordingly, the overland slope has been estimated. A database of all watersheds and subwatersheds has been prepared (ref. Appendix 'SW-A').

The parameter 'time to peak' has been estimated for all rural subwatersheds based on subwatershed data using the following relationship (ref: HYMO User's Manual, USDA, May 1973, calculations are included in Appendix 'SW-A'):

$$T_p = 0.0086 A^{0.422} S^{-0.46} \left(\frac{L}{W} \right)^{0.133}$$

Where,

Tp = Time to Peak (hr)
A = Total Basin Area, (ha)
S = Slope, (m/m)
L = Overland Flow Length, (m)
W = A / L, (m)

The STANDHYD command requires the parameter "directly connected imperviousness" for each urban subcatchment, which is the measure of the impervious area that is directly connected to the outlet, (e.g. the storm sewer network). Considering the nature of the urban area, with roadside swales and areas where the overall imperviousness is 30%, only 10 % of the impervious area would be assumed to be directly connected.

Initial abstraction (I_a) has been estimated using following relation:

$$I_a = 0.2\ [25.4\ ((1000/CN) - 10)]\ (mm)$$

The dominant land use in the area is agricultural in nature. There are 14 urban centres within the study area (Table 2.2.2). The urban centres are concentrated along Lake Erie and the Niagara River with the exception of Stevensville which is located on the Black Creek.

TABLE 2.2.2:
LOCATION OF URBAN CENTERS

Urban Centres	Watershed
Stevensville	Black Creek
Douglastown	Black Creek
Gilmore	Frenchman's Creek
Garrison	Lakeshore
Walden	Lakeshore and Kraft Drain
Fort Erie	Fort Erie and Frenchman's Creek
Lakeshore	Lakeshore
Bridgeburg	Fort Erie
Spears	Kraft Drain, Bertie Bay Drains, and Frenchman's Creek
Kraft	Kraft Drain
High Pointe	Bertie Bay Drains
Crescent Park	Bertie Bay Drains
Thunder Bay	Six Mile Creek
Ridgeway	Beaver Creek and Mann Drain

Portions of the headwaters of the Black Creek are in the City of Port Colborne and City of Niagara Falls (ref. Figure 1). The existing land use data has been compiled from the three Official Plans from: Town of Fort Erie, City of Niagara Falls and the City of Port Colborne. The land use mapping, representing existing land use, has been overlaid to the subwatershed plan in order to derive the land use data for the hydrologic model (ref Figure 2).

Imperviousness for various land uses has been estimated based on municipal drainage criteria (Storm Drainage Master Plan, Town of Fort Erie, 1999) as shown in Table 2.2.3. The total imperviousness in each subcatchment has been calculated using the land use mapping.

TABLE 2.2.3:
LAND USE AND RELATED IMPERVIOUSNESS

Land Use	Imperviousness %	Remarks
Rural Residential	20%	15 m land over frontage
Urban Residential	50%	Assumed maximum Imperviousness assigned to Apartments
Commercial & Institutional	70%	As defined for Downtown Commercial
Industrial	70%	Heavy Industry
Agriculture	0%	-
Open (natural, forest, range, wood)	0%	-
Rural	10%	That is agricultural activities, agriculture related commercial / industry, livestock, aggregate extraction, park, conservation area

Source Table 4.2 Storm Drainage Master Plan, Town of Fort Erie, 1999

Soil Data

The soil data has been provided by the Niagara Peninsula Conservation Authority (NPCA), in a GIS format. The data is based on the Ministry of Agriculture and Food data from 1989. The data contains detailed information, including the soil type name, soil texture and related hydrological groups. A soil map based on the hydrologic group has been prepared (ref. Figure 11). The SCS Curve Number (CN) values for various land uses are provided in Table 2.2.4. An areally-weighted CN number has been used to calculate the representative CN in each subcatchment (ref. Appendix 'SW-B'):

$$CN_{composite} = (\Sigma A_i \times CN) / \Sigma A_i$$

TABLE 2.2.4:
CURVE NUMBER (CN) FOR PERVIOUS AREA ACCORDING TO LAND USES TYPE[1.]

Land Use	Hydrological Groups			
	A	B	C	D
Agriculture: Cult. Land with out Contours	62	71	78	81
Forested (Good)	25	55	70	77
Rural	49	69	79	84
Rural Residential	49	69	79	84
Urban Residential	49	69	79	84
Commercial	49	69	79	84
Industrial	49	69	79	84

1. Reflects Antecedent Moisture Condition II

The summary of input data, prepared for the hydrologic simulation (SWMHYMO), has been summarized in Table 2.2.5.

TABLE 2.2.5:
SUBWATERSHED PHYSICAL PARAMETERS
EXISTING LAND USE

Watershed / Subcatchment	Area	Slope	CN II	TIMP	Length of Flow	Tp	Ia
	(km^2)	(%)		(%)	(m)	Hr	(mm)
Black Creek							
BLK 100	1.86	0.07%	80	<0.5%	2242	5.65	13.02
BLK 101	2.57	0.06%	80	<0.5%	2338	6.38	12.76
BLK 102	1.56	0.05%	81	1.0%	2871	6.55	11.92
BLK 103	1.63	0.11%	79	2.0%	2984	4.65	13.71
BLK 104	1.12	0.08%	78	<0.5%	1600	4.04	14.70
BLK 105	2.07	0.33%	80	3.5%	2052	2.72	12.66
BLK 106	3.03	0.25%	78	2.0%	2653	3.71	14.05
BLK 107	5.05	0.08%	79	2.0%	5980	8.94	13.33
BLK 200	2.95	0.16%	74	<0.5%	2405	4.45	17.99
BLK 201	3.92	0.22%	79	<0.5%	2465	4.18	13.59
BLK 202	1.34	0.30%	75	<0.5%	1344	2.26	16.49
BLK 203	4.20	0.16%	78	<0.5%	2638	4.98	14.08
BLK 204	2.52	0.12%	79	<0.5%	2566	4.81	13.45
BLK 205	2.99	0.22%	80	25.0%	2800	3.97	12.91
BLK 301	2.33	0.03%	80	<0.5%	1942	8.39	12.36
St John's Drain							
STJ 100	2.63	0.12%	80	<0.5%	2892	5.08	12.63
STJ 101	4.00	0.22%	80	<0.5%	3500	13.83	12.49
STJ 102	1.67	0.06%	79	<0.5%	2058	5.68	13.31

TABLE 2.2.5: Con't SUBWATERSHED PHYSICAL PARAMETERS EXISTING LAND USE							
Watershed / Subcatchment	Area	Slope	CN II	TIMP	Length of Flow	Tp	Ia
	(km^2)	(%)		(%)	(m)	Hr	(mm)
Schihl Drain							
SCH 100	2.20	0.10%	80	<0.5%	2084	4.93	12.69
SCH 101	0.76	0.11%	80	<0.5%	1800	3.23	12.36
Roth Drain							
RTD 100	5.81	0.05%	78	<0.5%	5500	12.75	14.33
Marsh Drain							
MAD 100	3.50	0.22%	77	<0.5%	2930	4.19	14.89
MAD 101	1.87	0.06%	79	<0.5%	2657	6.40	13.71
MAD 102	0.88	0.48%	80	<0.5%	1051	1.51	12.76
MAD 103	1.37	0.28%	78	<0.5%	1734	2.52	14.08
MAD 104	1.12	0.41%	80	<0.5%	1100	1.76	12.49
MAD 200	2.78	0.08%	75	<0.5%	2378	5.80	17.15
Snyder Drain							
SYN 100	1.06	0.19%	81	2.0%	2119	2.93	11.93
BEV 100	1.61	0.11%	78	2.0%	2263	4.31	14.09
BEV 101	2.60	0.07%	79	2.0%	2926	6.61	13.68
BEV 102	1.01	0.17%	67	2.0%	1890	2.95	25.52
BEV 103	0.79	0.29%	77	<0.5%	1597	2.06	15.17
BEV 104	2.33	0.27%	76	<0.5%	2438	3.23	16.03
BEV 105	0.73	0.10%	79	<0.5%	1432	3.11	13.16
BEV 106	1.16	0.46%	76	<0.5%	1204	1.73	16.32
BEV 107	2.55	0.65%	75	<0.5%	2254	2.18	16.49
BEV 108	1.03	0.06%	78	<0.5%	2578	5.10	14.75
BEV 200	1.68	0.77%	78	7.5%	1370	1.57	13.95
BEV 201	1.35	0.52%	76	<0.5%	1627	1.84	15.97
BEV 202	0.66	1.18%	71	42.5%	973	0.89	14.18
BEV 2020	0.43	0.48%	74	<0.5%	1680	1.39	18.11
BEV 203	0.56	1.23%	69	30.0%	892	0.82	17.66
BEV 204	0.25	0.80%	75	25.0%	624	0.72	17.39
BEV 205	2.30	0.70%	71	4.0%	2002	1.98	20.91
BEV 206	2.63	0.86%	75	2.0%	1972	1.86	16.97
BEV 207	1.77	1.10%	76	2.0%	1359	1.34	15.74
BEV 208	2.29	0.66%	75	<0.5%	2573	2.17	16.92
BEV 209	3.07	0.81%	75	1.0%	2040	2.02	16.51
BEV 210	6.05	0.33%	75	<0.5%	1748	3.55	17.32
BEV 211	0.92	0.10%	73	<0.5%	1537	3.50	19.00
Miller Creek							
MIL 100	4.45	0.33%	*78*	27.0%	2457	3.60	14.32
MIL 101	2.06	0.39%	*76*	14.0%	1962	2.49	15.61
MIL 102	2.50	0.22%	*78*	2.0%	2229	6.12	14.64

TABLE 2.2.5: Con't SUBWATERSHED PHYSICAL PARAMETERS EXISTING LAND USE							
	Area	**Slope**	**CN II**	**TIMP**	**Length of Flow**	**Tp**	**Ia**
Baker Creek							
BAK 100	1.57	0.13%	*77*	<0.5%	2290	4.32	15.29
BAK 101	0.66	0.16%	*77*	<0.5%	1565	3.22	14.83
BAK 102	0.32	0.20%	*74*	<0.5%	1000	1.65	17.66
BAK 103	0.56	0.26%	*82*	2.0%	1164	1.80	10.81
BAK 200	1.20	0.12%	*85*	17.5%	2582	4.76	8.72
Kraft Drain							
KRD 100	0.67	0.43%	*73*	62.0%	1380	1.70	15.93
KRD 101	1.15	0.59%	*74*	30.0%	1682	1.67	13.50
KRD 102	1.64	0.44%	*74*	25.0%	1608	2.44	17.40
KRD 103	2.09	0.35%	*76*	13.5%	2144	4.11	15.65
Bertie Bay Drain / Hollister Drain							
BER 100	1.84	0.37%	*79*	2.0%	2022	2.57	13.50
BER 101	1.03	0.37%	*80*	6.0%	1200	2.17	11.15
BER 102	0.89	0.37%	*74*	<0.5%	1000	1.73	17.85
HOL 100	4.50	0.29%	*68*	32.0%	5091	4.59	16.93
							0.00
SIX MILE CREEK							0.00
Mann Drain							0.00
MAN 100	1.85	1.14%	*78*	6.0%	1850	1.53	14.20
MAN 101	1.87	0.47%	*68*	27.0%	2902	2.62	18.98
MAN 102	0.75	0.33%	*73*	12.0%	1532	2.40	18.35
							0.00
Six Mile Creek							0.00
SIX 100	1.76	0.93%	*76*	<0.5%	1452	1.73	15.85
SIX 101	1.18	0.74%	*76*	<0.5%	1750	1.91	16.48
SIX 102	1.33	0.37%	*74*	4.0%	2270	2.33	18.08
SIX 103	2.21	0.37%	*70*	10.5%	2284	4.37	21.98
SIX 104	1.55	0.28%	*71*	36.0%	2680	3.11	15.29
SIX 200	0.81	1.05%	*78*	<0.5%	953	1.05	14.48
SIX 201	0.82	0.57%	*74*	<0.5%	1144	1.99	17.72
SIX 300	0.52	0.99%	*80*	<0.5%	760	0.85	12.76
SIX 400	3.40	0.48%	*76*	12.5%	3019	3.21	15.73
							0.00
NIAGARA RIVER # 16	0.87	0.29%	*74*	25.0%	1358	2.01	14.24
NIAGARA RIVER # 19	1.59	0.55%	*76*	2.0%	1992	2.30	16.29
NIAGARA RIVER # 20	0.07	0.69%	*79*	16.0%	436	0.91	13.21
NIAGARA RIVER # 21	0.36	0.38%	*77*	14.0%	787	1.20	15.57
NIAGARA RIVER # 22	0.60	0.47%	*75*	15.0%	1284	1.24	17.08
FORT ERIE	3.97	1.21%	0	60.0%	1736	2.44	0.00
LAKE SHORE	3.64	0.99%	0	49.0%	1420	2.06	0.00
LAKE ERIE	0.41	0.87%	0	8.0%	746	1.30	0.00

Meteorological Data

The design criteria for the Town of Fort Erie provides the distribution for the 2 year, 5 year, and 100 year events based on the Chicago Storm for the urban watersheds. The criteria for the rural watersheds require using the SCS type storm distribution from the City of Port Colborne. Since most of the watersheds are agricultural and rural nature, the 2 year to 100 year SCS type storm distribution for the City of Port Colborne has been used in this study.

2.2.3 Findings/Constraint Identification

Hydrologic Simulation

The SWMHYMO input file and the 100 year summary output files have been included in Appendix 'SW-B'. The 100 year peak flows have been compared with the previous studies (ref. Table 2.2.6).

TABLE 2.2.6:
100 YEAR PEAK FLOW COMPARISON AT SUBWATERSHED OUTLET
EXISTING LAND USE

	2006		1989[1]	
Subwatershed	**Area (ha)**	**Peak Flow (m^3/s)**	**Area (ha)**	**Peak Flow (m^3/s)**
Black Creek (At Confluence with Beaver Creek)	6374	66.91	-	51.00
Beaver Creek (At Confluence with Black Creek)	3777	40.66	-	29.10
Black Creek at Outlet	10656	110.53	10465	72.70
Six Mile Creek E.F	1805	47.40	1766	37.70
Miller Creek	901	14.71	724	7.94
Baker Creek	431	7.07	464	3.50
Kraft Drain	555	15.51	506	7.65
Frenchman's Creek	1640	24.65[2]	1528	17.70

1. Watershed Hydrology Study, Marshal Macklin Monaghan Ltd, 1989
2. Frenchman's Creek, Floodplain mapping, NPCA, May 2004

For comparison purposes the unit area peak flows have been compared from previous studies (ref. Table 2.2.7).

TABLE 2.2.7:
100 YEAR PEAK FLOW COMPARISON UNIT RESPONSE ($m^3/s/ha$)
EXISTING LAND USE

Watersheds	**PEL, 2006**	**MMM, 1986**	**NPCA 2004**
Black Creek at Outlet	0.010	0.007	n/a
Six Mile Creek	0.026	0.021	n/a
Frenchman's Creek	n/a	0.012	0.015
Baker Creek	0.016	0.008	n/a

PEL - Philips Engineering Ltd
MMM – Marshall Macklin Monaghan Limited
NPCA – Niagara Peninsula Conservation Authority

The SWMHYMO results of this study are comparable with the previous studies. Overall, the 1986 study has estimated relatively low flows, while a recent study (Floodplain Mapping - Frenchman's Creek, NPCA, 2004) has estimated comparatively higher flows. The Six Mile

Creek and Baker Creek have higher unit area peak flows than the Black Creek flows due to the urban nature of the Baker and Six Mile Creek watersheds.

For comparison purposes, the Regional Frequency Analysis (MTO) has been performed for the entire Black Creek and Beaver Creek (ref. Appendix 'SW-B'). The RFA results show the 25 year peak flow is 62.67 m^3/s at the outlet, while SWMHYMO simulated the 25 year peak flow of 70.68 m^3/s.

The above comparisons of peak flows suggest the reasonableness of the SWMHYMO results.

Model Calibration

For calibration purposes a node has been included in the SWMHYMO model at the Wingers Road Bridge, where a flow gauge was installed. The calibration watershed has a sizeable drainage area of 5161 ha with 20 subcatchments (ref. Figure 12).

A complete discussion on the calibration and sensitivity analysis exercise has been included in the Stormwater Management Technical Appendix.

Calibration Results

For three of the five selected events, the observed peak flows are higher than the simulated peak flows and the two events of July 17th, 1992 and September 21st, 1992 are lower, which is likely due to the initial wet conditions during the previous day's rainfall events. The observed hydrograph of September 3rd, 1992 event did not produce a reliable response, as was observed during July 17th event, with a similar depth of rainfall. The simulated 'time to peak' has been reasonable for all the events.

Although there is a significant difference between the observed and simulated runoff volumes, the simulated runoff coefficient consistently reflects the agricultural and rural nature of the subwatershed (i.e. C = 0.2 +/-).

The observed hydrographs have slow recession limbs compared with the simulated hydrographs. This is presumably due to the storage of runoff volumes within the natural areas, along with the wide and flat creeks with backwater conditions. These systems hold the runoff and release it at slower rates. This situation could not be accurately simulated to replicate the observed hydrograph. This significantly contributes to the underestimate of runoff volumes. Another limitation relates to the assumption of rainfall at one gauge station being uniform over the entire study area.

Based on the results and findings of the calibration exercise, it has been recommended that the subwatershed model be considered adequately calibrated, and the adjustment to the parameters has been applied to the other subwatersheds.

A complete listing of the calibrated modeled frequency flows for each of the watersheds has been included in Table 2.2.8.

TABLE 2.2.8: FREQUENCY FLOWS (m^3/s) EXISTING LAND USE											
Location		**Node**	**HEC-RAS Sec.**	**Culvert**	**Area**	**Frequency Flow Rates (m^3/s)**					
			(No.)	**(No.)**	**(ha)**	**2**	**5**	**10**	**25**	**50**	**100**
Black Creek											
Tributary 1	At outlet to Niagara River		1750	1	10656	9.62	29.31	46.11	70.20	89.88	110.53
Tributary 1	At QEW - Conf of Black and Beaver	BLK-19	2751	2	10151	9.04	28.03	44.31	67.70	86.88	106.93
Tributary 1	After Snyder Drain	BLK-18	3500		6374	6.74	19.12	29.11	43.28	54.93	66.91
Tributary 1	Before Snyder Drain	BLK-16	4000	22	5965	5.93	17.15	26.16	39.02	49.56	60.38
Tributary 1	After Conf. With Tr. 2	BLK14	6750	24	5758	5.67	16.46	25.10	37.48	47.58	57.96
Tributary 1	Before Conf. With Tr. 2	BLK13	7000	27	874	1.38	3.60	5.37	7.84	9.84	11.90
Tributary 1	After Blk101	BLK11	8750	28	443	0.69	1.79	2.65	3.85	4.82	5.83
Tributary 1	Headwater	BLK100	10632		186	0.38	0.92	1.35	1.94	2.40	2.87
Tributary 2	Before Conf. With Tr. 1 (Flow Gauge)	BLK25	20250	25	4884	4.29	12.87	19.75	29.65	37.75	46.08
Tributary 2	Add BLK301	BLK31	23500	31	4585	4.18	12.42	19.26	29.15	37.16	45.47
Tributary 2	Before Conf. With March Dr (Tr3)	BLK-24	24000	47	1493	1.85	5.85	9.20	14.05	17.99	22.03
Tributary 2	Headwater	BLK-23	25250	48	1241	1.39	4.65	7.38	11.93	14.63	17.96
Tributary 2	Headwater	Blk-22	29379	52	821	0.79	2.79	4.55	7.16	9.29	11.48
Tributary 3	Conf of Tr.4, Tr.5 with Tr.3	MAD-11	33552	39	1396	1.24	3.46	5.31	7.95	10.08	12.31
Tributary 3	Tr.6 in Tr. 3	MAD-13	31500	33	2747	2.21	6.27	9.71	14.62	18.55	22.70
Tributary 4	Tr.4	MAD-10	41750	43	815	0.89	2.58	4.01	6.08	7.76	9.52
Tributary 5	Tr.5	RTD-10	51500	44	581	0.44	1.16	1.74	2.55	3.19	3.86
Tributary 6	Conf. With Schihl Drain	STJ-11	61000	35	1126	1.21	3.30	4.97	7.33	9.19	11.14
Tributary 6	Headwater	STJ-10+STJ102	63000		830	0.73	1.99	3.02	4.49	5.63	6.85
Tributary 7	Headwater	SCH100+SCH101	72500		296	0.53	1.39	2.09	3.07	3.85	4.65
Beaver Creek											
Tributary 1	before conf. With Black Cr	BEV 29.1 + BEV 211	11750		3777	2.44	8.92	15.26	24.64	32.48	40.66
Tributary 1		BEV-29	14000		3080	1.90	6.80	11.87	19.32	25.54	32.31
Tributary 1	After Conf. With Tr. 2	BEV-27	17000	8	2544	1.87	6.02	9.90	16.16	21.03	26.53
Tributary 1		BEV-17	18966	17	1278	1.55	4.95	8.05	12.38	16.09	19.88
Tributary 1		BEV-16	19750	18	1023	1.33	4.01	6.30	9.62	12.38	15.21
Tributary 1		BEV-14	122048	19	907	1.25	3.66	5.69	8.63	11.07	13.55
Tributary 1	Tr.1 Headwater	BEV-13	124000	20	601	0.89	2.29	3.44	5.12	6.50	7.93

TABLE 2.2.8: FREQUENCY FLOWS (m^3/s) EXISTING LAND USE											
Location		Node	HEC-RAS Sec.	Culvert	Area	Frequency Flow Rates (m^3/s)					
			(No.)	(No.)	(ha)	2	5	10	25	50	100
Tributary 2	Before Conf with Tr. 1	BEV-26	201500	9	986	1.65	5.22	8.71	13.72	17.87	22.29
Tributary 2		BEV-23	203750	14	468	1.41	3.83	6.09	8.90	11.33	13.90
Tributary 2		BEV-21	204004		412	1.34	3.70	5.81	8.58	10.89	13.40
Tributary 2	Tr.2 Headwater	BEV-20	205500		303	0.71	1.85	2.77	4.05	5.07	6.12
Six Mile Creek											
Mann Drain	Mann Drain Tr. 3	MAN 101	303500	86	187	1.06	2.28	2.58	4.46	6.04	8.13
Mann Drain	Mann Drain Tr. 4	MAN 100	401250	85	185	0.77	2.15	3.29	4.89	6.17	7.5
Mann Drain	Mann Drain Tr. 3	MAN-10	301000	78	372	1.52	4.36	5.82	9.32	12.14	15.31
Six Mile Creek	Six Mile Cr. Tr. 1	SIX-40	105250	80	340	0.96	2.38	3.52	5.11	6.38	7.68
Six Mile Creek	Six Mile Cr. Tr. 2	SIX-11	202750	82	294	0.77	2.45	3.89	5.96	7.65	9.40
Six Mile Creek	Conf. Of Tr.1 and Tr. 2	SIX-22	102500	77	982	2.50	7.07	10.91	16.36	20.77	25.36
Six Mile Creek	Six Mile Cr. Tr. 1 and Mann Drain	SIX-14	101865	75	1805	4.82	13.15	20.10	30.46	38.81	47.40
Miller Creek											
Miller Creek	Headwaters	MIL 100	107250		445	0.92	2.49	3.76	5.54	6.98	8.46
Miller Creek		MIL-11	103028	60	651	1.18	3.35	5.12	7.63	9.68	11.80
Miller Creek	At outlet	MIL-12	100250	58	901	1.69	4.42	6.61	9.69	12.17	14.71
Kraft Drain											
Tributary 1	Headwater	KRD 100	101250		67	0.19	0.53	0.90	1.56	2.29	3.05
Tributary 1	Headwater	KRD 102	101500		164	0.58	1.64	3.03	5.30	7.33	9.67
Tributary 2	Headwater	KRD 103	201006	69	209	0.37	1.02	1.57	2.34	2.96	3.60
Tributary 3	Headwater	KRD-12	300755	70	182	0.71	1.92	3.24	5.31	7.10	9.23
At Outlet	Confluence of all Tributaries	KRD-13	100750	68	555	1.25	3.49	5.73	9.10	12.10	15.51
Baker Creek											
Baker Creek	Headwaters	Bak-10	102500	57	255	0.49	1.34	2.03	3.01	3.79	4.60
Baker Creek	Conf. With Dr. Cobb Drain	Outlet	100655	56	431	0.83	2.12	3.14	4.62	5.81	7.07

2.2.4 Summary of Significant Features/Constraints

Sufficient existing rainfall data and flow data has been collected to provide enough significant events for hydrologic model calibration. The Black Creek is a low-gradient system, affected by backwater from the Niagara River, and also has large amounts of marsh in the subwatershed. Consequently, the effectiveness of the calibration is limited, however the peak flow estimates are considered to be satisfactory for floodplain management purposes.

The topography and soils did not have any significant features from a hydrologic perspective. There are no large impoundments of water, such as lakes or dams, to restrict the flows and affect the hydrologic routing in the watersheds.

The models have been calibrated using the Black Creek watershed, and flows have been developed to enable the completion of the floodplain mapping.

2.3 Hydraulics/Floodplain Mapping

Importance:

Hydraulic characteristics of watercourse systems are important to the function of the watercourse network and the features they support, including:

- Natural fluvial processes
- Conveyance of flood flows
- Terrestrial and fish habitat functions
- Conveyance/interception of baseflow/seepage to receiving watercourse

2.3.1 Background Information Collection

- Frenchman's Creek Floodplain Mapping, NPCA, 2004
- Town of Fort Erie culvert assessment database and photos, 2003
- Town of Fort Erie Municipal Drain reports and mapping
- Watershed Flood Damage Assessment Study, Cumming Cockburn Ltd. 1988
- Floodplain Mapping Town of Fort Erie, Black Creek and Beaver Creek, General Report and Technical Report, DeLeuw-Cather (DeLCan), Canada Ltd, December 1985

2.3.2 Work Activities

All creek bridges and culvert structures, within the study area, have been field surveyed by the field staff of Philips Engineering Ltd. during February and March 2006 (ref. Appendix 'SW-C'). The US Army Corp of Engineering River Analysis System (HEC-RAS) has been used for the hydraulic analysis and floodplain determination (ref. Appendix 'WC-F').

RiverCAD™ has been used to develop the basic HEC-RAS model input from the digital topographic mapping. Additional structure data has been included based on field survey as noted.

The Town of Fort Erie assisted in the refinement of the drainage area delineation for all of the Municipal Drains. Numerous background reports that have been prepared were made available for review. Several drains are currently undergoing a reassessment. The most current digital mapping from the Town has been used for the study area delineation.

Channel roughness and floodplain roughness in each reach have been estimated based on field reconnaissance survey, aerial photographs, and site photographs. The boundary conditions in HEC-RAS, which includes the water surface elevations in the receiving water body (lake or river), have been obtained from the historic record. The boundary condition becomes a significant parameter since the backwater conditions in most of the creeks within the study area is significant.

The Ontario Power Generation flow gauge in the Niagara River recorded an average water surface elevation of 172.165 m between 1966 and 1983 and has been used for Black Creek, and the 100 year water surface elevation of 173.32 m, as recommended by the Ministry of Natural Resources (DelCan, 1985). The Frenchman's Creek model used the100 year boundary condition of 173.98 m (NPCA. 2003), therefore, the 100 year outlet boundary condition for the Miller Creek has been determined as 173.65 m, using linear interpolation.

The Canadian Hydrographic Service, a section of the Department of Fisheries and Oceans, has compiled the historic water surface elevations in Lake Erie. The, mean monthly water surface elevation is 174.4 m and the maximum monthly mean in any year is 174.86 (reported in 1987). Niagara Peninsula Conservation Authority has recommended the 100 year WSEL in Lake Erie to be 177.11 m, as noted in the Flood and Erosion Risk Maps (Marshal, Macklin, Monaghan, Canada-Ontario Flood Damage Reduction Study, 1991).

In order to determine the 100 year floodlines on the Fort Erie Creeks watersheds, two different downstream boundary conditions have been modeled:

- The 100 year hydrologic rainfall-runoff event peak flows run with the mean annual water surface elevation at the outlet (i.e. Niagara River or Lake Erie)

- The 100 year downstream boundary condition superimposed on the surrounding lands at the creek mouths

The greater of the two water surface elevations has been selected by the NPCA as the regulatory elevation.

2.3.3 Findings/Constraint Identification

Historic floodplain mapping is available for the Black Creek, Beaver Creek and Frenchman's Creek. The Black and Beaver Creek floodplain mapping is considered outdated since more detailed aerial photography has been converted to more accurate mapping. Some of the previous hydraulic section information was based on the MNR OBM product (1983), which has a 5 m contour interval. The NPCA has recently updated the floodplain mapping for Frenchman's Creek, using the most current topographic mapping (2002) which has a 1 m contour interval.

A total of 83 culverts and bridges have been field surveyed, including upstream and downstream cross-sections, road profile and a photographic inventory (ref. Appendix 'WC-E'). A list of structures have been included in Table 2.3.1.

Updated floodplain mapping has been prepared for Black Creek, Beaver Creek, Baker Creek, Miller Creek, Kraft Drain and Six Mile Creek and is available at the NPCA, under separate cover (ref. Figure 14).

TABLE 2.3.1:
FORT ERIE CREEKS STRUCTURE SUMMARY OF CULVERT DATA FROM FIELD AND BACKGROUND DATA

Culvert ID	Watersheds	Crossing	Size (m)		Number of Culverts	Footing Type	Material	Length (m)	Slope (m/m)	U/S Creek Invert (m)	U/S Creek Obvert (m)	Top of Road (m)
			Span (m)	Rise (m)								
1	Black Creek	Niagara Parkway	22.50	4.73	1.00	Arch	Stone	13.80	-0.02	169.66	173.69	174.46
1A	Black Creek	Netherby Road	17.80	1.77	1.00	Bridge Abutment	Stone / Steel	7.40	0.01	170.35	174.12	174.12
2	Black Creek	QEW	18.70	2.00	1.00	Arch	Concrete	35.00	0.01	171.25	174.36	175.50
3	Beaver Creek	College Road	7.60	1.64	1.00	Arch	Concrete	7.00	0.02	170.89	172.53	173.30
4	Beaver Creek	Eagle St.	6.10	2.15	1.00	Open Box	Corrugated Steel	18.00	0.01	171.33	174.5	174.89
5	Beaver Creek	Penn Central Railway	14.80	2.60	1.00	Bridge Abutment	Concrete/Steel	8.50	0.03	172.46	175.16	176.49
6	Beaver Creek	CNR	10.70	5.30	1.00	Bridge Abutment	Stone / Steel	8.40	-	173.28	177.38	178.80
7	Beaver Creek	Bowen Road	6.10	1.92	1.00	Open Box	Concrete	9.50	0.01	173.22	175.06	175.82
8	Beaver Creek	Winger Road	4.60	1.80	2.00	Bridge Abutment	Concrete	5.40	0.01	174.53	176.35	176.57
9	Beaver Creek	Bertie Road	4.10	1.60	1.00	Open Box	Concrete	11.00	0.01	176.54	177.10	177.83
10	Beaver Creek	Bertie Road	1.83	0.70	1.00	Open Box	Concrete	11.00	0.00	175.25	176.84	177.64
10A	Beaver Creek	Bertie Road	1.80	0.83	1.00	Open Box	Concrete	11.00	0.00	176.32	177.20	177.64
11	Beaver Creek	HWY 3	4.88	1.60	1.00	Open Box	Concrete	32.00	0.01	176.50	177.99	178.89
12	Beaver Creek	Gorham Road	4.88	1.54	1.00	Open Box	Concrete	24.20	0.00	176.62	179.10	178.89
13	Beaver Creek	Gorham Road	4.87	1.54	1.00	Open Box	Concrete	17.50	0.01	179.48	181.27	182.26
14	Beaver Creek	Nigh Road	3.60	1.26	1.00	U/s Open Box d/s Arch	Concrete	6.90	0.01	179.48	180.80	181.45
15	Beaver Creek	Gorham Road	3.67	1.60	1.00	Open Box	Concrete	21.80	0.01	180.67	182.16	183.58
16	Beaver Creek	Stevensville Road	6.10	1.60	1.00	Open Box	Concrete	21.90	0.01	173.09	174.64	176.86
17	Beaver Creek	Ott Road	2.40	1.52	2.00	Box	Concrete	12.50	0.00	176.06/175.9	177.58/177.42	177.77
17A	Beaver Creek	Ott Rd., N. of Culv. 17	2.40	1.20	1.00	Box	Concrete	12.50	0.00	176.01	177.21	177.77
18	Beaver Creek	House Road	4.30	1.90	1.00	Open Box	Concrete	18.00	0.04	180.63	182.74	183.76
19	Beaver Creek	HWY 3	3.66	2.14	1.00	Open Box	Concrete	42.60	0.00	182.54	184.60	186.86
20	Beaver Creek	Nigh Road	3.66	1.83	1.00	Open Box	Concrete	16.00	0.00	183.09	184.71	185.56
21	Beaver Creek	Point Abino Road	3.66	1.65	1.00	Open Box	Concrete	12.50	- 0.002	183.52	185.11	185.95
22	Black Creek	College Road	12.21	3.07	1.00	Bridge Abutment	Concrete / Steel	8.00	0.00	170.40	173.47	174.10
23	Black Creek	Eagle Road	21.20	2.49	1.00	Bridge Abutment	Concrete	6.70	0.01	170.70	173.19	174.41
24	Black Creek	Penn Central Railway	9.00	3.06	1.00	Bridge Abutment	Concrete / Steel	9.00	0.01	171.93	174.99	177.25
25	Black Creek	Winger Road	11.60	2.44	1.00	Bridge Abutment	Concrete / Steel	11.80	- 0.027	171.37	173.47	174.61
26	Black Creek	Winger Road	12.20	1.70	1.00	Bridge Abutment	Concrete / Steel	5.60	- 0.063	171.61	173.31	174.04

TABLE 2.3.1: FORT ERIE CREEKS STRUCTURE SUMMARY OF CULVERT DATA FROM FIELD AND BACKGROUND DATA												
Culvert ID	**Watersheds**	**Crossing**	**Size (m)**		**Number of Culverts**	**Footing Type**	**Material**	**Length (m)**	**Slope (m/m)**	**U/S Creek Invert (m)**	**U/S Creek Obvert (m)**	**Top of Road (m)**
			Span (m)	**Rise (m)**								
27	Black Creek	CNR	10.70	4.50	1.00	Bridge Abutment	Stone / Steel	18.00	-	172.87	177.37	178.79
28	Black Creek	Bowen Road	1.20	-	2.00	Bridge Abutment	Corrugated Steel	19.60	- 0.011	173.71	174.56	175.57
29	Black Creek	Stevensville Road	2.44	1.00	1.00	Open Box	Concrete	21.80	0.00	175.99	177.16	178.80
30	Black Creek	Stevensville Road	14.70	2.71	1.00	Bridge Abutment	Concrete	18.00	0.01	171.65	176.89	175.06
31	Black Creek	Ott Road	13.00	3.20	1.00	Bridge Abutment	Concrete / Steel	11.00	0.01	172.64	175.84	176.63
32	Black Creek	House Road	6.10	3.35	1.00	Box	Concrete	18.00	0.00	173.00	176.35	177.32
33	Black Creek	Fox Road	4.27	2.77	1.00	Open Box	Concrete	16.90	0.01	175.36	177.68	178.21
34	Black Creek	Penn Central Railway	7.00	2.30	2.00	Bridge Abutment	Stone / Steel	8.50	0.01	174.95	177.27	178.55
35	Black Creek	College Road	3.66	0.62	1.00	Open Box	Concrete	5.00	0.00	174.83	175.35	175.58
36	Black Creek	Point Abino Road	3.85	-	1.00	Circle	Corrugated Steel	24.00	0.01	173.95	176.11	177.37
38	Black Creek	Church Road	5.50	1.58	1.00	Open Box	Concrete	7.60	0.00	174.83	177.08	177.77
39	Black Creek	Burger Road	5.62	1.82	1.00	Open Box	Concrete	13.50	- 0.017	175.31	177.19	177.88
46	Black Creek	CNR	10.53	5.29	1.00	Bridge Abutment	Stone / Steel	8.30	0.08	174.35	179.57	180.36
47	Black Creek	Church Road	6.10	2.80	1.00	Open Box	Concrete	20.00	0.01	173.97	177.01	177.70
48	Black Creek	House Road	6.10	1.68	1.00	Bridge Abutment	Concrete / Steel	5.60	- 0.018	175.39	177.07	177.85
49	Black Creek	Point Abino Road	7.50	2.18	1.00	Con Span	Concrete	12.50	0.01	173.95	176.11	176.70
50	Black Creek	Burger Road	6.10	1.53	1.00	Open Box	Concrete	14.00	0.00	177.60	179.13	180.14
51	Black Creek	Holloway Road	2.75	1.35	2.00	Arch	Concrete	6.00	0.01	178.41	179.75	179.68
52	Black Creek	Zavitz Road	6.10	1.72	1.00	Open Box	Concrete	14.00	0.01	178.67	179.92	180.16
53	Black Creek	Leam Road	5.50	1.70	1.00	Open Box	Concrete	15.00	0.01	179.46	181.16	182.30
54	Black Creek	2nd Concession	5.50	1.56	1.00	Open Box	Concrete	14.00	0.01	179.93	181.49	181.96
55	Baker Creek	Niagara Parkway	12.00	2.10	1.00	Arch	Concrete / Stone	16.00	-0.02	171.28	173.44	174.53
56	Baker Creek	Schueigler Road	2.46	1.00	1.00	Open Box	Concrete	5.00	-0.05	171.35	172.65	173.28
57	Baker Creek	Townline Road	3.00	1.20	1.00	Box	Concrete	12.50	0.00	172.59	173.79	174.81
58	Miller Creek	Niagara Parkway	9.00		1.00	Arch	Concrete	11.50	0.00	171.53	174.59	175.26
59	Miller Creek	Miller Ave	4.20	2.10	1.00	Open Box	Concrete	12.50	0.02	171.69	173.82	174.40
60	Miller Creek	Abandond CNR										
61	Miller Creek	Sutherland	3.00	1.20	2.00	Open Box	Concrete	7.50	0.00	175.23	176.39	176.85
62	Miller Creek	Arcadia Road	4.20	1.20	1.00	Box	Concrete	17.50	-0.02	174.82	176.27	177.03
63	Miller Creek	Petit Road	3.50	1.35	1.00	Box	Concrete	14.50	0.00	175.68	177.04	177.61

TABLE 2.3.1:
FORT ERIE CREEKS STRUCTURE SUMMARY OF CULVERT DATA FROM FIELD AND BACKGROUND DATA

Culvert ID	Watersheds	Crossing	Size (m)		Number of Culverts	Footing Type	Material	Length (m)	Slope (m/m)	U/S Creek Invert (m)	U/S Creek Obvert (m)	Top of Road (m)
			Span (m)	Rise (m)								
64A	Miller Creek	Abundand Rail Track	2.50	2.10	1.00	Box	Concrete	7.00	0.00	178.01	180.26	182.25
64B	Miller Creek	CNR			1.00	Arch	Stone	12.00	0.01	178.19	180.33	182.54
64C	Miller Creek	Penn Central Railway			1.00	Open	Stone	12.00	-0.01	177.57	180.33	182.00
65	Miller Creek	Bowen Road	3.00	1.50	1.00	Open Box	Concrete	20.00	0.01	178.22	179.72	181.08
66	Miller Creek	Pettit Road	-	0.90	2.00	Pipe	Corrugated Steel	13.00	-0.01	179.80	180.67	182.18
67	Kraft Drain	Ashphalt Trail	3.00	2.00	1.00	CSPA	Corrugated Steel	5.00	0.00	175.11	177.14	179.08
68 A	Kraft Drain	Dominion Road	3.04	1.85	1.00	Box	Concrete	15.00	0.02	175.79	177.4	178.18
68 C	Kraft Drain	Edgemere Road	2.40	2.55	1.00	Open Box	Concrete	6.50	-0.01	174.94	177.47	177.86
68 B	Kraft Drain	Private Driveway	4.00	2.00	1.00	CSPA	Corrugated Steel	1.50	0.01	175.11	177.14	179.08
69	Kraft Drain	Kraft Road	-	0.85	1.00	CSP	Corrugated Steel	9.50	0.01	178.58	179.38	179.83
70	Kraft Drain	Kraft Road	1.25	0.60	1.00	Box	Concrete	9.00	0.01	180.02	181.23	181.80
71	Bertie Bay Drain	Macdonald Drive	1.00	1.00	1.00	Box	Concrete	17.00	0.01	175.55	176.54	177.00
72	Bertie Bay Drain	Walking Trail	1.08	0.90	1.00	Box	Stone	7.00	0.01	178.03	178.7	179.90
73	Six Mile Creek	Colony Road	14.40	2.60	1.00	Open Span	Steel / Wood	4.00	0.00	173.08	175.69	176.35
74	Six Mile Creek	Colony Road	31.00	2.20	1.00	Open Span	Steel / Wood	4.00	0.06	173.58	175.81	176.75
75	Six Mile Creek	Thunder Bay Road	9.00	2.50	1.00	Open Span	Concrete	9.00	0.01	173.23	175.73	176.27
76	Six Mile Creek	Walking Trail	7.60	2.90	1.00	Bridge Abutment	Steel / Stone	7.00	0.00	175.06	178.13	179.27
77	Six Mile Creek	Dominion Road	10.00	1.40	1.00	Bridge Abutment	Concrete	12.50	0.00	175.02	176.78	177.43
78	Six Mile Creek	Centralia Ave. N.	2.40	1.40	1.00	Open Box	Concrete	14.00	0.02	175.78	176.37	177.52
79	Six Mile Creek	Nigh Road	1.85	1.10	1.00	CSPA	Corrugated Steel	10.00	0.00	177.30	178.53	179.06
80	Six Mile Creek	Stone Mill Road	2.10	1.20	1.00	Open Box	Stone / Concrete	9.00	0.00	178.53	179.9	180.37
81	Six Mile Creek	Nigh Road	3.10	1.49	1.00	Open Box	Concrete	13.50	-0.01	177.29	178.77	179.35
82	Six Mile Creek	Centralia Ave. N.	2.00	1.00	1.00	Open Box	Concrete	8.40	-0.01	180.73	181.69	182.55
83	Six Mile Creek	Bernard Ave.	1.80	1.00	1.00	Open Box	Concrete	7.50	-0.01	177.97	178.93	179.68
84	Six Mile Creek	Bernard Ave.	1.20	0.60	1.00	Open Box	Concrete	7.80	-0.10	179.69	180.29	180.82
85	Six Mile Creek	Nigh Road	1.20	0.60	1.00	Open Box	Concrete	7.00	0.03	180.58	181.22	181.81
86A	Six Mile Creek	Nigh Road	1.50	1.00	1.00	Open Box	Concrete	23.40	0.00	180.12	181.3	181.85
86B	Six Mile Creek	Nigh Road	2.20	1.00	1.00	Open Box	Concrete	12.60	-0.06	180.24	181.1	181.46

2.3.4 Summary of Significant Features/Constraints

The hydraulic modeling and floodplain mapping has been prepared for the seven largest of the Fort Erie Creeks in the study area (Black, Beaver, Baker, Miller, Frenchman's, Kraft, Six Mile). The Black Creek outlet was shown to be the only reach where the downstream boundary condition was impacted by the 100 year water surface elevations in the receiving water body. This was not unexpected, given the gentle gradient of the Black Creek.

There are a number of building structures that have been identified within the 100 year Regulatory floodplains. The mapping and documentation of the floodlines are kept under separate cover by the NPCA, however the findings form part of the recommendations for management that are developed in the Watershed Plan.

2.4 Stream Morphology

This section covers the morphology and condition of the watercourses within the study area which includes a characterization of individual reaches, a historic analysis of the channel network and associated land use patterns, quantification of channel stability and overall health, and the evaluation of geomorphic conditions.

2.4.1 Background Information

This component of the watershed study provides an historical assessment of the Fort Erie Creeks Watershed using a series of aerial photographs, as well as a reach description summarizing present conditions observed during the November/December 2005 field reconnaissance. Historical analyses have provided insight into the degree of natural fluvial activity and human impacts within the study area, such as channel straightening or changes in land use and channel planform. Investigation of stream morphology initially involved collecting and reviewing background and historical information to identify channel characteristics (e.g. stream length and gradient) and historical changes (e.g. planform change).

Historical land use and channel changes have been evaluated over a 50-year time period for the entire study area. An examination of historical aerial photographs allows the natural tendencies of a river through time to be determined. Moreover, changes in land use and the subsequent response of the channel can be identified. Included in the historical analyses were aerial photographs taken in: 1955, 1978 and 2005 (Google Earth Digital aerial). Due to the scale of the aerial photographs, the size of some of the channels' patterns could not always be observed.

Historical Assessment

<u>Six Mile Creek</u>

In general, the land uses surrounding Six Mile Creek have not been altered since 1955. The majority of the lands remain enveloped in agricultural and scrubland designations, with minor residential parcels present around the main road intersections and the shoreline of Lake Erie.

Reaches SMC-1 through to SMC-5, SMC-9 and SMC-10 appear to have retained their natural meander form, with little alteration observed between the years studied. Reaches SMC-6 to SMC-8 however, appeared to have been modified/straightened into functioning drains for agricultural purposes prior to 1955. The sparse scrubland vegetation and agricultural crops present in the 1995 aerial photographs have been replaced with denser woodlot and scrubland parcels throughout most of the southern section of this watercourse. More specifically, the land uses surrounding Reaches SMC-2, SMC-3 and SMC-4 have progressed from agricultural fields in 1955 to dense woodlot areas in 2005. In 1955, two race tracks can be seen on a parcel of land lying between Reaches SMC-6 and SMC-9, north of the confluence of these reaches. These race tracks appeared to have been abandoned in 1978 where scrubland and meadow vegetation had begun to take over the area. No trace of these race tracks can be seen in the 2005 digital photographs. Therefore, this progression to a more naturally vegetated area would have decreased the amount of sediment entering Reaches SMC-6 and SMC-9.

There has not been any significant increase in residential development or road infrastructure observed for any reach within this watershed. Aside from the straightening of some of the upper reaches, there does not appear to be any significant change in the channel planform observed from 1955 to 2005. However, because of the scale and clarity of the 1955 and 1978 aerial photographs, determining changes in specific meander form and migration on a reach by reach basis could not be accurately assessed.

<u>Frenchman's Creek</u>

The main branch of Frenchman's Creek has a variety of surrounding land uses that progress from lakeshore residential, to scrubland/wetlands, followed by golf course property and then agricultural fields. Very little residential development was observed beyond the shoreline. There are a number of road crossings and associated infrastructure that separate the reaches and land use designations observed.

Aerial photographic coverage for Reaches FRC-1 through FRC-6 was not available for 1955; therefore, descriptions of these reaches were only based on the 1978 and 2005 photographs. The remaining reaches have been assessed over a full 50-year coverage.

The large channel widths of Reaches FRC-1and FRC-2 made it possible to analyze the channel planform and land use changes observed between 1978 and 2005. The mouth of FRC-1 was surrounded by agricultural fields in 1978. This agricultural land use appeared to be abandoned sometime before the 2005 aerial photograph was taken; presently, this portion of the watercourse is surrounded by scrubland and woodlot parcels. The remainder of this reach was surrounded by a low lying wetland area present in both 1978 and 2005. The upstream portion of this reach had formed lateral and point bars along the meander bends prior to 2005, however these bar formations were not observed in the 1978 aerial photographs.

The channel planform of Reach FRC-2 does not appear to have changed between 1978 and 2005, however the upstream portion of the reach in both photographs is obscured by vegetation. Therefore, an accurate determination of channel planform changes could not be determined. The land use surrounding this reach was consistent between the years with apparent changes observed.

Reaches FRC-3, FRC-4 and FRC-6 were completely obscured by vegetation in both the 1978 and 2005 aerial photographs. Therefore, characterization of channel planform changes could not be assessed. In 2005 the land use did not vary from the scrub and wetland features observed in 1978.

Reach FRC-5 was surrounded by the Rio Vista Golf and Country Club, established sometime before 1978. The vegetation surrounding most of the creek consisted of manicured fairway grasses and some dense plots of forest species. The channel planform appears to have changed between 1978 and 2005, with an increase in meander formation observed in the 2005 photographs. There was also an addition of one extra cart bridge that was constructed over the middle portion of the reach in 2005 that was not present in 1978. Otherwise, there did not appear to be any other observable differences to characterize this reach between the two years studied.

Observations for Reach FRC-8 suggest a slight change in the surrounding land use observed for all three years of photography. The downstream portion of the western bank has been used as a large cemetery since sometime before 1955, and only the amount of land used for burial sites has progressively increased from 1955. A large parcel of land was used as an automobile wreckage yard sometime prior to 2005 but was not present in 1955 and 1978. There did not appear to be any other changes in land use observed between 1955, 1978 and 2005. The vegetation immediately adjacent to the channel in this reach made it difficult to determine if changes in planform were present between the three years. For this reason, no conclusions regarding channel planform have been described for Reach FRC-7.

The majority of Reaches FRC-8, FRC-9 and the downstream portion of FRC-10 were surrounded by the Bridgewater Golf and Country Club, established sometime before 1955. The trees and shrubs growing within the golf course boundaries have aged and become denser, otherwise no other significant changes in surrounding land use were observed between the years studied. A few additional outbuildings and maintenance sheds were constructed along the southern bank of the downstream portion of FRC-8 prior to 2005, but this construction did not appear to require any alterations to the channel. A weir structure was built across the southern portion of the golf course property and Reach FRC-8 prior to 2005. This weir created a backwater affect upstream and a ponding area downstream of the weir that was observed in the 2005 aerial photographs. However, the quality and scale of the 1955 and 1978 has made it impossible to determine when this weir was built. Additional cart and maintenance bridges have been built across portions of both Reaches FRC-8 and FRC-9, but no other changes in channel planform were observed within these reaches.

The remaining section of Reach FRC-10, as well as Reach FRC-11 display a progression from agricultural land uses to somewhat more scrubland and wetland features. There was also an increase in the amount of road infrastructure present in 1978 and 2005 that required the altering of the channel planform for its construction. In 1955, the downstream portion of Reach FRC-11, and the upstream portion of FRC-12 consisted of a natural meander pattern. Between 1955 and 1978, Reach FRC-11 was completely modified and straightened so that it fit into the plans for the Q.E.W-Gilmore Road-Spears Road North intersections.

A steady progression in the transition from agricultural crops lands to scrubland and woodlots blocks was observed for the remaining four reaches located on the main branch of Frenchmen's Creek. In 1955 the majority of the surrounding parcels of land surrounding FRC-12, FRC-13, FRC-14 and FRC-15 consisted of agricultural fields with only small parcels of dense woodlot parcels. In 1978, all but a small portion of Reach FRC-14 and Reach FRC-15 were over taken by scrubland vegetation. By 2005, only the upper half of Reach FRC-14 remained agricultural fields. Due to the scale and quality of the 1978 aerial photograph, detailed accounts of channel planform changes could not be described for these reaches.

Millers Creek

This watercourse is surrounded by a mixture of agricultural fields, scrubland, and forest land uses with a small number of residential parcels intermixed within the vegetated areas. These land uses did not appear to have changed much from 1955 to 2005. Some agricultural fields in 1955 have become vegetated scrubland while other regions have become dense forested areas. Additional residential buildings were constructed prior to 1978 along both Cairns Crescent and Sutherland Drive that were not observed in 1955. A detailed review of aerial photographs of Reach MLC-1 and MLC-2 confirm significant changes in channel planform through the straightening of Millers Creek for road construction and residential development. As one travels upstream, the creek's natural meander-riffle cycle resumes and no further changes in land use or channel planform are observed.

Beaver Creek

This watercourse flows as a tributary to Black Creek that confluence immediately south of the Q.E.W. and Townline Road intersection. There is no aerial photographic coverage for Reaches BVC-12 to BVC-16, and BVC-20 to BVC-25 for either 1955 or 1978. Therefore, only the remaining reaches could be characterized and their historical information described.

There does not appear to be any significant changes in surrounding land uses that would account for any changes in channel planform observed for Beaver Creek. Scrubland and scrub forest remain the dominant surrounding land uses, with a few agricultural fields and residential parcels intermixed throughout the extent of the watercourse. Of the 26 reaches delineated for Beaver Creek, there only appeared to be three that actually had significant land use changes prior to 1978 that were observable in the aerial photographs. Reaches BVC-3 and BVC-4 were originally surrounded by agricultural fields and small parcels of scrubland in 1955. By 1978, the fields along the western bank were taken over by fairways and greens for the International Golf and Country Club. Only Reach BVC-17 of the remaining Beaver Creek Reaches shows any sign of change in surrounding land use. In 1955 and 1978, this reach was immediately surrounded by a thin strip of scrub forest and a large agricultural field along its eastern bank. Prior to the taking of the 2005 aerial photograph, a horse racing track was constructed within the agricultural fields of the eastern bank.

According to the detailed assessment of the reaches for all three years studied, there did not appear to be any significant change in the channel planform observed. That being said, the scale and thick vegetative cover present in the upstream reaches makes it difficult to determine the accurate location of the channel. Therefore, definitive changes in channel planform could not be assessed for those areas where scrublands and forest rendered channel banks challenging to see. In cases such as this, we can only rely on those areas that can be seen in the aerial photographs, as well as the areas where the watercourse is crossed by a bridge or road. There did not appear to any changes in the location of these road and bridge crossings either. Therefore, it can be stated that observable changes in the planform of the channel is unlikely for Beaver Creek.

Black Creek

This watercourse confluences with the Niagara River in the north-eastern portion of the study area. Black Creek feeds into this watercourse at Reach BLC-3, immediately south of the intersection of Townline Road and the Q.E.W. At its mouth, this watercourse is immediately surrounded by residential parcels fringing on agricultural fields. To reach this point the watercourse must flow down through an interchanging mixture of agricultural, scrubland and residential land uses surrounded by road infrastructure. An increase in the amount of road infrastructure from 1955 to 2005 has resulted in some changes to the land uses and channel planform observed between the years.

The upstream end of Reach BLC-1, the majority of Reach BLC-2 and the northern bank of Reach BLC-4 were all originally surrounded by agricultural fields in 1955, however by this time, a new subdivision was being built along the western bank in this area. By 1978, the subdivision appears to be 50% constructed, and by 2005, the subdivision appears to be completely finished. This increase in the amount of residential development would be accompanied by an increase in the impermeability and stormwater runoff of the lands along these banks. There did not appear to be any change in the channel planform associated with these land use changes. No meanders bends were lost or created, and no formation or destruction of bars and islands were observed throughout the 50 years of aerial photography.

In 1955, Reaches BLC-5 and BLC-6 were surrounded by agricultural fields on both the eastern and western banks. By 1978 the eastern bank was overtaken by fairways and greens constructed for the International Golf and Country Club. The construction of the golf course continued and as of the taking of the 2005 aerial photographs, the golf course surrounded Black Creek on both banks of Reaches BLC-5 and BLC-6. There did not appear to be any change in the planform of the channel associates with the land use changes and the construction of the golf course. However, it can be assumed that there was an increase in the amount of stormwater runoff affecting the channel in these reaches as a result of the land use change prior to 1978.

Except for a slight increase in the amount of residential development near the small hamlet of Stevensville located in the upstream portion of Reach BLC-9, there did not appear to be any change in the surrounding land uses or channel planform observed over the 50 years for reaches BLC7, BLC-8 and BLC-9. The dominant surrounding land use for all three reaches was agricultural fields observed in 1955 and has continued past 2005, with only a slight increase in the density of vegetation immediately surrounding the banks of the channel. No bar formations or islands were observed to have formed or been destroyed between the 50 years of aerial photography.

There did not appear to be a significant change between 1955 and 2005 that affected Reaches BLC-11 through BLC-15. The majority of these reaches were surrounded by agricultural fields in 1955, some of which had been abandoned to scrubland and scrub forest areas as of 1978, with no observable change in the channel planform reported between the years for most reaches. The confluence of Reach BLC-14 with Marsh Drain was re-aligned sometime after 1955 however. The channel was straightened slightly from it original meander form and a large reservoir/duck pond was created prior to 1978 at this confluence, although the area appears to be off-line. This area is now known as the Stevensville Conservation Area, and a circular drive and parking area were constructed between 1978 and 2005 to accompany this newer land use. This change in channel planform resulted in a shorter, straighter section of the watercourse through the conservation lands.

Reaches BLC-16 and BLC-17 were poorly vegetated scrubland areas in 1955 that were left to grow and vegetate. By 2005 the land uses had become densely vegetated, forested woodlot areas that, because of their density made it impossible to characterize any potential channel planform changes that may have occurred over the 50 year period. Therefore, all that can be stated is that there was no significant change in surrounding land use that would account for any planform changes observed in the field.

Reaches BLC-18 and BLC-19 were completely surrounded by agricultural fields in the 1955 aerial photograph. By 1978, some trees had begun to grow and cover the banks of the reaches, but the dominant land use remained agricultural fields. This still remains true as of the 2005 aerial photographs as well. Although the natural meander planform of the watercourse for Reaches BLC-18 and BLC- 19 could not be seen in the 1978 aerial photographs, a comparison of the channel formation present in both 1955 and 2005 suggest that there have been no modifications made to the planform.

There was no 1955 and 1978 aerial coverage of Reaches BLC-20 through to BLC-32, therefore, a historical characterization of these reaches could not be completed for this portion of the report.

2.4.2 Work Activities

The desktop mapping and geomorphic assessment, completed at the study outset, provided insight into the controls, modifying influences and general characteristics of the channels. In order to secure insight into the condition (e.g. stable, stressed) of the channel, a Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) have been conducted on 23 reaches within the study area (ref. Table 2.4.1).

Rapid Field Assessment

As part of the field evaluation protocol, the purpose of the rapid geomorphic assessment is to provide a synoptic survey meant to quickly and qualitatively assess channel reaches in order to identify any specific problems as well as assess overall stability and sensitivity. By walking each reach in its entirety, areas of active erosion can be documented, basic channel dimensions can be collected and an understanding of the active channel processes affecting a reach can be gained. The rapid assessment portion of a Watershed study evaluates each reach through the application of two different channel assessment techniques, the Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT). This assessment is generally completed for all third order and higher reaches within the study area. Depending on the size of the study area and the goals of the project, however, lower order tributaries may also be included in the survey.

The stability of each reach has been quantified with an RGA, which documents observed indicators of channel erosion and deposition (MOE, 1999). Observations are quantified using an index that identifies channel sensitivity to aggradation, degradation, channel widening and planimetric adjustment. The index produces values that indicate whether the channel is “in regime” or stable (<0.20), stressed/transitional (0.21-0.40) or adjusting (e.g. incising, widening and/or aggrading) (>0.41).

The RSAT provides a broader view of the system by also considering the ecological functioning of the stream (Galli, 1996). This includes observations of channel stability, scour/deposition, instream habitat, water quality, riparian conditions and biological indicators such as the abundance of benthic invertebrates. Each indicator was ranked numerically, a lower value indicates poorer stream health and a higher value represents a rich, healthy stream. The RSAT score ranks the channel as maintaining a low (<20), moderate (20-35) or high (>35) degree of stream health. Also included in the RSAT are general observations of channel dimensions, such as bankfull widths and depths, substrate size, bank heights, vegetation cover, channel hardening and other disturbances.

It should be noted that not all reaches have been walked in entirety due to accessibility and time constraints, and as a result, Table 2.4.1 represents conditions which partially characterize reaches which were observed during field reconnaissance in November and December 2005.

Due to the fact that channel processes were inferred in the mapping and aerial photograph analysis, field conditions were confirmed through a detailed field investigation. As such, the following sections summarize results obtained from the detailed geomorphic assessment.

Detailed Site Assessment

Utilizing the combined RGA and RSAT scores, four reaches were chosen for more extensive characterization. Initially, five detailed sites were chosen (one on each creek) however, due to the marsh/backwater state of Beaver Creek; only one monitoring site was established in Reach BVC-2.

The location of the detailed sites was determined based on the objective to provide representative coverage of the watershed, both from a spatial and morphologic perspective. Reach BLC-9 was chosen to provide conditions representative of Black Creek, while Reach SMC-2 was meant to provide representative data for Six Mile Creek (downstream end). Reaches FRC-9 and MLC-3 provided insight into conditions along a particularly sensitive and geomorphologically active section of the Local Management Area of 2.18. Finally, BVC-2 was chosen to represent conditions at the downstream extent of the Beaver Creek where only 1 monitoring site was established.

At each of the detailed sites, cross-sections were measured at ten locations, including pools, riffles and transitional areas. At each cross-section, bankfull widths and depths, entrenchment, as well as low flow dimensions were recorded. Substrate was sampled using a modified Wolman pebble count. Sub-pavement was also characterized at each cross-section. Bank assessment included measurements of heights, angle, bank composition, in-situ shear strength, vegetation and rooting depths. These 10 cross-sections were placed over a minimum of two meander wavelengths and included one control cross section located at top of bank. This control cross section involved the installation of permanent pins in order to allow for future monitoring. Erosion pins were also installed at each site to monitor rates of migration within the reach. A level survey of the site extending upstream and downstream of the 10 cross-section locations was also conducted. The survey included bankfull elevations, maximum pool depths, top and bottom of riffles and any obstruction to flow and provided measures of energy gradient, inter-pool gradient and riffle gradient. Results of the detailed field investigation are summarized in the site descriptions for each reach which was assessed over the course of field reconnaissance completed in between November and December 2005.

2.4.3 Findings/Constraint Identification

Rapid Field Assessment

Based on the results obtained from the rapid field assessment, channel stability and health of a variety of reaches contained in the study area were summarized in Table 2.4.1 (ref. Figure WS-2 and Appendix 'WC-B' for reach locations). The rapid assessment method of evaluating geomorphic conditions on a watershed-scale through the scoring of individual reaches supports the selection of representative detailed field sites from both a spatial and morphologic standpoint. As such, the Reach Names which were bolded in Table 2.4.1 indicate the reaches where detailed field work was conducted. It should be noted that the site selection for the detailed work was impart attributed to the health and stability of the reach, in addition to the accessibility of the site.

TABLE 2.4.1:
RAPID FIELD ASSESSMENT SUMMARY FOR FORT ERIE WATRSHED

Creek	Reach Name	RSAT SCORE	RSAT CONDITION	RGA SCORE	RGA CONDITION
BLACK CREEK	BLC-1	21	MODERATE	0.20	IN REGIME
	BLC-2	21	MODERATE	0.21	IN REGIME
	BLC-5	23	MODERATE	0.21	IN REGIME
	BLC-6	23	MODERATE	0.21	IN REGIME
	BLC-7	22	MODERATE	0.18	IN REGIME
	BLC-8	22	MODERATE	0.18	IN REGIME
	BLC-9	19.5	LOW	0.37	TRANSITIONAL
	BLC-10	16	LOW	0.19	IN REGIME
BEAVER CREEK	BVC-2	24.00	MODERATE	0.30	TRANSITIONAL
	BVC-3	24.50	MODERATE	0.22	TRANSITIONAL
SIX MILE CREEK F.E.	SMC-1	23	MODERATE	0.25	TRANSITIONAL
	SMC-2	22.5	MODERATE	0.24	TRANSITIONAL
	SMC-3	23	MODERATE	0.18	IN REGIME
FRENCHMAN'S CREEK	FRC-1	20	MODERATE	0.27	TRANSITIONAL
	FRC-2	22.5	MODERATE	0.29	TRANSITIONAL
	FRC-3	22.5	MODERATE	0.2	IN REGIME
	FRC-5	14	LOW	0.21	TRANSITIONAL
	FRC-8	22	MODERATE	0.30	TRANSITIONAL
	FRC-9	14	LOW	0.39	TRANSITIONAL
	FRC-10	26.5	MODERATE	0.32	TRANSITIONAL
MILLER CREEK	MLC-1	20.5	MODERATE	0.15	IN REGIME
	MLC-2	23.5	MODERATE	0.11	IN REGIME
	MLC-3	26	MODERATE	0.34	TRANSITIONAL

Detailed Site Assessment

The results from the Detailed Site Assessment are documented in Appendices 'WC-B', 'WC-C', and 'WC-D', where cross-sectional, bank, planform and substrate characteristics are provided. This field assessment has enabled the quantification of channel processes and functions such as linkages to floodplains which occur at the cross-section and reach scale. The collected data will also be suitable for detailed analyses of sediment transport, channel thresholds and stability.

In addition to the Detailed Site Assessment, the Appendices 'WC-B', 'WC-C', and 'WC-D' include detailed reach descriptions, as well as a summary of the site conditions which were either observed during the "road-side" assessment or through the completion of detailed field work. These descriptions provide a synopsis of the present geomorphic conditions which were recorded during field reconnaissance completed in November and December 2005, as well as in the Summer of 2006. As such, the reach descriptions only present a snap-shot of the present field conditions, and may not typify the exact watercourse conditions for the entire reach.

The aforementioned significant features are some of the factors imposing a risk to the channel and its stability. Although results documented in Table 2.4.1 illustrate additional reaches having low channel stability, there were no significant features within the proximity of these systems which would have resulted in the present condition of the channel.

2.5 Fish and Aquatic Habitat

Importance:

Aquatic resources include aquatic habitats and the communities of organisms which they support. Investigations are focused on fish and fish habitat. Fish populations and communities are indicators of ecosystem health, and angling is a popular form of outdoor recreation. Fish habitat is protected under the Fisheries Act.

2.5.1 Background Information

- "Niagara Regional Municipality, Fish Habitat Types with Management Rationale" (MNR, February 25, 2000)
- 2003, 2004 and 2005 fish collection data from the MNR, Vineland Office.
- Royal Ontario Museum historical fish collection data.
- Colour digital aerial photography.
- Map showing potential barriers to fish migration (NPCA).
- Known spawning locations for musky (NPCA).
- Known spawning locations for smallmouth bass in Lake Erie from MNR (Brunet *et al*, 1987).
- Proposed Environmental Policies Natural Heritage Map that includes fish habitat mapping (Regional Municipality of Niagara website).
- Fisheries and habitat information for drains (NPCA)
- Friends of Fort Erie Creeks 2004 Summer Work Report.

2.5.2 Work Activities

Field Investigations

The large study area, with many hundreds of kilometres of watercourses, necessitated a scoped, efficient and effective approach to field investigations. This focused on the information required to characterize the watershed's aquatic resources at a relatively coarse scale. Generally, effort was directed toward fish community characterization in areas where the fish community was largely unknown, the investigation of barriers to fish migration, and in gathering additional habitat detail to refine the watercourse descriptions, the characterization of constraints, and the identification of rehabilitation opportunities. It was not possible to inventory specific habitats (i.e. pike spawning habitats) at the level of this subwatershed study.

An initial field reconnaissance was undertaken during the fall of 2005, but the primary field investigations occurred in the spring and summer of 2006, when spawning, general habitat, fish migrations, and fish communities were investigated. Twenty-two locations were electrofished on April 25 and 26, 2006, to generally characterize spring fish communities, and provide basic fish community information over the portions of the study area not sampled by the regular MNR sampling program. An iterative process between aerial photographic interpretation and field investigation/ground truthing was undertaken to characterize stream habitat over the entire study area. During all these investigations many hundreds of digital photographs were taken at associated coordinates determined with a hand-held GPS unit, to facilitate habitat characterization and the determination of constraints and opportunities.

The information gathered throughout the winters of 2005/2006 and 2006/2007, as well as the results of the field investigations, have been compiled and analyzed. The general results are provided in Section 2.5.3. A copy of the data collection sheets, waypoint chart, and a CD containing all of the photos are included in Appendix 'NH-B'.

2.5.3 Findings/Constraint Identification

Overview

The clay soils and relatively flat topography of the study area has resulted in generally low gradient watercourses and swamp habitats. This has resulted in few barriers to fish movement, either at natural topographic breaks or at infrastructure crossings such as roads, railways, pipelines, etc. Black, Beaver, and Baker Creeks are the lowest gradient watercourses, while the remainder have slightly higher gradients that are reflected in their fish communities.

Instream habitat diversity within the study area can generally be characterized as below average. Rather than being a mix of low gradient (flatwater and sluggish), medium gradient (runs and short riffle sections) and high gradient (long sections of riffles and rapids), watercourses in the study area are mostly low-gradient, and many sections have been dredged and/or straightened to facilitate the drainage of agricultural and residential land. While there are many areas of good quality flatwater habitat, and occasionally sections of watercourse with coarse substrates and higher gradient riffle or run habitats, the study area watercourses are usually variations of flatwater habitats as illustrated in the map of instream habitats (ref. Figure AB-1).

The close proximity of the diverse aquatic habitats and communities found in the Niagara River and Lake Erie habitats, and the presence of a number of fish species that are at the northern limit of their range in southern Ontario, but are more widely distributed in the United States, result in study area watercourses having diverse low-gradient, warm- and cool-water fish communities. Typical of most watercourses, fish community diversity in the study area generally decreases as one moves farther upstream, however, some fish species that are typical residents of larger lakes or rivers and would not normally be found in streams, are also found significant distances from the Niagara River and Lake Erie in the low-gradient watercourses of the study area. Some of the common fish species found here only occur in the extreme southern part of Ontario. At least two fish species-at-risk (river redhorse and grass pickerel), and potentially others, are known to occur within the study area. The common and scientific names of fishes discussed in this report are listed in Tables 2.5.1 and 2.5.2.

The Ministry of Natural Resources (Vineland Office) has classified fish habitat in all the main watercourse channels in the Niagara Region (ref. "Fish Habitat Types with Management Rationale, Niagara Regional Municipality", MNR, February 25, 2000). The fish communities/habitat definitions in this document are as follows (ref. Appendix 'NH-A' for full definitions).

Type 1: areas that limit the overall productive capacity (i.e. if these areas are harmfully altered the productive capacity of the area would be reduced). Sensitive fish species (part or all of their life cycle) and/or habitats are present (including springs, seeps, upwelling areas, seasonally inundated spawning habitats, refugia, nursery areas, over-wintering areas, and ephemeral pools). These areas require a high degree of protection, however may also be enhanced with care, and can achieve a high potential for habitat compensation.

Type 2: this habitat is important but below its productive capacity and is ideal for enhancement or restoration projects. Sensitive species may or may not be present part or all of the time. Fish community is below potential due to habitat related issues, however may be increased if the limiting factors are reversed.

Type 3: areas with low productive capacity, where common species may or may not be present, and no sensitive species and/or specialized habitat are present (incidental exceptions of fish presence may occur in some locations, e.g. the Welland Shipping Canal). Areas can negatively affect downstream, down-drift or connected fish habitats, and should not be considered for compensation opportunities.

The standard DFO system, supported by MNR, groups fish habitat into three classes (DFO 1998, MNR 1999). These are:

Critical Habitat: those fisheries habitats which have high productive capacity, are rare, highly sensitive to development, or have a critical role in sustaining fisheries (e.g., spawning and nursery areas for some species, and ground water discharge areas).

Important Habitat: those fisheries habitats which are moderately sensitive to development and, although important to the fish population, are not considered critical (e.g. feeding areas, and open water habitats of lakes).

Marginal Habitat: those fisheries habitats which have low productive capacity or are highly degraded, and do not currently contribute directly to fish productivity. They often have the potential to be improved significantly (e.g., a portion of a waterbody, such as a channelized stream, that has been highly altered physically).

Figure AB2 presents the MNR assigned classes for watercourses within the study area and Figure AB-1 presents the findings of the field inventory and observed characteristics of the watercourses.

<u>Black Creek</u>

Black Creek is the largest watercourse within the study area. It is approximately 21 km long, and drains approximately 50% of the study area. The difference in elevation from the source of Black Creek to its mouth is only about 8.5 m. Black Creek is approximately 30 m wide just upstream from its mouth at the Niagara River. The lower 6.2 km of Black Creek is essentially flat water, with the next 5 km upstream having a somewhat higher gradient as indicated by shallower water with runs, a few pools, and a few gentle riffles (ref. Figure AB-1). The upper 10 km of Black Creek has a very low gradient, with portions of the watercourse apparently artificially deepened to facilitate drainage of the large headwater swamp, known as Humberstone Marsh. The Black Creek channels within Humberstone Marsh are straight, and may be largely artificial.

All of the main Black Creek channels are classed by the MNR as *Critical Habitat*, with the exception of a few small tributaries in the lower watershed, and the headwater areas within and upstream of Humberstone Marsh, which are classed by the MNR as *Important Habitat* (ref. Figure AB-2). Muskellunge spawning habitat has been identified in the Niagara River adjacent to the mouth of Black Creek (ref. Figure AB-2).

The fish community within Black Creek is typical of a low-gradient, warmwater stream, of moderate size in this part of Ontario, dominated by Centrarchids (largemouth bass, rock bass, sunfishes, crappies), bullheads, common white sucker, certain minnow species, and Esocids (northern pike, grass pickerel, and muskellunge in Tables 2.5.1 and 2.5.2.). The northern pike and grass pickerel spawn in shallow or flooded areas over vegetation in early spring (Becker, 1983; Scott and Crossman, 1973), and would likely find numerous locations to spawn along the margins and in the headwaters of this low-gradient stream. Gizzard shad, which inhabit the open waters of larger rivers and lakes, are known to ascend smaller streams or ditches to spawn and the young are later abundant in such places if the gradient is sufficiently low (Becker, 1983). Young-of-the-year (YOY) gizzard shad were found on several occasions during summer as far as 10 km upstream in Black Creek (ref. Figure AB-1). Emerald shiners, typically a fish of large water such as the Niagara River or Lake Erie, but often migrate short distances up watercourses (Becker, 1983) with low gradients until being blocked by some barrier, were collected in the headwaters of Black Creek in Humberstone Marsh in April 2006, attests to the low gradient of this stream and the lack of barriers to fish movement (Table 2.5.1 CPA 2006 collections).

<u>Beaver Creek</u>

Beaver Creek is the largest tributary of Black Creek, and is approximately 14 km long. The first kilometre from the outlet of Beaver Creek, is a broad flatwater channel with an almost continuous marsh along each side. Upstream from there, Beaver Creek flows through a broad riparian swamp for approximately 11 km (ref. Figure AB-1). Only the upper 2 km is not in swamp, and that is where about half of the elevation difference of approximately 12 m between the headwaters and the mouth occurs. As a result of the bordering wetlands, Beaver Creek has less encroachment by agriculture and residential land uses, with very few sections of straightened or otherwise altered channel.

All the Beaver Creek channels that are classified by the MNR, are classed as *Type 1 Critical Habitat* (ref. Figure AB-2).

The fish community within Beaver Creek is typical of a low-gradient, warmwater stream in this part of Ontario, dominated by Centrarchids (largemouth bass, rock bass, sunfishes), bullheads, common white sucker, certain minnow species, and Esocids (northern pike, grass pickerel) (Table 2.5.1 CPA 2006 collections, Tables 2.5.2 and 2.5.3). Suitable spawning habitat for Esocids is likely to be present along the swampy margins of this low-gradient stream.

Baker Creek

Baker Creek has one of the smallest watersheds in the study area, and is approximately 4 km long from mouth to headwater. The lower 0.5 km or so is a flatwater stream at the level of the Niagara River. Upstream of here most of Baker Creek is bordered by a swamp. Judging by the forest growth and the sections of straightened channel throughout, the swamp appears to be regenerating from past attempts at agriculture. It appears that most of the channels in the upper swamp portions of the watershed are either constructed or straightened natural channels (ref. Figure AB-1).

All the Baker Creek channels that are classified by the MNR are classed as *Type 1/Critical Habitat* (ref. Figure AB-2).

The fish community within Baker Creek has been adequately sampled by the MNR at its mouth at the Niagara River, and sampled approximately 1.7 km upstream from the mouth by the ROM in 1974 and as part of this study in April 2006 (Table 2.5.1 CPA 2006 collections, Tables 2.5.2 and 2.5.3). It appears that the fish community of Baker Creek is typical of a small, low-gradient, warmwater stream in this part of Ontario, and is similar to the fish communities in Black and Beaver Creeks. Suitable spawning habitat for Esocids is likely to be present along the swampy margins of this low-gradient stream. Emerald shiners were collected 1.7 km upstream of the mouth in April 2006, attesting to the low gradient and barrier-free condition of the downstream sections of watercourse.

Miller Creek

Miller Creek is approximately 7.5 km long from its headwaters to its mouth at the Niagara River. The elevation difference over this length is approximately 23 m, and consequently Miller Creek has a higher gradient than the other watercourses (ref. Figure AB-1). The surrounding land is also better drained. The watercourse generally flows through woodlands except for a few portions in the lower 1 km where residential properties line the bank, and about another 1.5 km of watercourse that is bordered by agricultural lands. Much of Miller Creek appears to have a natural channel, except for a 1.3 km straightened portion immediately upstream of the QEW, and a 1.5 km straightened portion downstream of Bowen Road.

All the Miller Creek channels that are classified by the MNR are classed as *Type 1/Critical Habitat*, except for one small tributary and a small portion of headwater that are classed as Important Habitat (ref. Figure AB-2). Muskellunge spawning habitat has also been identified in the Niagara River adjacent to the mouth of Miller Creek (ref. Figure 2.5.16).

The fish community within Miller Creek is typical of a small, low-gradient, warmwater stream in this part of Ontario, dominated by Centrarchids (largemouth bass, rock bass, sunfishes), bullheads, common white sucker, certain minnow species, and Esocids (northern pike, grass pickerel) (Table 2.5.1 CPA 2006 collections, Tables 2.5.2 and 2.5.3). The northern pike and grass pickerel spawn in shallow or flooded areas over vegetation in early spring (Becker, 1983; Scott and Crossman, 1973), and would likely find locations to spawn in flooded areas along the stream margins or in attached wetlands. The presence of creek chub (Table 2.5.2: MI-3; and Table 2.5.3: ROM-6) may reflect the higher gradient with some granular substrate in portions of this watercourse.

Frenchman's Creek

Frenchman's Creek is approximately 13.2 km long from its headwaters to its mouth at the Niagara River. The elevation difference over this length is approximately 25 m. Approximately half of Frenchman's Creek is situated in woodlands, with most of the rest in golf courses, agricultural fields, and within transportation corridors. The creek flows for approximately 650 m through a swamp located about 1.2 km upstream from the Niagara River. There are some small areas of swamp along the creek, but the next sizeable swamp is approximately 8.8 km upstream, west of the QEW. There is also a swamp in the extreme headwaters. This is referred to as the "Upper Frenchman's Creek Wetland Complex", and was documented most recently by the MNR on October 28, 2004. The channel appears to be mostly natural downstream of the QEW, which comprises about 70% of the watercourse length, with the remainder upstream of the QEW a mixture of natural and straightened channels (ref. Figure AB-1). A range of substrates were observed, including silt or mud, sand, cobble/gravel and bedrock.

All the Frenchman's Creek channels that are classified are classed by the MNR as *Type 1/Critical Habitat*, except for five small tributaries downstream of the QEW that are classed as *Type 2*/*Important Habitat* (ref. Figure AB-2). Muskellunge spawning habitat has also been identified in the Niagara River adjacent to the mouth of Frenchman's Creek (ref. Figure AB-2).

The fish community within the downstream kilometre of Frenchman's Creek is typical of a low-gradient, warmwater stream in this part of Ontario, with community diversity enhanced due to the close proximity of the Niagara River (Table 2.5.2: FR-1 and FR-2). Upstream of this the fish community reflects the variety of habitats present, with fishes that prefer slower, deeper waters, such as brown bullhead, largemouth bass, and sunfishes, and others that prefer or require faster waters with coarse substrates, such as longnose dace and creek chub.

Kraft Drain

Kraft Drain has one of the smallest watersheds in the study area, and is approximately 3 km long from its headwater to its mouth at Lake Erie. The headwaters are approximately 15 m in elevation above Lake Erie. The first 0.5 km upstream from the mouth is a meandering watercourse through a lakeside residential area and a small strip of woodland. Upstream of here the watercourse has been straightened and ditched (ref. Figure AB-1). The lower half of this straightened portion is surrounded by a swamp, which appears to be regenerating from past attempts at agriculture, judging by the growth of tree cover and the appearance of the land in the aerial photography. The meandering channel of the original watercourse can be discerned in the aerial photographs to the east of the straightened channel. The upstream half of the straightened portion of watercourse is situated in a mainly open, though currently inactive, agricultural area.

All the Kraft Drain channels that are classified by the MNR, are classed as *Type 3/Marginal Habitat* (ref. Figure AB-2).

The downstream portion of Kraft Drain has a relatively diverse community of fishes, with 15 species captured in April 2006 (Table 2.5.1: CPA-18 and CPA-19, CPA 2006 collections). Two of these species (spottail shiner and emerald shiner) are typically lake or large river fishes, but also typically enter smaller tributary streams during the spring. Evidence of groundwater inputs to Kraft Drain in the straightened channel just downstream of CPA-19 suggests that this relatively diverse fish community, compared to the generally lower diversity of fish communities in other study area watercourses or tributaries of the same size, may be due in part to cooler water temperatures and the presence of flow during the dry part of summer. The presence of adult white suckers in April, 2006, and suitable white sucker spawning substrate in the vicinity and downstream of Dominion Road, indicates that this watercourse is a spawning area for white sucker.

Six Mile Creek

Six Mile Creek is the largest watershed within the study area that flows to Lake Erie. It has several branches, but it is approximately 7 km from the mouth to the headwater following the longest branch. The maximum headwater elevation is about 20 m above the level of Lake Erie. For most of the first 2 km upstream from Lake Erie, Six Mile Creek meanders within a swampy corridor, though it is evident that some reaches have been straightened (ref. Figure AB-1). Upstream of this the watercourse splits into two branches of approximately equal size, with each of these splitting again less than a kilometre farther upstream. Most of these upstream channels are fairly small, and are composed of both naturally meandering and straightened sections, situated within active and inactive agricultural lands, including some areas that appear to be in the process of reverting to swamp habitat. A variety of substrate and low-gradient fish habitat types were observed. Historically, Six Mile Creek appears to have been heavily impacted by agricultural encroachment, but in many places is in the process of re-naturalizing.

All the Six Mile Creek channels that are classified by the MNR are classed as *Type 1/Critical Habitat* (ref. Figure AB-2). Areas identified as smallmouth bass spawning habitat occur in Lake Erie (ref. Figure AB-2).

The fish community in the lower portion of Six Mile Creek, in the deeper pond-like section from the mouth at Lake Erie to the vicinity of Dominion Road, is diverse with a combination of 16 species of fish captured from two locations. Five fish species were captured over two locations in the upper portion of the watershed, and no fish were captured or observed at the most northern location fished. As is often found in low gradient watercourses connected to lakes, the fish community was a mix of stream and lake species. The presence of white sucker suggests that this watercourse may be used by this species for spawning, however, suitable coarse substrates may be in short supply. Along with the capture of 3 yearling quillback in the vicinity of Dominion Road, the habitat in the lower portion of Six Mile Creek corresponds to the description of quillback spawning habitat in Scott and Crossman (1973), suggesting that this may be a spawning area for this species (Table 2.5.1 CPA 2006 Collections).

TABLE 2.5.1: C. PORTT AND ASSOCIATES 2006 FISH COLLECTION																							
Common name	**Scientific name**	**CPA-1**	**CPA-2**	**CPA-3**	**CPA-4**	**CPA-5**	**CPA-6**	**CPA-7**	**CPA-8**	**CPA-9**	**CPA-10**	**CPA-11**	**CPA-12**	**CPA-13**	**CPA-14**	**CPA-15**	**CPA-16**	**CPA-17**	**CPA-18**	**CPA-19**	**CPA-20**	**CPA-21**	**CPA-22**
banded killifish	*Fundulus diaphanus*												2	1					6	1			
spottail shiner	*Notropis hudsonius*						2						17						5				
emerald shiner	*Notropis atherinoides*		>100	>100			1[+]	21*					63	4					>400	1			48
sand shiner	*Notropis stramineus*													1					20				
mimic shiner	*Notropis volucellus*													1									
striped shiner	*Luxilus chrysocephalus*																		4				
common shiner	*Luxilus cornutus*							1						1					3	1			
spotfin shiner	*Cyprinella spiloptera*													3		2			14	19			
bluntnose minnow	*Pimephales notatus*						2							25					38**	52		4	3
fathead minnow	*Pimephales promelas*						3			1					1				1	3			
creek chub	*Semotilus atromaculatus*																		26**	15			
northern pike	*Esox lucius*																		1				
central mudminnow	*Umbra limi*		2					4				3		1				4					
pumpkinseed	*Lepomis gibbosus*	5	4	1	2*			10	3		2	1		3		1		1		2			1
quilback	*Carpiodes cyprinus*													3									
common carp	*Cyprinus carpio*				2*									3									
white sucker	*Catostomus commersonii*		2					1*	2*	2				2		1			3**	5			1
green sunfish	*Lepomis cyanellus*		2	2				17	3	1	3			2		3			3	4			2
round goby	*Neogobius melanostomus*												6										
grass pickerel	*Esox americanus vermiculatus*							10	1**	2	1	1											
rock bass	*Ambloplites rupestris*																						1
golden shiner	*Notemigonus crysoleucas*	3*	1		1																		
largemouth bass	*Micropterus salmoides*	2*	1	1	5*		1		4*					2						3			
tadpole madtom	*Noturus gyrinus*							1															
rudd	*Scardinius erythrophthalmus*									1													
* juvenile fish																							
** others were observed but not captured																							

TABLE 2.5.2:
RECENT MINISTRY OF NATURAL RESOURCES FISH COLLECTIONS, 2003 - 2005, FORT ERIE.
(ref. FIGURE AB-1)

Location (see key below)	**BL-1**	**BL-2**	**BL-3**	**BL-4[1]**	**BE-1**	**BE-2**	**BA-1**	**MI-1**	**MI-2**	**MI-3**	**FR-1**	**FR-2[1]**	**FR-3**	**FR-4**	**FR-5[1]**	**FR-6**	**FR-7**	**FR-8**	**FR-9**	**FR-10**
Number of collections	1	7	3	6	1	1	3	1	2	2	1	4	1	1	2	1	1	1	1	1
Collection method	EF boat	6 seine 1 EF	seine	seine	seine	seine	seine	seine	seine	1 seine 1 EF	EF boat	seine	EF	EF	EF	EF	EF	EF	EF	EF
Years	2004	2003-5	2003-5	2003-5	2003	2003	2003-5	2003	2003,5	2003,4	2004	2003-5	2003	2003	2003	2003	2003	2003	2003	2003
gizzard shad (*Dorosoma cepedianum*)		X		X				X												
longnose gar (*Lepisosteus osseus*)							X													
northern pike (*Esox lucius*)	X	X	X	X	X	X	X		X	X		X			X					
muskellunge (*Esox masquinongy*)	X							X			X									
grass pickerel (*Esox americanus vermiculatus*)	X	X	X	X	X	X	X			X										
central mudminnow (*Umbra limi*)		X	X	X			X	X	X	X		X						X	X	X
carp (*Cyprinus carpio*)		X		X		X		X	X	X	X				X	X	X	X		
goldfish (*Carassius auratus*)	X						X	X	X		X	X						X		
common shiner (*Luxilus cornutus*)			X	X			X				X	X			X					
striped shiner (*Luxilus chrysocephalus*)				X																
golden shiner (*Notemigonus crysoleucas*)	X	X	X	X	X	X	X	X	X	X		X						X		
emerald shiner (*Notropis atherinoides*)		X		X			X		X	X	X									
fathead minnow (*Pimephales promelas*)		X							X			X						X		X
bluntnose minnow (*Pimephales notatus*)	X	X		X			X	X	X	X		X			X	X		X	X	
creek chub (*Semotilus atromaculatus*)										X		X	X	X	X	X	X	X	X	X
longnose dace (*Rhinichthys cataractae*)																X				
common white sucker (*Catostomus commersonii*)	X	X	X	X		X	X	X	X	X	X	X	X	X	X			X	X	X
shorthead redhorse (*Moxostoma macrolepidotum*)								X												
silver redhorse (*Moxostoma erythrurum*)									X											
redhorse (*Moxostoma* sp.)											X	X								
brown bullhead (*Ameiurus nebulosus*)	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X			
black bullhead (*Ameiurus melas*)	X	X	X	X			X			X										
yellow bullhead (*Ameiurus natalis*)				X																
tadpole madtom (*Noturus gyrinus*)		X	X	X			X	X	X	X										
yellow perch (*Perca flavescens*)	X	X	X	X	X	X	X	X	X	X	X	X			X					
johnny darter (*Etheostoma nigrum*)		X	X	X	X			X	X	X		X	X	X	X			X	X	
walleye (*Sander vitreus*)			X																	
largemouth bass (*Micropterus salmoides*)	X	X		X	X	X	X	X	X	X	X	X			X	X				
smallmouth bass (*Micropterus dolomieu*)		X									X	X								
rock bass (*Ambloplites rupestris*)	X	X		X	X		X	X	X	X										
pumpkinseed (*Lepomis gibbosus*)	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X		
bluegill (*Lepomis macrochirus*)	X	X	X	X			X	X		X		X			X					
green sunfish (*Lepomis cyanellus*)		X	X	X		X	X		X	X		X	X		X	X	X	X		
white crappie (*Pomoxis annularis*)	X	X	X	X				X												
black crappie (*Pomoxis nigromaculatus*)	X	X	X																	
brook silverside (*Labidesthes sicculus*)		X																		
bowfin (*Amia calva*)			X	X		X														
banded killifish (*Fundulus diaphanus*)							X	X	X											
round goby (*Neogobius melanostomus*)							X	X				X								
trout-perch (*Percopsis omiscomaycus*)											X									
white perch (*Morone americanus*)												X								

[1] Combination of two MNR fishing sites located within 100 m of each other.

BL = Black Creek. MI = Miller Creek.
BE = Beaver Creek. FR = Frenchman's Creek.
BA = Baker Creek.

TABLE 2.5.3: ROYAL ONTARIO MUSEUM FISH COLLECTIONS, FORT ERIE (ref. FIGURE AB-1)								
Station	**ROM-1**	**ROM-2**	**ROM-3**	**ROM-4**	**ROM-5**	**ROM-6**	**ROM-7**	**ROM-8**
Watercourse	**Black Cr**	**Black Cr**	**Black Cr**	**Beaver Cr**	**Baker Cr**	**Miller Cr**	**Frenchman's Cr**	**Six Mile Cr**
Number of collections at location	2	1	1	1	1	1	1	1
Year	1974	1974	1974	1974	1974	1974	1974	1976
grass pickerel				X			X	
central mudminnow	X	X	X	X	X	X	X	
goldfish				X				
golden shiner	X						X	
emerald shiner					X		X	
bluntnose minnow						X		
creek chub						X		
common white sucker							X	
brown bullhead	X						X	
black bullhead	X						X	
yellow bullhead								X
tadpole madtom	X							
pumpkinseed	X	X		X	X	X	X	X

2.5.4 Summary of Significant Features/Constraints

The majority of watercourses within the study area contain good quality, low gradient warmwater aquatic habitat, with the exception of recently straightened and/or cleaned watercourses. Where adequate sampling has occurred, fish communities have been found to be appropriately diverse for the existing habitat, indicating that the aquatic ecosystems are generally healthy.

The sampling conducted by C. Portt and Associates as part of the study, and those undertaken by MNR are considered to be adequate since they attempted to collect all fish in available habitats within an area that was within a short distance of the access point. The Royal Ontario Museum (R.O.M.) records however, are not considered to be adequate to describe fish community since the cataloguing of specimens is focussed on the needs of the museum collection, and therefore not all of the species captured at a location are catalogued.

Setbacks from the top-of-bank of watercourses will pose constraints to development. MNR setback requirements are 30 m from the top of bank for *Critical Habitats*, and 15 m for both *Important* and *Marginal Habitats* (Ian Barrett, Fisheries Biologist, NPCA. Pers. Comm., February 28, 2006). Where no top-of-bank is delineated, some definable standard such as the waterline of a two-year return flow event is suggested (Ian Barrett, Fisheries Biologist, NPCA pers. comm., February 28, 2006).

Where watercourse crossings or other works that may potentially impact fish habitat are required, consideration under the *Fisheries Act* is required.

2.6 Natural Heritage System

Natural areas provide habitat, moderate floods, filter pollutants, uptake carbon dioxide, offer shade and wind protection, reduce costs of energy and of water infrastructure and provide recreation and beauty.

Characterization of the natural heritage system in the Fort Erie Creeks watershed includes:

- A summary of natural heritage features
  - Current extent and type
  - Wetland location and status
- Historical assessment of the natural heritage system
  - Long term change

More recent trends
Change in extent of slough mosaic

- An evaluation of significance and constraints of the current natural heritage system and its functions
  - Vegetation and wildlife
  - Site criteria; and
  - Subwatershed criteria

Current natural area extent and dominant community type are the basis for characterization. An emphasis has been placed on wetlands, the dominant natural system of the study area. The availability of information on the location and status of all wetlands in the watershed is essential to the application of planning policies that protect those valuable ecosystems. In the Fort Erie Creeks Watershed, flat relief and extensive poorly drained soils support numerous wetlands, some of which have not been formally identified or evaluated. Many small sloughs dot the less altered landscapes and often maintain small swamp inclusions within a matrix of slightly drier systems. Delineation of slough wetlands at a regional scale is very difficult. In regeneration areas, earlier cultivation obscured the slough form and further confounds accurate wetland boundary mapping. The study area is among the most problematic in southern Ontario for wetland delineation.

An analysis of historical trends in the type and extent of natural heritage features provides insight into the effects of land use transitions on the features and functions of the current natural areas. Historical analysis also assists understanding of currently underrepresented ecosystems relative to pre-settlement ones.

Ranking of significance of natural areas according to pre-determined evaluation criteria identifies natural features and functions to protect as well as areas where ecological services are deficient and enhancement or restoration is needed.

The characterization provides a baseline for future judgement of the level of attainment of the watershed plan objectives.

2.6.1 Background Information

The background information was collected and reviewed for use in the characterization. Valid subwatershed comparisons required data to be consistent across the study area. Some higher resolution data in the Settlement Area are also included to offer additional guidance for those areas under greatest development pressure. The data sets used for each set of characterization analyses, and the reasons for their choice, are presented in Table 2.6.1.

TABLE 2.6.1: TERRESTRIAL NATURAL HERITAGE INFORMATION USED FOR CHARACTERIZATION				
Title	**Source**	**Date**	**Scale**	**Reason Chosen**
Status of Information on Wetland Location				
Evaluated Wetlands - MNR Jun 05 update	MNR	2005	1:10,000	Most recent and most complete set of evaluation data – developed from air photo interpretation and field checks.
Fort Erie Natural Areas Inventory: near urban	Fort Erie Report by Dougan and Assoc	2003	1:60,000	For the Settlement Areas, independent wetland designations at a comparable level of detail as the Evaluated Wetlands. The subtleties of wetlands in the flat landscape support the value of two estimates. Both sets of data affect the protection designations in the Settlement Area.
SOLRIS Forest Extent Boundaries	MNR	2002		The Fort Erie area landscape can support many small wetlands even beyond evaluated areas. This was estimated by a combination of wooded area on wet soils.
Soils	Ont. Min. of Agricul. & Food	1989	1:25,000	See above. In Niagara, the soils data are detailed enough for a valid wetland estimate at a regional scale
Preliminary Results of the Fort Erie Agricultural Area Natural Areas Inventory	Fort Erie. Report by Bert Miller Nature Club	2006	~ 1:17,000	A check for the estimates of unevaluated rural wetland
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
Summary of Natural Area Locations, Extent and Cover Type				
Fort Erie Natural Areas Inventory (NAI): near urban	Fort Erie. Report by Dougan and Assoc.	2003	1:60,000	Most recent, complete and detailed available data for the Settlement Areas
Evaluated Wetlands - MNR Jun 05 update	MNR	2005	1:10,000	With Wooded Areas, most recent, complete and detailed available data for beyond the Settlement Areas
SOLRIS Forest Extent Boundaries	MNR	2002		See above
Air Photo Mosaic	Niagara Region	2002	High resolution	For mapping rural shrub extent
Preliminary Results of the Fort Erie Agricultural Area Natural Areas Inventory	Fort Erie. Report by Bert Miller Nature Club	2006	~ 1:17,000	Cover type using Ecological Land Inventory for several rural natural areas
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
Long term change				
Soils	Ont. Min. of Agricul. & Food	1989	1:25,000	Soils can classify natural landscape types – complete coverage for original; where current natural area for current
Current Cover – see Summary of Natural Area Locations, Extent and Cover Type databases above				Best estimate of current natural area extent
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
More Recent Trends				
Wooded Areas - NPCA 2000	NPCA, MNR	2000	1;10,000	A comparable mapping to the wooded area extent mapped in 1967 for a fair comparison and valid trends. Available overlaid on 1967 (NWQPS)
1967 Land Use	Geogratis	1967	1:50,000	The oldest historic forest extent in digital form
Historic National Topographic System NTS editions (Welland: 30L/14 and Fort Erie: 30L/15)	Viewed at University of Ottawa Map Library	1930's to 1990's	1:50,000	Standardized method of mapping forest areas over several decades.
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
Slough Mosaic Change				
Air Photo Mosaic	Niagara Region	2002	High resolution	For mapping estimate of landscape with remaining slough mosaic
Soils	Ont. Min. of Agricul. & Food	1989	1:25,000	Coincidence of remaining slough mosaic with certain soil types allows an estimate pf original extent of the slough mosaic pattern
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
Significance: Vegetation and Wildlife				
Fort Erie Natural Areas Inventory: near urban	Fort Erie	2003	1:60,000	Most recent, complete and detailed available data for the Settlement Areas
Wetland Evaluations	MNR	2004/5	1:10,000	Adds data for the rural areas
Ontario Breeding Bird Atlas	Bird Studies Canada	2006		Most recent bird information
NHIC	NHIC, MNR	2006		Ontario's information centre on significant plants and animals. Included Ontario Herpetofaunal Summary Atlas

TABLE 2.6.1: TERRESTRIAL NATURAL HERITAGE INFORMATION USED FOR CHARACTERIZATION				
Title	**Source**	**Date**	**Scale**	**Reason Chosen**
Significance/Constraints: Sites				
Core Natural Heritage Map incl. Environmental Protection Areas Environmental Conservation Areas Natural Heritage Corridors	RMN Planning Department	2005	1:100,000	Consistent ranking of site significance across the whole study area (parts of 3 municipalities). The June 2005 draft was the most recent digital version: it was updated using the 2 data sources below
Evaluated Wetlands - MNR Jun 05 update	MNR	2005	1:10,000	Updated the Natural Heritage Map to include recently evaluated wetlands.
Approved Subdivision Plans	RMN Planning Department	2006		Updated the Natural Heritage Map to account for already approved plans of subdivision.
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study
Significance/Constraints: Subwatershed				
Output from Status of Information on Wetland Location and from Summary of Natural Areas Locations, Extent and Cover Type (see above in table)				Best available information on of wetlands, forest and natural cover.
Subwatersheds	Philips	2006		Developed from DEM and field checks for this study

2.6.2 Work Activities

Available data (ref. Table 2.6.1) for natural heritage resources have been analysed for extent, type, change, significance and constraints – all on a subwatershed basis. This characterization lays the basis for development of subwatershed-specific strategies, targets and action plans. The resolution of all analyses is at a regional scale, appropriate for watershed and subwatershed planning. Site planning will require more detailed analyses.

Current Extent and Type:

i. Wetland location status

Available data on wetland location included the most recent available data on MNR's evaluated wetlands and the Settlement Area's Natural Areas Inventory (NAI). The watershed's wetlands are so extensive, complex and difficult to delineate that evaluation extent has grown as MNR has had the opportunity for further investigation. The "moving target" of protected extent creates planning dilemmas. Swamps are the most difficult wetland type to delineate in these landscapes. An estimate of total wetland location was conducted; the coincidence of forest cover on saturated soils (Kingston and Presant, 1989) indicates the possibility of wetland for areas not yet evaluated (Snell et al, 1998). Wetland boundary estimates mapped by NWQPS using this method correspond closely with the wetland boundaries evaluated post-NWQPS, a confirmation of the estimate method's validity for the regional scale (1:25,000) of the soil data.

The most recent available (June 2005) Evaluated Wetlands were mapped, noting the Provincially Significant Wetlands. "Possible" wetland was identified as area not mapped as wetland by MNR but:

- For the Settlement Area, classified wetland by the Natural Areas Inventory (Dougan and Associates, 2003); or
- For the rural area, forest coinciding with wet soil (Kingston and Presant, 1989) for 50-100% of the soil unit.

Available rural NAI field results assembled by the Bert Miller Nature Club provided a spot check for the possible additional wetland. MNR generated a few wetland boundary revisions over the course of the project; the June 2005 set provided at project start-up was used as a consistent date.

Total wetland area estimate used the evaluated wetland area plus 40% of the area of possible wetlands. The 40% figure is based on Niagara Area of Concern (AOC) air photo sampling to estimate the proportion of wet slough area within possible wetlands (Snell et al, 1998); the method corresponds with that used for wetland area by Niagara Water Quality Protection Strategy (NWQPS).

ii. A summary of natural area locations, extent and cover type

In the Settlement Area, the Natural Areas Inventory was summarized using the dominant cover type.

The Bert Miller Nature Club is conducting a natural area inventory in the rural areas of the Town of Fort Erie. Comprehensive data were not available to allow complete cover mapping of the rural area. At report preparation, MNR had not released the area's Southern Ontario Land Resource Information System (SOLRIS) cover mapping. For the rural area, a combination of the SOLRIS forest extent and evaluated wetland mapping allowed distinction of treed areas and open meadow/marsh. Interpretation of the 2002 air photo mosaic provided an estimate of shrub/meadow areas.

Historical Context for the Natural Heritage System

i. Long Term Change

Natural communities were defined on the basis of their soil landscape. Categories included mineral, organic and alluvial landscapes. The mineral soil areas were further divided by their dominant drainage into upland (well-drained), mesic (imperfectly drained) and lowland (poorly or very poorly drained) as well as into deep fine soils (clays, clay loams and silty clays), deep coarse soils (sands and gravels) and shallow (less than 1 meter) over bedrock.

The soil units included in each landscape class are listed in Table 2.6.2.

TABLE 2.6.2: LANDSCAPES' DOMINANT SOIL SERIES	
Landscape	**Dominant Soil Series***
Fine soil Mesic	Beverly, Chinguacousy, Cashel, Haldimand, Niagara, Oneida, Ontario, Peel, Tavistock
Fine soil Lowland	Jeddo, Lincoln, Malton, Maplewood, Toledo, Welland
Coarse soil Upland	Fonthill, Fox, Plainfield, Beach-scarp complex
Coarse soil Mesic	Berrien, Walsingham
Coarse soil Lowland	Granby
Shallow on Bedrock Upland	Farmington
Shallow on Bedrock Mesic	Franktown
Shallow on Bedrock Lowland	Brooke
Organic Wetland	Lorraine
Occasionally Inundated	Alluvial

* includes soil series from Sheet 7 of Niagara Soils (Kingston and Presant, 1989). Some may be beyond the study area.

Originally, the natural landscapes covered the whole watershed. Current landscapes were classified using the same landscape classes by overlaying the current natural areas on the soil coverage. Proportional comparisons were calculated based on the area with data, omitting built-up areas where soils are not mapped.

ii. Recent Change

Two investigations were conducted:

- A digital overlay of 1967 forest extent (Canada Land Inventory) on 2000 forest extent (NPCA). Resolution differences limited the interpretation to woodlots greater than 2 hectares, the lower resolution of the two coverages. Slight shifts in registration of the 1967 coverage limited the interpretation to a visual comparison; and
- A visual comparison of the historic editions of the National Topographic System. They were based on aerial photography of 1936, 1965, 1976, 1980 and 1990 for Welland (30L/14) and of 1936, 1969, 1976, 1980 and 1990 for Fort Erie (30L/15).

iii. Slough Mosaic Change

Landscape units retaining the slough (shallow closed depression) pattern characteristic of the area's natural landscapes were interpreted from the 2002 air photo mosaic. Distribution was compared with the soils to establish correspondence and a basis for estimating the original slough mosaic distribution.

iv. Significance

Vegetation and Wildlife

Significance of vegetation and wildlife species and communities was summarized from the Natural Areas Inventory (Dougan and Associates, 2003) supplemented by the Ontario Breeding Bird Atlas Data, Natural Heritage Information Centre data, wetland evaluation data, a brief discussion with the investigator for the Bert Miller Nature Club (A. Garafalo, pers. comm.) as well as consultation with NPCA and local MNR staff. Ratings were based on species at risk lists of COSEWIC and OMNR and on NHIC's rare species list available in 2006.

Site Criteria

The most recent rating of site significance that consistently covers the whole study area is Niagara Region's Core Natural Heritage map approved in December 2005 (Regional Municipality of Niagara, 2005). It rates provincially significant areas – Provincially Significant Wetlands, Provincial Life Science ANSI's – as Environmental Protection Areas. It rates regionally significant areas - significant woodlands, significant wildlife habitat, regionally significant life science ANSI's, other evaluated wetlands, significant valley lands, publicly owned conservation lands – as Environmental Conservation Areas. Significant habitat of threatened and endangered species qualifies as Environmental Protection Area but has not been mapped; a check with MNR indicated no information was available at report writing (Vlasman, Kara, pers. comm.). The above levels of significance meet criteria listed in the Provincial Policy Statement (2005). Development and site alteration will not be permitted in Environmental Protection Areas but may be permitted in Environmental Conservation Areas if it has been demonstrated that there will be no significant negative impact (Regional Municipality of Niagara, 2005).

The Region's Draft Core Natural Heritage Map was updated to 2006 conditions by adding the June 2005 evaluated wetlands and deleting three small areas where draft plans of subdivision were approved prior to the significance mapping.

The Town of Fort Erie and the City of Port Colborne both have recent draft Official Plans (OPs). Their use for study area-wide significance rating is limited by: a) differing environmental designations; and b) environmental designation criteria that extend beyond significance (e.g., hazards, rehabilitated waste disposal sites). Although consistent significance rating required use of the Region's rating, the draft OP's will be incorporated into the Strategy.

The significance of every natural area (totalling 455 units) in the Settlement Area was rated in the Natural Areas Inventory (Dougan and Assoc., 2003). Several natural areas in agricultural Fort Erie have been inventoried and rated by the Bert Miller Nature Club (2006): these ratings are incorporated into Fort Erie's Draft OP that will be incorporated into the Strategy. The lack of a comprehensive rural inventory, however, precludes use for a watershed-wide significance analysis.

Subwatershed Criteria

All subwatersheds – both those within the Niagara River Area of Concern and those in the Lake Erie basin - were analysed for their status compared to the minimum habitat guidelines Environment Canada (2004a) developed to assist restoration planning in Areas of Concern. Parameters used and their guidelines are:

- Percent wetlands: >6% per subwatershed; >10% per major watershed
- Percent forest: >30%
- Size of the largest forest patch: at least one patch over 200 ha with a minimum of 500 m width

- Percent of interior forest: >10% over 100 m from the forest edge; and > 5% over 200 m from the forest edge
- Proximity to other forest patches: none more than 2 km from another.
- Riparian vegetation: $\geq$ 75% of all stream length naturally vegetated to a minimum of 30 m width on both sides of the streams.

Wetland percentage used the evaluated wetland area plus 40% of the area of possible wetlands mapped on Figure NH 1 (see *Wetland location status* section above). Forest extent was the total of the Settlement Area's Treed and Sparse Treed cover types from the Natural Areas Inventory and of the rural area's Treed Cover from SOLRIS Forest Boundaries (2002). Riparian analyses used all natural cover types.

2.6.3 Findings/Constraint Identification

The Fort Erie Creeks Watershed falls within the Deciduous Forest Region, also known as the Carolinian Zone or Lake Erie Lowlands. This zone lies along the north shore of Lakes Erie and Ontario and the south-east shore of Lake Huron. It is the northern extension of the large deciduous forest of north-eastern United States. Many of the trees found here are at the northern limit of their range and biodiversity is the highest of all Canada's vegetation zones. Approximately one-third of Canada's species-at-risk under the Species at Risk Act are found in this relatively small eco-region (Environment Canada, 2004b).

The moderate climate and rich soils of Ontario's Deciduous Forest Region resulted in massive clearing for agriculture. This heritage and ready access to lake transportation laid the basis for population growth and today's extensive urbanization. Over 90 per cent of Ontario's 10 million residents live in the Deciduous Forest Region (OMNR, 2002). It contains Ontario's most threatened habitats. Over 125 species in Carolinian Canada are considered vulnerable, species of special concern, threatened or endangered by either the federal or provincial government. Over 400 species in Carolinian Canada are considered rare by the Natural Heritage Information Centre (Carolinian Canada, 2004).

The Deciduous Forest Region has the lowest percentage of natural areas in Ontario. Forest extent averages 11%. The Niagara Peninsula watershed exceeds that average at 17.6% (NWQPS, Phase 2, 2003). Much of that elevated level can be attributed to the relatively high forest extent in the south-east portion of the peninsula, including the Fort Erie Creeks watershed where some areas exceed 30%. Since much of the Fort Erie Creeks watershed's forest is wetland, NWQPS total wetland estimates for these Local Management Areas exceed the 10% minimum guideline.

The Fort Erie Creeks Watershed rates very well in terms of forest and wetland extent relative to much of southern Ontario and the Deciduous Forest Zone.

Current Extent and Type

Wetland location status

Wetland information is presented in Figure NH 1 and summarized in Table 2.6.3. Evaluated wetland covers 13.2% of the study area. Beyond evaluated areas, possible wetland inclusions are estimated to add approximately 600 hectares for a total wetland coverage estimate of 16.6%. The highest wetland concentrations occur in Baker Creek and Kraft Drain watersheds; the lowest concentrations occur in the most highly urbanized subwatersheds – Fort Erie and Lakeshore. The largest wetland is Humberstone Marsh in the Black Creek headwaters.

Almost all evaluated wetlands are rated Provincially Significant. Only Bertie Bay Drain subwatershed has a substantial area of evaluated wetland with local significance (ref. Figure NH 1).

TABLE 2.6.3:
WETLAND ESTIMATES BY SUBWATERSHED

Subwatershed	Subwatershed Area (ha)	Evaluated Wetland (ha) June 2005	Area Containing Possible Wetland (ha)	Total Wetland Area Estimate* (ha)	Estimated % Wetland
Baker	455.0	151.4	74.0	181.0	39.8
Beaver	3478.9	399.4	258.5	502.8	14.5
Bertie Bay Drains + L. Erie 1	868.3	106.6	67.2	133.5	15.4
Black	6872.3	825.5	590.9	1061.9	15.5
Fort Erie	397.5	0	0	0	0
Frenchman’s Creek	1723.5	278.9	112.7	324.0	18.8
Kraft Drain	554.7	153.5	146.2	212.0	38.2
Lakeshore	364.4	21.7	43.7	39.2	10.8
Miller	795.5	153.4	60.3	177.5	22.3
Niagara R. Shore	349.4	37.7	43.5	55.1	15.8
Six Mile Creek	1813.4	211.6	97.1	250.4	13.8
TOTAL	17,662.9	2339.7	1494.1	2937.3	16.6

* Evaluated area + 40% of Area Containing Possible Wetland. This is a conservative estimate: areas containing possible wetland include only those with forest cover types.

In the Settlement Area, the Natural Area Inventory wetlands included most evaluated wetland but extended further. Evaluated wetlands very rarely extended beyond Natural Area Inventory ones and in most of those instances occurred on soils mapped as 100% poorly drained, a situation supporting the probability of wetland inclusions. The dominance of 100% poorly drained soils within evaluated wetlands extended to the rural area.

Where the Agricultural Area NAI investigated non-evaluated areas for which soil maps indicate possible wetland, the NAI confirmed wetland presence (Bert Miller Nature Club, 2006) and the validity of the forest-wet soil overlay method to flag possible wetland.

Summary of natural area locations, extent and cover type

The distribution of the natural areas’ dominant cover types is shown on Figure NH 2 and quantified by subwatershed in Table 2.6.4.

TABLE 2.6.4: COVER TYPE PERCENTAGES BY SUBWATERSHED							
Subwatershed	**Subwatershed Area (ha)**	**Aquatic**	**Beach/Dunes**	**Prairie**	**Shrubs/ Meadow/ Marsh**	**Trees (incl. Sparse Trees)**	**Total Natural Cover**
Baker	455.0				25.5	47.2	72.7
Beaver	3478.9				5.9	23.9	29.7
Bertie Bay + L. Erie 1	868.3	1.1		0.1	16.7	24.5	42.4
Black	6872.3				8.8	20.4	29.3
Fort Erie	397.5		0.1		2.2	1.0	3.2
Frenchman's	1723.5				13.8	22.6	36.5
Kraft	554.7				19.9	42.8	62.7
Lakeshore	364.4		4.6		1.8	22.9	29.3
Miller	795.5				17.1	28.8	46.0
Niagara River Shore	349.4				21.7	27.4	49.0
Six Mile	1813.4			0.7	15.4	23.1	39.3
TOTAL Study Area	17,662.9	0.1	0.1	0.1	10.9	23.4	34.5

Trees, including sparse trees, cover 23.4%; shrubs, meadow or marsh cover 10.9%; and aquatic, beach/dunes and prairie are each 0.1% of the Fort Erie Creeks watersheds. Total natural cover is 34.5%.

Baker and Kraft subwatersheds both exceed 40% forest. All other subwatersheds, except the built-up Fort Erie one, fall in the 20-30% range.

Shrub and meadow are more common in the "urban fringe" subwatersheds (Baker, Frenchman's, Kraft Miller, Niagara River Shore, Bertie Bay) at 13.8 to 25.5% compared to either the built-up (Fort Erie, Lakeshore) or rural (Beaver and Black) ones, all of which are less than 8.8%.

Though mapped only for the Settlement Area, the single aquatic system is in Bertie Bay subwatershed; the beach/dune communities are concentrated in Lakeshore subwatershed; and prairie is concentrated in Six Mile Creek subwatershed.

The total natural area is highest for Baker Creek subwatershed at 72.7%, followed by Kraft Drain subwatershed at 62.7% - both extremely high percentages for southern Ontario. The only subwatershed below 29% is the highly urban Fort Erie one.

A history of cultural influence determines the existence and composition of almost every shrub and meadow community; among treed community types, cultural influence is flagged for plantations (ref. Figure NH 2 Settlement Area only).

Shrub and meadow cover types tend to have a shorter duration than the other types. Shrub and meadow undergo succession to forest and are easy to clear for agriculture or development. A comparison for two recent dates (2002 air photo mosaic and 2005 Google Earth) confirms the flux of this cover type but, for that period, the relatively constant total area and distribution of change.

Historical Context for the Natural Heritage System

Changes are summarized for both long-term (since pre-settlement) and more recent trends.

Long Term Change

The original communities are indicated by the landscapes mapped on Figure NH 3a. Areas without soil data are not classified. Table 2.6.5: *Original* rows list percentages by each subwatershed's classified area. Much of the forest grew on lowland areas with fine-textured soils. A significant area, however, was dry enough to reach the mesic category and there were also major areas that were shallow soil on bedrock – predominantly upland and mesic in character. Communities on coarse soils were very small, corresponding to Lake Erie shore areas and to remnants of glacial lake beaches.

The current natural landscapes are presented on Figure NH 3b and listed in Table 2.6.5: *Current* rows.

TABLE 2.6.5:
ORIGINAL AND CURRENT NATURAL LANDSCAPES BY SUBWATERSHED*: Percentages Are % of Natural Landscapes

Subwatershed	Fine Soil Low-land (%)	Fine Soil Mesic (%)	Alluvial (%)	Shallow Low-Land (%)	Shallow Mesic (%)	Shallow Upland (%)	Coarse Soil Mesic (%)	Coarse Soil Upland (%)	Organic (%)	Original Natural Area on Mapped Soils (ha)	Current Natural Area on Mapped Soils (ha)
Baker Creek											
Original	78.9	19.1	2.0	-	-	-	-	-	-	448.4	
Current	82.4	15.8	1.8	-	-	-	-	-	-		332.6
Beaver Creek											
Original	40.1	33.5	10.1	-	5.9	10.4	-	0.1	-	3115.7	
Current	43.4	18.1	22.9	-	5.8	9.8	-	0.0	-		976.0
Bertie Bay Drain + L. Erie 1											
Original	57.5	17.2	-	1.2	7.4	16.1	-	0.5	-	492.1	
Current	70.5	7.9	-	1.8	8.0	11.7	-	0.1	-		315.2
Black Creek											
Original	73.6	18.3	4.8	-	0.7	1.3	trace	-	1.2	6827.7	
Current	79.9	7.9	8.3	-	0.1	0.9	trace	-	2.8		1922.4
Fort Erie											
Original	83.5	16.5	-	-	-	-	-	-	-	10.9	
Current	79.5	20.5	-	-	-	-	-	-	-		7.3
Frenchman's Creek											
Original	61.6	20.1	6.0	0.8	6.9	2.2	-	2.3	-	1167.9	
Current	64.1	19.8	10.1	0.5	2.7	2.4	-	0.5	-		576.1
Kraft Drain											
Original	71.1	22.9	6.0	-	-	-	-	trace	-	468.1	
Current	73.0	19.5	7.5	-	-	-	-	0	-		333.4
Lakeshore											
Original	96.6	-	0.1	-	-	-	-	3.3	-	118.6	
Current	98.5	-	0	-	-	-	-	1.5	-		78.2
Miller Creek											
Original	57.8	18.7	2.5	-	14.9	3.6	1.2	1.2	-	740.4	
Current	64.1	20.8	4.6	-	5.0	3.6	0.9	1.0	-		354.4
Niagara R. Shore											
Original	71.6	28.1	0.4	-	-	-	-	-	-	264.3	
Current	85.1	14.6	0.3	-	-	-	-	-	-		143.3
Six Mile Creek											
Original	43.5	21.9	8.6	4.8	9.0	12.1	-	0.2	-	1390.0	
Current	47.4	12.3	14.7	7.1	5.9	12.6	-	trace	-		629.0
TOTAL Study Area											
Original Natural	62.0	22.1	5.9	0.5	3.9	4.7	trace	0.3	0.5	15044.1	
Current Natural	67.0	13.4	10.3	0.9	2.7	4.5	0.1	0.1	1.0		5667.9
Current Slough Mosaic %	88.0	7.6	2.1	0	0.5	0.5	0.1	0.1	1.1		

* built-up areas excluded

The main percentage shift from "original" to "current" status for the full study area is a lower proportion of the natural area on mesic sites and a higher proportion on alluvial and lowland sites; lack of wetness and inundation limitations favoured agricultural use of mesic sites. Within subwatersheds, changes in relative proportions from original to current conditions are:

- Close to same – Baker, Frenchman's, Kraft, Lakeshore, Miller, Fort Erie
- A shift from fine soil mesic to alluvial – Beaver, Six Mile
- A shift from fine soil mesic to fine soil lowland – Bertie Bay, Niagara River Shore
- A shift from fine soil mesic to fine soil lowland and alluvial – Black, Six Mile

Among the shallow over bedrock landscapes, mesic areas are under-represented today relative to original proportions. The coarse soil communities, always very small, have almost disappeared.

Recent Change

The sequence of changes since 1936 is presented by subwatershed in Table 2.6.6. Figure NH 4 summarizes recent forest changes.

TABLE 2.6.6:
CHANGES THROUGH FIVE NATURAL TOPOGRAPHIC SURVEY EDITIONS – BY SUBWATERSHED

Subwatershed & Date	Streams/Shores	Land Use	Forest
Black: 1936	Drains through and below Humberstone Marsh, rest natural. Shows tributary linking up with later north tributary of Beaver	Scattered farm houses + 1 road of homes in Stevensville. A few houses in Snyder. QEW + RR's	Humberstone Marsh the biggest. Elsewhere evenly scattered.
1965	A few more drains. Tributary cut off to the Beaver	Few more homes in Stevensville. Douglastown started. Auto wrecker and dump beside Humberstone. Marsh	Very little change
1976	Same	Very similar. Wrecker & dump gone.	Very similar. A bit more along creeks but most bare.
1980	Similar	Similar. New ponds near Douglastown's new interchange	Very little change. A bit lost to the ponds
1990	Similar	Similar. Ponds labelled Waste	Very little change
Beaver: 1936	Most streams natural. With stream to Black, smaller basin than later	Development at Ridgeway + homes along Ridge Rd near Garrison + scattered farmsteads	Scattered but much of Beaver valley vegetated. Only upper reaches not.
1965	Above Stream into Beaver Creek	Some growth in Ridgeway & along Ridge Rd. New Quarry near Ridgemount	Very little change
1976	Same	Same	Little change. Riparian of upper trib added
1980	A few new tributaries show up	Similar	Little change. A couple small additions.
1990	Same	Similar	Little change. A bit more.
Baker: 1936	Natural form	Few homes, power line	Headwaters forested
1969	A creek that not on 1936 map is flowing into Miller Ck	Little change	Bit of spread
1976	Same	Same	Very similar
1980	Creek reversed into Baker; new drains	Very similar	Some spread in lower area and along Baker Creek
1990	Same	Few more homes	Some further spread in lower area
Miller: 1936	Natural form	Little built-up. RR, QEW & power line	Scattered woodlots
1969	A creek near mouth that reversed to Baker later	Few homes, dump in headwaters	Bit more forest along creek
1976	Same	Dump grown. New Auto wrecker	Little change except some clearing near RR & QEW
1980	Creek now to Baker	Auto wrecker bigger	Some expansion. Cleared in 1976 back as forest
1990	Same	Auto wrecker bigger	More spread. Most of creek system wooded but not headwaters

TABLE 2.6.6 Con't: CHANGES THROUGH FIVE NATURAL TOPOGRAPHIC SURVEY EDITIONS – BY SUBWATERSHED			
Subwatershed & Date	**Streams/Shores**	**Land Use**	**Forest**
Niagara River Shore: 1936	No creeks.	Some houses along Niagara Pkwy	A few scattered woodlots
1965 & 1969	2 creeks shown	More homes along Pkwy	A bit more wooded
1976	Same	A few more homes	A bit less wooded
1980	Same	Very similar	Some spread
1990	Same	Very similar	A bit of spread
Frenchman's Creek: 1936	Natural form	Development in Fort Erie Race Track vicinity. Many RR's and QEW.	Very scattered. Little along creek
1969	More creeks shown	Same + another sports track + quarry in headwaters	Little change except expansion of woodlot in lowest reach.
1976	Same	Similar + new auto wreckers and chemical plant near Conrail. QEW intersection	A few upper woodlots expanded a bit.
1980	Same	Little change	Many woodlots expanding
1990	Same	Little change	Similar. A little spread.
Fort Erie: 1936	Only 3 small streams	Mostly built up. RR and QEW	Very little
1969	North stream gone	New park; STP where creek gone	None
1976	Same	Same	None
1980	Same	Same	Woodlot in north
1990	Same	Same	Same
Lakeshore: 1936	Irregular shore & further out than later	Some built-up	Very little
1969	Smoothed out shore	Similar	Bit more both inland & near shore
1976	Same	Few more homes	Spread further
1980	Same	Same	Spread still more
1990	Same	Few more homes	Spread still more
Kraft Drain: 1936	Natural stream form	Scattered homes	Relatively little
1969	Same	Few more homes	Similar
1976	Same	Same	Spread along creek and connecting woodlots
1980	Drains added	Few more homes. Chemical plant noted	Lot of spread
1990	Same	Same	More spread
Bertie Bay Drains: 1936	Irregular shore & further out than later No streams mapped	S ½ of Crescent Park built-up. Scattered homes elsewhere. Many shore cottages.	Scattered woodlots
1969	2 drains extend inland & to quarry ponds north of Dominion Road (ref. NTS mapping)	More homes in N ½ & scattered elsewhere. More cottages	Very slight spread
1976	Same	N ½ of Crescent Park filling in	Some spread in mid-area
1980	Same	Very similar. Few more cottages	Much more spread mid and lower areas, much of creeks within forest
1990	Same	Very similar	Most woodlots spread
Six Mile Creek: 1936	Natural streams	Some built-up in headwaters	Scattered woodlots, little along creeks
1965	Some drains	Some built-up spread esp. near mouth at Wavecreast/Thunder Bay	Little change except woodlot gone under Thunder Bay development
1976	Same	Very similar	Some spread especially towards shore S. of Dominion Rd.
1980	More drains	Very similar	Some spread esp. in upper reaches
1990	Same	Very similar	Small amount of spread
1990	Same	Little change	Similar. A little spread.

Forest change has been in the context of other land use changes. Urban expansion in the watershed has been minor since 1936. Thunder Bay, Crescent Park and Douglastown have shown the greatest growth in extent. Strips of homes along Niagara Parkway, Ridge Road and Lake Erie shoreline have gradually filled in. Interchanges were added to the QEW between 1969 and 1976. These changes removed a few forested areas. In recent decades, however, forest cover has expanded with the greatest increases in the eastern subwatersheds where regeneration has more than balanced the losses (ref. Figure NH 4). Fort Erie subwatershed is an exception: it has been built-up since 1936 and shown little woodland extent or regeneration since. Figure NH4's pattern is confirmed by the historic discussions for stream assessment (Section 2.4.1.1) and fisheries (Section 2.5.3).

Large relatively mature woodlots are concentrated at Humberstone Marsh and in a band within 3 km of the Niagara River in Baker, Miller and lower Frenchman's Creek subwatersheds. Many represent older regeneration on once-cleared land abandoned long ago. Much of the more immature woodland developed in the two decades from 1970 to 1990. The highest proportion of immature forest relative to more mature forest is in Six Mile Creek subwatershed.

Beaver Creek valley land was relatively well vegetated even in 1936; most other creek systems were less protected but have improved in riparian forest extent in more recent decades.

Influences on forest besides urban presence and limited urban expansion include drains and contaminant sources. In 1936, the only obvious drains were through and downstream of the Humberstone Marsh. Drains gradually extended throughout the study area from the 1960's on. Possible point sources of contamination appear over the decades including dumps, auto wreckers and chemical plants (ref. Potential Point Sources on Subwatershed Local Opportunities Maps).

Other observations include:

- The prevalence of orchards pre-1960's compared to later dates;
- Stream re-direction: a large tributary of Beaver Creek showed as part of the Black Creek system in 1936. A small stream that flowed into Miller Creek was altered into a drain flowing to Baker Creek between 1976 and 1980; and
- The 1936 Lake Erie shoreline was much more irregular and extended further into the lake than noted on any later maps. This pattern very likely reflected the low lake levels of the 1930's.

In summary, over the past 70 years, the Fort Erie Creek Watershed subwatersheds show a pattern distinct from most of southern Ontario – a pattern of little urban expansion and significant increase of immature forest.

<u>Slough Mosaic Change</u>

Figure NH 7 presents the swale mosaic analysis. Landscape units retaining a slough (shallow, closed depression) pattern within them are estimated to cover 1395.2 hectares. Table 2.6.5 bottom row shows the current slough pattern distribution by landscape for the 1388.2 hectares with soil data. Slough mosaic patterns favour fine soil lowland compared to its total extent (which corresponds to original natural extent). Of the 88% of the total slough pattern that occurs within fine soil lowland, almost all (78.1%) coincides with lacustrine deposits. The lacustrine soils are noted for their "rippled" micro-topography; poorly drained soils have the highest presence of sloughs. Assuming the original slough mosaic pattern corresponded to poorly drained lacustrine soils, approximately 6000 hectares of the original 7400 hectares of slough patterned units (81.1%) have had their micro-topography levelled (ref. Table 2.6.7 and Figure NH 7). This estimate is conservative, overlooking sloughs in other landscapes and the lack of data for urban areas. Of the original 42.2% of the watershed estimated to have had slough mosaic units, 8.0 % of the study area remains in slough mosaic units, most of it (6.8%) in natural cover. Figure NH 7 indicates the widespread levelling of the slough mosaic both in current agricultural land and in abandoned areas that have since regenerated natural cover.

TABLE 2.6.7:
SLOUGH MOSAIC UNIT COVER TYPE PERCENTAGES BY SUBWATERSHED

Subwatershed	Subwatershed Area (ha)	Original Slough Mosaic: Lincoln, Malton & Welland soils *	Current Treed Slough Mosaic	Current Non-Treed Natural Slough Mosaic	Current Slough Mosaic Without Natural Cover	Current Total Slough Mosaic	Total Natural Cover	Levelled Slough Mosaic *: % of Watershed	Levelled Slough Mosaic *: % of Original Slough Mosaic	Slough Mosaic Loss Indicator: ∑ last 2 columns
Baker	455.0	75.1	7.1	1.2	0.1	8.3	72.7	66.7	88.9	155.6
Beaver	3478.9	16.0	2.4	0.7	0.3	3.4	29.7	12.7	79.1	91.8
Bertie Bay + L. Erie 1	868.3	29.5	0.7	0.6	0.1	1.4	42.4	28.0	95.1	123.1
Black	6872.3	65.7	9.0	2.2	2.3	13.6	29.3	52.1	79.2	131.3
Fort Erie	397.5	2.3	0	0	0	0	3.2		100	100
Frenchman's	1723.5	28.2	6.4	1.8	0.3	8.5	36.5	19.7	69.8	85.9
Kraft	554.7	41.4	0.7	0.1	tr	0.9	62.7	40.5	97.8	138.3
Lakeshore	364.4	17.8	0.5	0	0	0.5	29.3	17.3	97.1	114.4
Miller	795.5	53.9	6.6	2.6	0.5	9.7	46.0	44.2	82.0	126.2
Niagara River Shore	349.4	54.1	9.2	0.4	4.8	14.5	49.0	39.7	73.3	113.0
Six Mile	1813.4	20.2	1.0	0	0	1.1	39.3	19.1	94.7	113.8
TOTAL	17,662.9	42.2	5.4	1.4	1.1	8.0	34.5	34.2	81.1	115.3

* Built-Up areas are not included. Original extents are estimates.

The severity of slough mosaic levelling varies among subwatersheds. Although all subwatersheds have had over two-thirds of their original slough pattern levelled, the south-central subwatersheds (Beaver Creek, Frenchman's Creek, Six Mile Creek and Bertie Bay) had less original extent to alter (ref. Table 2.6.7 and Figure NH 7).

Significance

Significance is summarized at three levels: species – plants and wildlife, site and subwatershed.

<u>Plants and Plant Communities</u>

According to Dougan and Associates (2003), 486 vascular plants have been recorded to date for the Fort Erie Settlement Area, 454 of which were confirmed to be present in 2002. Of those, 78% are native and a high proportion is Carolinian, restricted in Ontario to a range south of Toronto. Many are considered significant:

- Nationally, there are 12 species regulated under the Species at Risk Act, six of which are historical observations. Thirty-five species are considered nationally rare (Argus et al. 1987);
- Provincially, two historic species are regulated under the Ontario Endangered Species Act; 48 species are rated provincially rare by Natural Heritage Information Centre (NHIC), of which nine are historic records; and
- Regionally, Ontario Ministry of Natural Resources rates 36 species significant, of which nine are historic (Dougan and Associates, 2003).

The regulated species are listed in Table 2.6.8. For further detail see Dougan and Associates, Volume 2 (2003).

TABLE 2.6.8: REGULATED PLANT SPECIES-AT-RISK (Dougan and Associates, 2003)

Scientific Name	Common Name	National Status (COSEWIC)	Provincial Status (COSSARO)	Recovery Plan
Arisaema dracontium	Green Dragon	SC		
Chimaphila maculate var maculata	Spotted Wintergreen	END		Yes
Cypripedium candidum	Small White Lady's Slipper	END	END	
Eurybia divaricatus	White Wood Aster	THR		Yes
Hibiscus moscheutos ssp moscheutos	Swamp Rosemallow	SC		
Liatris spicata	Spiked Blazing Star	THR		
Liparis liliifolia	Purple Twayblade	END	THR	
Morus rubra	Red Mulberry	END		Yes
Phegopteris hexagonoptera	Broad Beech Fern	SC		
Ptelea trifoliata	Hop Tree	SC		
Quercus shumardii	Shumard's Oak	SC		
Viola pedata	Bird's-foot Violet	END		

END = Endangered. Facing imminent extirpation or extinction throughout its range
THR = Threatened. Likely to become endangered if nothing is done
SC = Special Concern. Not endangered or threatened but particularly sensitive

It should be noted that historic records do not eliminate the possibility of current undocumented presence if suitable habitat persists.

Although some species are less at risk in the United States, populations at the northern end of their range - as are many of the rare species in Fort Erie watersheds - are often genetically important for adaptation to northern habitats (Environment Canada, 2004b).

Significant communities have status regionally, provincially or globally because of the restricted abundance and range. In the Settlement Area, significant communities are largely associated with the Lake Erie shoreline and include: Great Lakes Coastal Marsh, Prairie Meadow Marsh, Tallgrass Prairie and Great Lakes Dunes. Other significant communities are Pin Oak Swamp which is common throughout the study area, and Southern Arrow-wood Mineral Thicket Swamp (Dougan and Associates, 2003).

The only Life Science Area of Natural and Scientific Importance (ANSI) in the study area is Humberstone Muck Basin Swamp Forest, at the headwaters of Black Creek and part of the wetland commonly known as Humberstone Marsh. Elsewhere in the agricultural area, outside the evaluated wetlands, the most significant areas are on the east side of Ridge Road along the Onondaga Escarpment ridge (A. Garafalo, pers. comm.).

The documented locations of rare species and significant communities indicate the importance of the Lake Erie shore, Humberstone Marsh, the corridor within a few kilometres of the Niagara River north from Fort Erie and the Onondaga Escarpment. By subwatershed, these areas include:

- The shore of Lakeshore, Kraft Drain, Bertie Bay Drains (including Lake Erie 1) and Six Mile Creek subwatersheds;
- Upper Black Creek subwatershed;
- Frenchman's Creek, Miller Creek, Baker Creek and Niagara River Shores subwatersheds; and
- The divide between upper Beaver Creek and Six Mile Creek subwatersheds. LandCare Niagara's Natural Heritage Framework (1998) also includes the well-vegetated Beaver Creek valleylands.

All designations are current as of 2006 and will need periodic review as Species-At-Risk lists change.

Wildlife

According to information gathered as part of the Fort Erie Natural Areas Inventory (NAI) (Dougan & Associates, 2003), as well as recent results of the Ontario Breeding Bird Atlas (OBBA), approximately 200 resident or breeding wildlife species (i.e. excluding migrants) have been documented from the Fort Erie Creeks watersheds area and immediate vicinity including Point Abino. Only the lists for amphibians and reptiles (24), birds (119) and mammals (15) from the NAI can be considered complete or comprehensive. The remaining wildlife species on file are composed of insects (36) and crustaceans (1).

While most of the species have been recently documented (as is the case with the results of the OBBA), a few of the records are very dated, going back to the late 19th century and first half of the 20th century. Examples are: Spring Salamander (1877), Spotted Turtle (1914), Loggerhead Shrike (1906), Piping Plover (1934, 1936), Grey Fox (1952) and Prothonotary Warbler (1959), and Woodland Vole (1946), most (or all?) of which have been extirpated as breeding residents.

Of the 200 wildlife species, nineteen (19) are designated as 'Species at Risk', i.e., they are designated as "Special Concern", "Threatened", or "Endangered" in Canada (COSEWIC, 2005) or Ontario (OMNR, 2005). Included are: one (1) species of insect, seven (7) species of amphibians and reptiles, nine (9) species of birds and two (2) species of mammal. Nine (9) of the nineteen (19) species have been reported in the last two decades.

According to the Natural Heritage Information Centre, 19 species are regarded as provincially 'rare', [i.e., those designated as S1, S2, or S3 (NHIC, 2006)]. Not all of the species are the same as the 'Species at Risk'. Both sets are included and distinguished in Table 2.6.9. Designations change as species' status changes through time – either because of recovery or of heightened risk.

TABLE 2.6.9: PROVINCIALLY & NATIONALLY SIGNIFICANT WILDLIFE SPECIES							
	Common Name	Scientific Name	Conservation Status			Recent or Historic	Data Source
			National	Provincial			
			COSEWIC†	OMNR‡	SRank*		
	Damselflies & Dragonflies						
1	Swamp Darner	*Epiaeschna heros*			S3	Recent	A
	Butterflies						
1	Monarch	*Danaus plexippus*	SC	SC	S4	Recent	A
	Amphibians & Reptiles						
1	Northern Dusky Salamander	*Desmognathus fuscus*	NAR	END-R	S1	Historic	B
2	Spring Salamander	*Gyrinophilus porphyriticus*	SC	EXP	SX	Historic	B, C, D
3	Fowlers Toad	*Bufo fowleri*	THR	THR	S2	Recent	B, C, D
4	*Spotted Turtle*	*Clemmys guttata*	*END*	*END*	*S3*	*Historic*	*C*
5	Blanding's Turtle	*Emydoidea blandingii*	THR	THR	S3?	Historic	B, C
6	Eastern Hog-nosed Snake◊	*Heterodon platirhinos*	THR	THR	S3?	Recent	B
7	Milksnake	*Lampropeltis triangulum*	SC	SC	S3	Recent	B
	Birds						
1	Great Egret	*Casmerodius albus*			S2B	Recent	E
2	Black-crowned Night-Heron	*Nycticorax nycticorax*			S3B	Recent	E
3	Red-shouldered Hawk	*Buteo lineatus*	NAR	SC	S4B	Recent	E, F
4	Northern Bobwhite	*Colinus virginianus*	END	END	S1S2B	Recent	E
5	Piping Plover	*Charadrius melodus*	END	END-R	S1B	Historic	C, D
6	Red-headed Woodpecker	*Melanerpes erythrocephalus*	SC	SC	S3B	Recent	A, E
7	Loggerhead Shrike	*Lanius ludovicianus*	END	END-R	S2B	Historic	C, D
8	Tufted Titmouse	*Baeolophus bicolor*			S2S3	Recent	A, C, D, E
9	Cerulean Warbler	*Dendroica cerulea*	SC	SC	S3B	Recent	C, D, E
10	Prothonotary Warbler	*Protonotaria citrea*	END	END-R	S1S2B	Historic	C, D
11	Hooded Warbler	*Wilsonia citrina*	THR	THR	S3B	Recent	A, E
12	Yellow-breasted Chat	*Icteria virens*	SC	SC	S2S3B	Recent	E
	Mammals						
1	*Woodland Vole*	*Microtus pinetorum*	*SC*	*SC*	*S3?*	*Historic*	*D*
2	Grey Fox	*Urocyon cinereoargenteus*	THR	THR	SZB	Historic	C, D

Legend

Note: -- Species in italics may not have been recorded in the study area. Associated accuracy is very low.

◊ The recent Eastern Hog-nosed Snake observation was included because it was documented only a short distance outside the study area boundary. Therefore, it seems possible it could be found in the study area in the future.

† **COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2005.** Canadian Species at Risk. Committee on the Status of Endangered Wildlife in Canada. Web site: http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm [accessed 25 April 2006]

‡ **OMNR (Ontario Ministry of Natural Resources). 2006.** Species at Risk in Ontario List: Ontario Ministry of Natural Resources Species at Risk Unit, June 30, 2006. http://www.mnr.gov.on.ca/mnr/speciesatrisk/status_list.html#thr

* **NHIC (Natural Heritage Information Centre). 2006a.** NHIC List of Ontario Insects: Odonata. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=iiodo

NHIC (Natural Heritage Information Centre). 2006b. NHIC List of Ontario Insects: Lepidoptera. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=iilep

NHIC (Natural Heritage Information Centre). 2006c. NHIC List of Ontario Amphibians. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=aa

NHIC (Natural Heritage Information Centre). 2006d. NHIC List of Ontario Reptiles. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=ar

NHIC (Natural Heritage Information Centre). 2006e. NHIC List of Ontario Birds. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=ab

NHIC (Natural Heritage Information Centre). 2006f. NHIC List of Ontario Mammals. Ontario Natural Heritage Information Centre Home Page. http://www.mnr.gov.on.ca/MNR/nhic/queries/listout.cfm?el=am

SC = Special Concern; THR = Threatened; END = Endangered; END-R = Endangered – Regulated; NAR = Not at Risk

S1 = Extremely rare in Ontario; usually 5 or fewer occurrences in the province or very few remaining individuals; often especially vulnerable to extirpation.

S2 = Very rare in Ontario; usually between 5 and 20 occurrences in the province or with many individuals in fewer occurrences; often susceptible to extirpation.

S3 = Rare to uncommon in Ontario; usually between 20 and 100 occurrences in the province; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances. Most species with an S3 rank are assigned to the watch list, unless they have a relatively high global rank.

S4 = Common and apparently secure in Ontario; usually with more than 100 occurrences in the province.

S5 = Very common and demonstrably secure in Ontario.

S? = Not Ranked Yet, or if following a ranking, Rank Uncertain (e.g. S3?). S? species have not had a rank assigned.

SX = Apparently extirpated from Ontario, with little likelihood of rediscovery. Typically not seen in the province for many decades, despite searches at known historic sites.

SZ = Not of practical conservation concern inasmuch as there are no clearly definable occurrences; applies to long distance migrants, winter vagrants, and eruptive species, which are too transitory and/or dispersed in their occurrence(s) to be reliably mapped; most such species are non-breeders, however, some may occasionally breed.

SZB = Breeding migrants/vagrants.

Recent = 1986 to 2006; Historic = 1985 and before.

A = Fort Erie Natural Areas Inventory (NAI) 2002 field data

B = Ontario Herpetofaunal Summary data (current as of March 2003)

C = OMNR NRVIS data (current as of 2002). Includes only data of individuals known to be from within study area.

D = Rare species information from Natural Heritage Information Centre (NHIC) database (current as of March 2006)

E = Ontario Breeding Bird Atlas data (current as of March 21, 2006)

F = Bird Life of Canada's Niagara Frontier by R.W. Sheppard (1970). Published by the Niagara Falls Nature Club.

All designations are current as of 2006 and will need periodic review as Species-At-Risk lists change.

The Niagara Area Ministry of Natural Resources office is currently preparing “habitat mapping” for the Fowler’s Toad and other Threatened and Endangered species. Map availability must await approval by the various recovery teams and vetting through guidelines for official designation as “significant habitat of Threatened and Endangered species” under the Provincial Policy Statement (Vlasman, Kara, pers. comm.). Fowler’s Toad habitat for breeding, foraging and hibernation includes several Lake Erie shore communities including ponds, creek outfalls, beaches, and rock areas and interconnecting corridors.

According to the 2005 Provincial Policy Statement (PPS), the long-term protection of natural heritage features, including Significant Wildlife Habitat (SWH), is a key objective (OMMAH, 2005). More specifically the PPS states “*Development and site alteration shall not be permitted in… significant wildlife habitat…unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions*.”

PPS implementation requires the identification of Significant Wildlife Habitat (SWH). As of March 2006, however, none has been officially identified or designated. The Ministry of Natural Resources provides technical expertise and guidance for the identification of SWH; designation rests with either the local municipality or the Regional Municipality of Niagara.

The Fort Erie Natural Areas Inventory identified several features as potential Significant Wildlife Habitat (Dougan & Associates, 2003a) including:

- Winter deer yards
- Colonial bird nesting site
- Waterfowl stopover and staging area
- Migratory stopover areas for shorebirds, land birds, and butterflies
- Raptor winter feeding and roosting areas
- Turkey Vulture summer roosts
- Bat hibernacula / reptile hibernacula
- Rare vegetation communities and specialized habitats for wildlife
- Habitat for area-sensitive species
- Amphibian woodland breeding ponds
- Habitats for species of conservation concern
- Animal movement corridors.

Ministry of Natural Resources NRVIS (Natural Resources Values Information System) database maps deer yard areas in many of the larger woodlots throughout the study area. The colonial bird-nesting site is a heronry in upper Frenchman’s Creek subwatershed. For additional information on the other potential Significant Wildlife Habitat features, ref. Volume 1 of the Natural Areas Inventory (Dougan & Associates, 2003).

In fall and winter, waterfowl assemble by the tens of thousands along the open Niagara River. Estimates for that season include over 20% of the global population of Bonaparte’s Gull, up to 14% of the North American Herring Gull population and over 1% of the North American Ringbilled Gull (spring migration only), Canvasback and Common Merganser populations. Greater Scaup and Common Goldeneye can also occur in very significant numbers, often approaching 1% of the North American population (IBA Site Summary for the Niagara River Corridor, Bird Studies Canada). The area meets the criteria for a globally significant Important Bird Area (IBA); the Niagara River Corridor IBA extends along the entire Niagara River shoreline and several kilometres inland.

Site Significance

Site significance is described by:

1. Outlining the watershed natural areas' ecological services;
2. Presenting the results of Provincial, Regional, site significance ratings; and
3. Presenting the results of Local site significance ratings.

1. Ecological Services

The natural areas of the Fort Erie Creeks Watershed provide valuable hydrological, biological, social and climate moderation services. The main hydrological services in the study area are flood moderation and water quality improvement. The watershed's wetland extent and natural slough mosaic form are highly effective at both of these services. Evidence includes the slow recession limbs of observed event hydrographs compared to simulated ones (Section 2.2). Some of the symptoms of urbanization noted by the stream assessment (Section 2.4) may result from slough mosaic levelling and the accelerated runoff caused by agriculture. Wetland and slough mosaic importance will grow as urbanization increases imperviousness and compaction and as climate change intensifies storms. Floodplain wetlands are also widespread and play important buffer roles. The clay substrate limits most groundwater interactions to possible local recharge through fractured clay, especially where there are at least occasionally unsaturated conditions. Recharge may also occur on higher bedrock sites. For any such instances, (all areas sensitive to contamination), the natural ecosystem helps filter contaminants before recharge. The wetland evaluations consistently score high in hydrological values. Natural area distribution is widespread, reinforcing flood moderation roles. There are very few steep slopes requiring erosion control. Most are limited to dunes along Lake Erie, some of which are suffering from loss of natural cover as development occurs. Riparian buffers play a valuable role in stream protection, filtering pollutants as well as providing shade and food sources for stream biota.

Biological values also tend to be high. The study area's location in the Carolinian Zone, Canada's zone of highest biodiversity, combines with one of the highest natural area extents in the Zone to boost the biological importance. Comparable or higher natural area concentrations in the Zone occur only at Six Nations Reserve, Walpole Island Reserve, The Pinery, Long Point and parts of Norfolk County. The study area differs from these areas in its proximity to urban population, a feature that raises its social value for recreation, education and aesthetics. The watershed is also a critical link in the corridor from the American Carolinian Zone. Adaptation to climate change will require species and community migration northward. The Great Lakes and cleared land pose major barriers. The study area is a natural funnel for migration past the lower Great Lakes barrier. The Canadian watersheds further north along the Niagara River are relatively barren of natural area. Migration into southern Ontario for successful climate change adaptation, assuming breaching of Buffalo's urban barrier, will likely be heavily reliant on the Fort Erie watersheds' natural area.

Natural areas provide or potentially can provide products such as timber.

The immature forest age classes can play a role in carbon uptake as they grow, assisting in climate change mitigation. In addition, the high natural area extent near built-up areas moderates high summer temperatures both through shade and evapotranspiration effects, provides winter wind breaks and plays a significant role in improving air quality (American Forests, 1999).

2. Provincial and Regional Significance

Site significance is mapped on Figure NH 5; percentages are presented in Table 2.6.10. The highest concentrations of provincially-significant Environmental Protection Areas (EPA) are in the watersheds of Baker Creek, Kraft Drain and Miller Creek. This pattern corresponds with the pattern of more mature forest indicated on Figure NH 4. Only Lakeshore and Fort Erie are below 10% designated as Environmental Protection Area. The highest concentrations of regionally significant Environmental Conservation Areas (ECA) occur in Bertie Bay Drains (including Lake Erie 1) and in the Niagara River Shore subwatersheds.

Combining the EPA and ECA significance categories shows a pattern of highest percentage in the Settlement Area subwatersheds, excluding the two most built-up subwatersheds, (i.e., Fort Erie and Lakeshore). In rural areas, significant areas are much sparser.

TABLE 2.6.10
SIGNIFICANT NATURAL AREAS – PERCENTAGES BY SUBWATERSHED (as of June 2005)

Subwatershed	% EPA*	% ECA*	% EPA + ECA	% LSA* (of part of basin in Settlement Area)
Baker	33.3	21.3	54.5	66.5
Beaver	11.7	12.2	23.9	26.7
Bertie Bay Drains + L. Erie 1	1.9	38.8	40.7	39.8
Black	12.0	11.5	23.5	40.8
Fort Erie	0	5.5	5.5	2.3
Frenchman's Creek	16.6	20.0	36.6	27.6
Kraft Drain	27.4	24.7	52.1	57.2
Lakeshore	5.5	26.7	32.2	20.7
Miller	20.5	20.1	40.6	44.8
Niagara R. Shore	12.0	37.8	49.8	39.2
Six Mile Creek	12.0	19.7	31.7	38.8
TOTAL	12.9	16.4	29.3	37.8

* EPA is Environmental Protection Area.
* ECA is Environmental Conservation Area.
* LSA is Locally Significant Area

3. Locally Significant Areas

Figure NH 5 also shows the Settlement Area's Locally Significant Areas (LSA) as mapped by the Natural Areas Inventory (Dougan and Assoc., 2003). Table 2.6.10 includes LSA percentages within the Settlement Area. Since the Agricultural Area's LSA inventory to date has assessed only a small number of the natural areas, Agricultural Area LSA percentages are not included. In the Settlement Area, LSA area extent ranges from a low of 2.3% within the built-up Fort Erie subwatershed to two-thirds of Baker Creek subwatershed. Of the total Settlement Area, 37.8% is rated Locally Significant, a high proportion of valuable "green infrastructure" compared to most southern Ontario municipalities. Since these significant areas represent the full range of significance from local to provincial, they generally correspond with the Environmental Protection Areas and Environmental Conservation Areas mapped by the Region and often extend further. Very little Environmental Protection Area is not rated Locally Significant within the Settlement Area; scattered areas of Environmental Conservation Areas, however, do not correspond. The differences reflect some differences in criteria for the two levels of investigation, Locally Significant Area criteria being more site-specific.

Subwatershed Criteria

Environment Canada (2004a) developed guidelines that use landscape ecology concepts to set benchmarks to assist development of natural heritage strategies and planning both for Areas of Concern and for other southern Ontario watersheds. Most of the study area is within the Niagara River Area of Concern. The guidelines are not intended as strict targets but as useful ecological "yardsticks" that should be considered within the unique context of each study area. Guidelines represent minimum desirable habitat proportions. Landscapes with habitat exceeding these minimum amounts should be conserved and enhanced whenever possible (Environment Canada, 2004a).

Important parameters include percentage of wetlands, forests, interior forests and riparian cover. Other forest parameters include largest patch and distance between patches.

Wetlands in the Fort Erie study area, in addition to being valuable habitat, play important hydrological roles. The numerous sloughs in the natural clay plain landscape trap water, both moderating floods and treating contaminants. The guidelines use studies (e.g., Hey and Wickencamp, 1996) that find hydrological services improve most markedly with additional wetland area up to the 10 percent level of wetland coverage. Improvements continue as wetland area increases beyond 10 per cent of the watershed but at a slower rate. The maximum wetland extent possible provides the best hydrological services.

Forest extent is an important factor in habitat quality. The 30% minimum threshold identified as a guideline by Environment Canada (2004a) has been shown to be a level that supports most or all of the bird species of the geographical range (Freemark, 1988, Cadman et al, 1987). Forest can provide hydrological services of water retention and water quality improvement. Many species also require large forest patch sizes to approximate conditions of the original landscape and avoid disturbances associated with the forest edge (Tate, 1998). This requirement is reflected in parameters for the size of the largest patch and for percentage of interior forest.

Connectivity among forest patches is an important factor for re-colonization by wildlife. Abundant forest cover within two kilometres of a forest patch was found to be a significant predictor for forest-interior birds (Austin and Bradstreet, 1996).

Riparian buffers protect stream quality and provide habitat.

Although the slough mosaic is not part of Environment Canada's guidelines, its presence in natural areas is also noted because of its important role in the study area's natural area functioning – both biological and hydrological.

Table 2.6.11 presents the results of the subwatershed analyses for the habitat guidelines. Shaded cells indicate that the minimum guideline is met.

TABLE 2.6.11
STATUS OF SUBWATERSHED HABITAT RELATIVE TO MINIMUM GUIDELINES (Shaded cells indicate guideline is met)

Subwatershed	% wetland	% forest	Area largest forest patch (ha)	% Interior forest: 100 m edge	% Interior forest: 200 m edge	Number of patches >2 km from another	% Riparian Buffers (30 m)	% Natural Area With Slough Mosaic (no guideline)
Baker	39.8	47.2	98.3	9.2	0.8	0	78.8	8.3
Beaver	14.5	23.9	94.4	1.9	0.1	0	51.3	3.1
Bertie Bay Drains + L. Erie 1	15.4	24.5	54.5	3.4	0.1	0	83.7	1.3
Black	15.5	20.5	280.5 + beyond basin	3.0	0.5	0	42.9	11.2
Fort Erie	0	1.0	7.1	0	0	0	NA	0
Frenchman's Creek	18.8	22.7	117.4	6.2	1.8	0	58.3	8.2
Kraft Drain	38.2	42.8	103.7	11.8	1.9	0	91.7	0.8
Lakeshore	10.8	22.9	39.1	0.7	0	0	36.3	0.5
Miller	22.3	28.8	98.0	5.6	0.5	0	62.9	9.2
Niagara R. Shore	15.8	27.4	85.5	3.1	0.1	0	51.6	9.6
Six Mile Creek	13.8	23.2	85.4	2.2	0	0	69.4	1.0
TOTAL	16.6	23.4	280.5 + beyond basin	3.5	0.5	0	53.8	6.8

Wetland and Forest Percentages: Every subwatershed except the almost completely built-up Fort Erie subwatershed meets and considerably exceeds the minimum wetland guideline of 10% cover per watershed and 6% per subwatershed. All but Fort Erie subwatershed exceed two-thirds of the 30% minimum forest guideline but only Baker Creek and Kraft Drain subwatersheds exceed 30%, both by a substantial margin. The study area's forest and wetland percentage values are high for southern Ontario. The wetland estimates exceed those of NWQPS because much more area has been mapped as evaluated wetland since NWQPS. The newly evaluated areas were flagged by NWQPS as probably containing wetland inclusions but were counted as only 40% wetland in area on the basis of the slough extent within those areas. The shift to the evaluated wetland designation maintains the locations but boosts the area calculation to 100%. Inclusion of shrub areas as possible future forest pushes percentages near or over 30% for all subwatersheds but Fort Erie (ref. Table 2.6.4).

Largest Forest Patch: If roads are considered patch boundaries, no forest patch exceeds 200 ha. Overlooking road effects, only Humberstone Marsh in Black Creek exceeds the minimum guideline of 200 ha area at least 500 m in width, and it further exceeds the guideline when area beyond the basin is included. The only other large patch that crosses the study area boundary is the northernmost woodlot – a small corner of a large (over 100 ha) woodlot extends into the study area. Beaver Creek's largest forest patch is partially in Black Creek subwatershed. If the Beaver Creek valley land system were included, the area would exceed 200 ha. In all subwatersheds, many of the forest patches are separated from others by relatively small intrusions.

Interior Forest: Interior forest greater than 100 m and 200 m from the forest edge is mapped in Figure NH 6. Only Kraft Drain meets the 10% interior forest (>100 m) minimum guideline. If, however, rural roads and hydro corridors are not considered forest edge, Baker Creek also meets the 10% guideline and approaches the 5% minimum guideline for area greater than 200 m from the edge. Frenchman's Creek and Miller Creek subwatersheds exhibit moderate amounts of interior forest. Disregarding the Fort Erie subwatershed where there is no interior forest, the lowest interior forest percentages occur in Beaver Creek, Lakeshore and Six Mile Creek subwatersheds. Lakeshore subwatershed's percentage would improve significantly, especially for interior greater than 100 m from the edge, if roads are not counted as edge. Bertie Bay Drains and Niagara River Shore, although approaching the study area's average interior percentage for greater than 100 m from the edge, fare poorly for percentage of area greater than 200 m.

Distance to the Nearest Woodlot: The entire study area meets the minimum guideline of all forest patches being within 2 km. Many species, however, need closer proximity for successive migration, colonization and on-going population health. The Core Natural Heritage Map of the Region, municipal draft OP's, Land Care Niagara (1998) and the Natural Areas Inventory propose corridor systems. The most complete existing corridors occur between the QEW and the Niagara River through Lower Frenchman's Creek, Miller Creek and Baker Creek subwatersheds. Beaver Creek valley lands are also very well connected. Proposed corridors with significant current gaps occur in the subwatersheds flowing into Lake Erie and some of the rural headwaters links both among study area subwatersheds and beyond.

Riparian Buffer: Baker Creek, Bertie Bay Drains and Kraft Drain subwatershed stream systems exceed the minimum guideline of 75% natural riparian buffers within 30 m of the streams. All but Black Creek and Lakeshore streams exceed 50%. Overall, the study area has 53.8% natural riparian cover.

Natural Area With Slough Mosaic: The subwatersheds with the highest proportion of their natural area containing slough mosaic are Black Creek and the broad corridor of Frenchman's, Miller and Baker Creeks. Although Environment Canada (2004a) offers no guidelines, a target consistent with natural landscape functioning could be the proportion of natural area originally containing the slough mosaic (for estimates, see Table 2.6.7 Original Slough Mosaic column). No subwatershed approaches their original proportion, an indication of the widespread levelling that has occurred even under the regenerating natural areas. For the whole study area, the current proportion of 6.8% of the natural area containing slough mosaic units is far lower than the 42.2% estimate for original conditions.

Issues

The Regional and Municipal Official Plans protect the extent of much of the natural area from development. Among development issues, particular concern applies to lakeshore development. Fort Erie's shoreline vegetation communities of dunes, coastal marshes, prairie meadow marsh and tallgrass prairie are extremely significant, some rated as very rare globally (Dougan and

Associates, 2003). Similarly, associated wildlife species are highly significant. A well-known example is the threatened Fowler's Toad. Much of the shoreline has been developed and proximity to large populations raises development pressure on the remainder. Future development applications may encounter constraints as MNR identifies significant wildlife habitat.

Despite good Official Plan protection of natural area extent, several issues remain that can affect natural area functioning. One relates to the extensive levelling of the original slough micro-topography for improved agricultural drainage. When these areas regenerate natural cover following abandonment, they lack much of their capacity for water retention and offer much lower hydrological services than unlevelled natural areas (NWQPS: Phase 2, 2003). Their range of microhabitats is far lower than their unaltered form, permanently thwarting prospects of greatly improved biodiversity for both vegetation communities and wildlife as areas mature. The same prospect awaits restoration areas unless the micro-topography is also restored.

The above issues and others, including lack of riparian buffers, effects of agricultural runoff and climate change are discussed under Impact Assessment in Section 4.3.

In the time period of the watershed plan, predictions of reduced oil access and increased prices could impose significant changes on society. Implications to the watershed natural areas may include:

- Increased pressures on shorelines as large nearby populations seek recreation closer to home;
- Increased pressures on urban natural areas as infill strives to reduce car use;
- Care in shoreline planning to accommodate wind power generation;
- Increased agricultural effects as local food sources become more competitive; and
- Possible use of fast-growing willow for ethanol production.

Administrative issues include:

- The range of habitat types and issues requiring a range of management strategies; and
- Lack of one information hub for ecosystem data. Planning decisions can suffer from missing or un-coordinated information.

Economic issues, also common to other parts of southern Ontario, include:

- The need for improved rural income to fund stewardship practices; and
- The need for recognition of the value of ecosystem services and green infrastructure.

2.6.4 Summary of Significant Features/Constraints

Subwatersheds in the For Erie Creeks Watershed Area are rich in wetland and natural area extent. These features provide valuable habitat, hydrological services and recreational potential. Biological importance is highest at the Lake Erie shoreline, Humberstone Marsh, the large mature and connected woodlots inland from the Niagara River north of Fort Erie, and the Onondaga Escarpment. The original landscapes are generally represented in their original proportions; many of the mesic sites, however, are shrub communities rated Locally Significant but overlooked by the Regional designation. A major issue is the natural areas' relative immaturity and history of clearing. Historical cultivation often obliterated the slough mosaic's micro-topography that is critical to both hydrological services and biodiversity. Immature communities also tend to be less diverse and less representative of the original natural heritage. Existing protection designations will maintain areas as they develop into more mature successional stages but active management will be needed to restore the micro-topography and to allow the sites to maximize their ecological services from a hydrology and associated wildlife management perspective. The watershed's landscape characteristics raise the vulnerability of its natural areas to climate change effects.

The natural areas, although extensive, are often fragmented. In some cases, relatively little restoration could provide a large boost in interior extent. Urban proximity, however, can be in itself detrimental to the presence of some interior species. A balance is required between urban infill requirements to avoid the detrimental effects of sprawl and the potential for improving interior extent. The larger blocks through lower Frenchman's Creek, Miller Creek and Baker Creek subwatersheds combine maturity, size, and potential for improved forest interior extent with a lower built-up density and may present the best options for restoration effort to increase interior extent, subject to Fort Erie's Proposed Draft Official Plan. They also are part of the Important Bird Area corridor associated with the Niagara River.

Natural communities along the Lake Erie shoreline are highly significant, very limited in extent and under strong development pressure.

The rural subwatersheds have lower coverage of both wetland and forest than the Settlement Area subwatersheds. Compared to their original landscape proportions, they are lacking in mesic natural areas. Their recent history has been less dynamic than in the Settlement Area, resulting in a relatively high proportion of mature sites but less forest regeneration. An important exception is the expansion in the Beaver Creek valley land forest cover. Much of the Black Creek valley land system, and parts of the upper Frenchman's and upper Beaver Creek systems lack natural cover. The headwaters of all three systems also have core areas that could be connected for improved interior habitat. The distance from urban influence would raise the potential of interior forest reaching its habitat potential. Agricultural needs, however, are important considerations.

The Official Plans protect Environmental Protection Areas and require maintenance of natural area function for intrusion into Environmental Conservation Areas. These designations apply to a large proportion of the natural areas and to over 29% of the watershed. A concentration of the Environmental Protection Area and Environmental Conservation Area designations occurs in the Settlement Area and will be a major constraint on the location of future development.

2.7 Water Quality

Importance:

Development of the study area would require the application of stormwater quality management practices, in order to meet Federal and Provincial objectives for the protection of fisheries and downstream riparian interests.

2.7.1 Background Information Collection

- Water Quality spreadsheets received from the NPCA, including the following information (ref. Appendix 'SM-C'):

- NPCA monthly grab sampling data current to June 2007
  - NPCA monthly field data current to June 2007
  - NPCA grab sampling data for 2001-2002
  - NPCA BioMAP results current to most recent sampling event in fall 2005
  - Historic NPCA BioMAP data
  - Monitoring station information (i.e. GIS coordinates)

2.7.2 Work Activities

- A mass balance has been completed as part of the NWQPS, using event mean concentrations for loading.

- The Groundwater Study has been reviewed to identify high sensitivity groundwater sites in the watershed.

- Existing benthic invertebrate data has been compiled and assessed using appropriate water quality indices. Water chemistry data has been compiled and reviewed in the context of the provincial water quality guidelines.

- The Study Team has identified potential sources of pollution in the watershed characterization phase, which has assisted in developing the management strategies and opportunities for water quality enhancement (ref. Section 2.8.3).

2.7.3 Findings

Currently, the NPCA, in collaboration with other partners, has a network of surface water and groundwater monitoring stations. There are currently two types of surface water quality monitoring programs that are ongoing in the study area which characterize the water quality and have the potential to identify spatial and temporal trends. One type monitors surface water quality directly and the other monitors the benthic invertebrate community using the BioMAP protocol.

2.7.3.1 BioMAP Sites

The NPCA operates a biological surface water quality monitoring program using benthic macroinvertebrates as indicators of water quality. The benthic macroinvertebrates monitoring program was initiated in 1995 using the BioMAP protocol. There are currently five BioMAP stations (one in Black Creek and four in Frenchman's Creek) located within Fort Erie Creek watersheds (the location of BioMAP stations is shown in Figure 20). The results of the 2001 to 2003 analyses have been summarized in the Table 2.7.4 below. The BioMAP analysis at all five monitoring sites indicate that water quality is impaired.

TABLE 2.7.4: NPCA BENTHIC INVERTEBRATE WATER QUALITY DATA FOR BLACK CREEK AND FRENCHMAN'S CREEK: 2001-2004					
Monitoring Stations	**Date Sampled**	**WQI (d) Results**	**Status**	**WQI (q) Results**	**Status**
BL001	Fall 2001	6.0	Impaired	2.0	Impaired
FR000	Spring 2002	7.45	Impaired	2.50	Impaired
FR000	Spring 2003	5.78	Impaired	2.25	Impaired
FR001	Spring 2003	6.38	Impaired	2.25	Impaired
FR003	Spring 2003	5.59	Impaired	2.30	Impaired

Source: Niagara Peninsula Conservation Authority
WQI (d)= calculated Water Quality Index for benthic invertebrate density (quantitative)
WQI (q)= calculated Water Quality Index for benthic invertebrate diversity (qualitative)

The NPCA also collected BioMAP samples in 1997 and 1998 within the study area, at the following locations:

TABLE 2.7.5 NPCA HISTORIC BENTHIC SAMPLING				
Year	**Date**	**Location**	**WQI (d)**	**Status**
1997	May 12-20	Frenchman’s Creek and Bowen Road	6.5	Poor
1997	Summer	Black Creek and Winger St/Main St	N/A	Fair-Poor
1997	Summer	Black Creek and Stevensville Conservation Authority	N/A	Fair-Poor
1997	Summer	Frenchman’s Creek at Gilmore Rd	N/A	Fair-Poor
1998	May 4-12	Frenchman’s Creek upstream of golf course	8.5	Poor
1998	May 4-12	Frenchman’s Creek in pond	8.2	Poor
1998	May 4-12	Frenchman’s Creek downstream of the weir	7.6	Poor
1998	October 22	Frenchman’s Creek upstream of golf course	5.8	Poor
1998	October 22	Frenchman’s Creek in pond	1.6	Poor
1998	October 22	Frenchman’s Creek downstream of the weir	6.6	Poor

2.7.3.2 Surface Water Quality Monitoring Network

The NPCA also has networks of sampling and collections sites for various monitoring programs conducted by the Authority within the Niagara Watershed. The monitoring sites include both BioMAP and water quality grab-sampling sites. In 2007, within the Fort Erie Creeks Watersheds Plan study area, there were 6 water quality monitoring stations (ref. Figure 20). Six Mile Creek Station SM001 and Krafts Drain Station KD001 were added to the monitoring network in 2007. As a result, there is very limited data currently available. Grab samples have been collected monthly by the NPCA during the ice-free season, and laboratory analysis have been performed in collaboration with the Region of Niagara Environmental Laboratory. We note the following Provincial Water Quality Objectives (PWQO) for reference purposes (MOE 1999), with values in mg/ℓ, except for E. coli (CFU/100 ml).

Aluminum	0.075 mg/ℓ
Ammonia as N	0.02 mg/ℓ
Beryllium (<75 mg/ℓ $CaCo_3$ hardness)	0.011 mg/ℓ
Beryllium (>75 mg/ℓ $CaCo_3$ hardness)	1.1 mg/ℓ
Boron	0.2 mg/ℓ
Bromide	0.2 mg/ℓ
Cadmium (<100 mg/ℓ $CaCo_3$ hardness)	0.0001 mg/ℓ
Cadmium (>100 mg/ℓ $CaCo_3$ hardness)	0.0005 mg/ℓ
Chromium	0.001 mg/ℓ
Cobalt	0.0009 mg/ℓ

Copper	0.005 mg/ℓ
E. coli	100 CFU/100 ml
Iron	0.3 mg/ℓ
Lead	0.005 mg/ℓ
Molybdenum	0.04 mg/ℓ
Nickel	0.025 mg/ℓ
Phosphorus (total)	0.03 mg/ℓ
Silver	0.0001 mg/ℓ
Thallium	0.0003 mg/ℓ
Zinc	0.02 mg/ℓ

Data from the selected sampling stations, for the years 2003 to 2007, have been summarized in Table 2.7.6.

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Alkalinity	Aluminum	Ammonia as N	Barium	Beryllium	Boron	Bromide	Cadmium	Calcium	Chloride	Chromium	Cobalt	Conduc-tivity	Copper	E. coli	Fluoride	Hardness	Iron	Lead	Magnesium	Manganese	Molybdenum
BL001	22-May-03	74	3.4	<0.4	<0.1	<0.1	0.05	<0.2	<0.005	22.1	21	<0.02	<0.02	287	0.01		0.1	95.6	4.1	<0.1	10.6	0.06	<0.02
BL001	25-Jun-03	127	1.71	0.15	0.042	<0.008	<0.08	<0.05	<0.005	63.3	15	<0.02	<0.007		<0.02		0.22	208	2.7	0.02	12.3	0.145	<0.03
BL001	23-Jul-03	124	3.62	<0.04	0.055	<0.002	0.08	<0.05	<0.001	43	35	<0.006	0.002		0.007		0.21	171	3.91	<0.02	14.4	0.236	<0.01
BL001	20-Aug-03	143	1.95	<0.04	0.042	<0.002	<0.02	<0.05	<0.001	43.1	30	<0.006	<0.002		<0.006		0.24	155	2.64	<0.02	11.7	0.164	<0.01
BL001	24-Sep-03	127	1.25	<0.04	0.039	<0.002	<0.02	<0.2	<0.001	47.8	18	<0.006	<0.002		<0.006		0.2	177	1.79	0.02	14.1	0.172	<0.01
BL001	22-Oct-03	104	1.01	<0.04	0.037	<0.002	<0.02	<0.2	<0.001	56.3	42	<0.006	<0.002		<0.006		0.2	193	1.65	<0.02	12.7	0.058	<0.01
BL001	19-Nov-03	89	3.93	<0.04	0.046	<0.002	<0.02	<0.2	<0.001	35.8	13	<0.006	0.003	335	0.008		0.11	139	4.95	<0.02	12	0.092	<0.01
BL001	24-Mar-04	55	3.4	0.09	0.04	<0.02	<0.05	<0.2	<0.005	29.9	20	<0.005	<0.005	254	<0.005		0.13	119	3.93	<0.02	10.7	0.057	<0.005
BL001	20-Apr-04	73	3.7	<0.4	0.43	<0.0007	0.13	<0.2	<0.0005	31	19	0.0031	0.0016	264	0.0087		0.19	117	5.1	0.0038	9.7	0.082	0.0008
BL001	19-May-04	121	2.65	<0.04	0.05	<0.02	0.06	<0.2	<0.005	49	14	<0.005	<0.005	355	0.014		0.17	177	4.83	<0.02	13.5	0.32	<0.005
BL001	29-Jun-04	158	4.4	<0.04	0.07	<0.02	0.06	<0.2	<0.005	62.7	13	0.005	<0.005	451	0.009		0.19	220	7.11	<0.02	18.5	0.359	<0.005
BL001	28-Jul-04	116	2.28	<0.04	0.05	<0.02	0.05	<0.2	<0.005	45.6	21	<0.005	<0.005	405	0.007		0.25	168	3.41	<0.02	13.1	0.128	<0.005
BL001	24-Aug-04	157	0.14	<0.04	0.07	<0.02	0.42	<0.2	<0.005	138	80	<0.005	<0.005	1820	<0.005		0.06	529	0.07	<0.02	44.9	0.046	<0.005
BL001	14-Sep-04	68	1.22	<0.04	0.04	<0.02	<0.05	<0.2	<0.005	31.6	6	<0.005	<0.005	226	0.007		0.19	110	1.95	<0.02	7.5	0.068	<0.005
BL001	13-Oct-04	155	1.83	<0.04	0.05	<0.02	<0.05	<0.2	<0.005	66.9	11	<0.005	<0.005	438	0.008		0.2	236	2.65	<0.02	16.9	0.162	<0.005
BL001	5-Apr-05	32	6.23	<0.07	0.038	<0.001	<0.03	<0.2	<0.002	10.6	6	<0.009	<0.003	105	<0.004	111	0.09	45	4.64	<0.01	4.57	0.052	<0.003
BL001	10-May-05	102	2.12	<0.07	0.039	<0.001	0.05	<0.2	<0.002	46.9	21	<0.009	<0.003	385	0.005	488	0.2	169	3.1	<0.01	12.7	0.14	<0.003
BL001	21-Jun-05	139	3.03	4.63	0.063	<0.001	0.07	<0.2	<0.002	65.3	28	<0.009	<0.003	493	0.01	866	0.22	236	4.33	<0.01	17.9	0.272	<0.003
BL001	12-Jul-05	155	3.97	0.07	0.086	<0.001	0.17	<0.2	<0.002	83.5	40	<0.009	<0.003	710	0.007	435	0.29	326	4.42	<0.01	28.5	0.381	<0.003
BL001	9-Aug-05	171	2.78	<0.7	0.096	<0.001	0.19	<0.2	<0.002	101	54	<0.009	<0.003	880	0.007	49	0.28	411	3.07	<0.01	38.6	0.201	<0.003
BL001	14-Sep-05	91	1.93	0.04	0.063	<0.001	0.1	<0.2	<0.002	85.7	18	<0.009	<0.003	617	0.01	83	0.17	308	2.35	<0.01	22.8	0.096	<0.003
BL001	12-Oct-05	95	1.12	<0.7	0.041	<0.001	0.05	<0.2	<0.002	57.2	22	<0.009	<0.003	435	0.006	291	0.15	202	1.55	<0.01	14.6	0.039	<0.003
BL001	8-Nov-05	88	1.14	<0.7	0.039	<0.001	<0.03	<0.2	<0.002	52.5	14	<0.009	<0.003	408	0.005	91	0.28	189	1.25	<0.01	14.1	0.032	<0.003
BL001	25-Apr-06	95	0.65	<0.04	0.03	<0.001	0.03	<0.2	<0.0001		44	0.003	0.0006	416	0.004	1450	0.16		1.21	0.001		0.05	<0.005
BL001	24-May-06	130	0.3	0.08	0.02	<0.001	0.05	<0.5	<0.0001	54.8	44	0.002	0.0006	477	0.004	219	<0.2	197	1.28	<0.001	14.6	0.08	<0.005
BL001	27-Jun-06	187	0.47	0.09	0.04	<0.001	0.14	<0.2	<0.0001	88.6	37	0.003	0.001	836	0.003	2908	0.23	393	1.13	<0.001	41.7	0.45	<0.005
BL001	25-Jul-06	176	0.32	0.06	0.04	<0.001	0.2	<0.2	<0.0001	103	34	0.001	0.0005	947	0.002	79	0.32	496	0.33	<0.001	58	0.1	<0.005
BL001	29-Aug-06	137	0.47	0.04	0.04	<0.001	0.09	<0.2	<0.0001	59.1	21	0.001	0.0009	500	0.003	461	0.22	236	0.83	<0.001	21.5	0.3	<0.005
BL001	27-Sep-06	110	0.48	<0.04	0.03	<0.001	0.05	<0.2	<0.0001	48.2	24	0.001	0.0005	393	0.004	461	0.19	273	0.69	<0.001	15.2	0.04	<0.005
BL001	24-Oct-06	46	1.57	0.04	0.03	<0.001	0.02	<0.2	<0.0001	14.5	<4	0.001	0.0006	133	0.005	93	0.1	36	1.36	0.002	6.4	0.02	<0.005
BL001	28-Nov-06	82	0.69	0.11	0.03	<0.001	0.03		<0.0001	38	8	0.002	0.0006	305	0.004	219	<0.08	138	1.29	0.001	10.5	0.05	<0.005
BL001	27-Mar-07	58	1.37	0.09	0.03	<0.001	0.02	<0.2	<0.0001		25	0.003	<0.0002	272	0.004	66	0.13		1.36	0.002		0.03	<0.005
BL001	25-Apr-07	89	0.75	0.11	0.03	<0.001	0.04	<0.2	<0.0001		24	0.003	0.001	394	0.005	1990	0.18		1.5	0.002		0.13	<0.005
BL001	28-May-07	142	0.85	0.08	0.05	<0.001	0.07	<0.2	<0.0001		29	0.003	0.002	547	0.007	411	0.22		2.58	0.003		0.39	<0.005
BL001	25-Jun-07	185	0.24	0.08	0.04	<0.001	0.04	<0.2	<0.0001	111	46	0.002	0.0003	1020	0.001	613	0.31	564	0.29	<0.001	69.7	0.05	<0.005

TABLE 2.7.6 Con't
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Nickel	Nitrate as N	Nitrite as N	pH	Phosphate	Phosphorus (Total)	Potassium	Silver	Sodium	Strontium	Sulphate	Thallium	Tin	Titanium	Total Coliform	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Solids	Total Suspended Solid	Uranium	Vanadium	Zinc
BL001	22-May-03	<0.09	0.6	<0.2	7.3	<0.2	0.2	3.73	<0.02	16.7	0.3	28	<0.1	<0.3	<0.7		309	2.8	336	27	<1.0	<0.03	<0.1
BL001	25-Jun-03	<0.05	0.1	<0.05	7.5	<0.05	0.2	3	<0.02	31.5	1.22	31	<0.1	<0.05	<0.07		426	2.9	452	26	<0.1	<0.02	<0.2
BL001	23-Jul-03	<0.02	0.6	<0.05	7.7	<0.05	0.18	5	<0.005	17.6	0.67	76	<0.1	<0.05	0.06		487	2.2	496	9	<0.1	0.007	<0.06
BL001	20-Aug-03	<0.02	<0.1	<0.05	7.74	<0.05	0.23	5.6	<0.005	17.1	0.49	17	<0.1	<0.05	<0.05		348	1.6	364	16	<0.1	<0.006	0.14
BL001	24-Sep-03	<0.02	<0.2	<0.05	7.9	<0.2	0.22	5.3	<0.005	14.3	0.72	53	<0.1	<0.05	<0.05		657	0.68	640	19	<0.1	<0.006	<0.06
BL001	22-Oct-03	<0.02	<0.4	<0.2	7.41	<0.2	0.15	6	<0.005	27.6	1.09	100	<0.1	<0.05	<0.05		417	1.13	424	7	<0.1	<0.006	<0.06
BL001	19-Nov-03	<0.02	<0.4	<0.2	7.41	<0.2	0.25	4.9	<0.005	8.98	0.36	57	<0.1	<0.05	0.06		340	1.23	388	48	<0.1	0.006	<0.06
BL001	24-Mar-04	<0.005	0.6	<0.2	7.61	<0.2	0.14	2.9	<0.02	12.6	0.313	36	<0.1	<0.05	<0.1		240	1.19	252	13	<0.1	<0.005	<0.02
BL001	20-Apr-04	0.025	<0.4	<0.2	7.26	<0.2	0.26	3.3	<0.0003	13		25	<0.0005	0.002	0.069		288	2.09	336	28		0.0066	0.036
BL001	19-May-04	<0.005	0.7	<0.2	7.67	<0.2	0.43	3.2	<0.02	11.9	0.597	39	<0.1	<0.05	<0.1		316	2.02	412	22	<0.1	0.008	<0.02
BL001	29-Jun-04	0.022	<0.4	<0.2	7.87	<0.2	0.37	4.2	<0.02	12	0.841	62	<0.1	<0.05	<0.1		500	1.11	568	36	<0.1	0.009	0.03
BL001	28-Jul-04	<0.005	<0.4	<0.2	7.71	<0.2	0.44	3.4	<0.02	14.4	0.512	55	<0.1	<0.05	<0.1		292	1.37	408	43	<0.1	<0.005	<0.02
BL001	24-Aug-04	<0.005	0.1	<0.2	8.6	<0.2	0.08	11.5	<0.02	181	1.93	78	<0.1	<0.05	<0.1		1130	1	1600	8	<0.1	<0.005	<0.02
BL001	14-Sep-04	0.029	<0.4	<0.2	7.4	<0.2	0.23	3.9	<0.02	4.5	0.346	30	<0.1	<0.05	<0.1		280	1.61	316	21	<0.1	<0.005	<0.02
BL001	13-Oct-04	0.021	4	<0.1	7.63		0.27	5.3	<0.02	7.6	0.815	50	<0.1	<0.05	<0.1		500	3.23	536	10	<0.1	<0.005	<0.02
BL001	5-Apr-05	0.01	<0.4	<0.2	7.3	<0.2	0.23	3.01	<0.03	4.2	0.102	9	<0.02	<0.02	0.09	>2420	124	1.19	212	30	<0.1	0.01	0.023
BL001	10-May-05	0.02	<0.4	<0.2	8.06	<0.2	0.18	3.09	<0.03	13.7	0.639	58	<0.02	<0.02	0.04	1410	340	1.73	394	13	<0.1	<0.01	0.013
BL001	21-Jun-05	0.02	0.5	<0.2	7.7	<0.2	0.3	4.46	<0.03	19.8	0.832	71	<0.02	<0.02	0.06	2420	440	2.18	464	12	<0.1	<0.01	0.014
BL001	12-Jul-05	<0.01	<0.4	<0.2	8.12	<0.2	0.18	4.73	<0.03	23.9	1.36	162	<0.02	<0.02	0.1	>2420	604	1.7	704	16	<0.1	<0.01	0.019
BL001	9-Aug-05	<0.01	<0.4	<0.2	8.35	<0.2	0.15	6.01	<0.03	40.9	1.88	218	<0.02	<0.02	<0.03	>2420	674	2.4	882	20	<0.1	<0.01	0.015
BL001	14-Sep-05	0.01	<0.4	<0.2	8.18	<0.2	0.13	3.91	<0.03	11.3	1.11	190	<0.02	<0.02	0.04	>2420	494	1.4	554	17	<0.1	<0.01	0.013
BL001	12-Oct-05	<0.01	<0.4	<0.2	7.68	<0.2	0.18	4.36	<0.03	15.2	0.595	89	<0.02	<0.02	<0.03	>2420	352	1.6	354	7	<0.1	<0.01	0.023
BL001	8-Nov-05	0.01	<0.4	<0.2	7.61	<0.2	0.09	3.94	<0.03	10.9	0.619	95	<0.02	<0.02	<0.03	>2420	360	1.4	304	<5	<0.1	<0.01	0.01
BL001	25-Apr-06	<0.005	<0.4	<0.2	7.68	<0.2	0.15		<0.0001		0.389	43	<0.0001		<0.01	>4840	340	1.79	368	10		0.002	<0.01
BL001	24-May-06	0.02	<1	<0.5	8.02	<0.5	0.15	1.8	<0.0001	24.2	0.74	45	<0.0001		0.01	>2420	392	2.12	476	6		0.003	<0.01
BL001	27-Jun-06	0.015	<0.4	<0.2	7.94	<0.2	0.09	4.1	<0.0001	25.9	1.41	192	<0.0001		0.02	9678	612	2.13	780	9		0.004	<0.01
BL001	25-Jul-06	0.009	<0.4	<0.2	8.15	<0.2	0.05	5.8	<0.0001	40.4	1.74	268	<0.0001		0.02	>2420	772	1.09	820	11		0.003	<0.01
BL001	29-Aug-06	0.009	<0.4	<0.2	8.22	<0.2	0.14	5.2	<0.0001	17.9	0.767	88	<0.0001		0.01	>2420	368	1.47	424	21		0.003	<0.01
BL001	27-Sep-06	0.011	<0.4	<0.2	7.68	<0.2	0.17	6.5	<0.0001	18.9	0.436	48	<0.0001		0.02	>2420	308	1.64	372	15		0.002	<0.01
BL001	24-Oct-06	0.015	<0.4	<0.2	7.21	<0.2	0.33	4.9	<0.0001	3	0.12	12	<0.0001		<0.01	>2420	236	1.28	268	14		0.003	0.01
BL001	28-Nov-06	0.023	<0.4	<0.2	7.57		0.15	3	<0.0001	7	0.37	40	0.002		<0.01	>2420	244	1.76	352	12		0.002	<0.01
BL001	27-Mar-07	0.013	<0.4	<0.2	7.23	<0.2	0.22		<0.0001		0.252	25	<0.0001		0.07	690	258	1.53	288	28		0.004	<0.01
BL001	25-Apr-07	0.02	<0.4	<0.2	7.78	<0.2	0.21		<0.0001		0.438	54	0.0006		0.01	>2420	442	2	484	47		0.003	0.01
BL001	28-May-07	0.025	<0.4	<0.2	7.62	<0.2	0.25		<0.0001		1.02	88	0.0003		0.02	>2420	560	2.8	622	51		0.005	0.01
BL001	25-Jun-07	<0.005	<0.4	<0.2	7.82	<0.2	0.15	6	<0.0001	36.9	1.19	332	<0.0001		<0.01	>2420	918	2.4	938	41		0.004	0.01

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Alkalinity	Aluminum	Ammonia as N	Barium	Beryllium	Boron	Bromide	Cadmium	Calcium	Chloride	Chromium	Cobalt	Conduc-tivity	Copper	E. coli	Fluoride	Hardness	Iron	Lead	Magnesium	Manganese	Molybdenum
BL003	22-May-03	95	2.7	<0.4	<0.1	<0.1	0.05	<0.2	<0.005	42.2	58	<0.02	<0.02	563	0.007		0.2	162	3.7	<0.1	12.7	0.07	<0.02
BL003	25-Jun-03	134	0.17	0.17	0.03	<0.008	0.11	<0.05	<0.005	83.2	48	<0.02	<0.007		<0.02		0.22	304	0.4	<0.01	23.4	0.086	<0.03
BL003	23-Jul-03	136	1.77	<0.04	0.043	<0.002	0.07	<0.05	<0.001	55	57	<0.006	<0.002		<0.006		0.23	202	1.98	0.05	14.4	0.092	<0.01
BL003	20-Aug-03	134	0.75	<0.04	0.03	<0.002	0.08	<0.05	<0.001	59.9	52	<0.006	<0.002		<0.006		0.21	194	0.88	<0.02	10.8	0.045	<0.01
BL003	24-Sep-03	116	0.27	<0.04	0.024	<0.002	<0.02	<0.2	<0.001	43.8	39	<0.006	<0.002		<0.006		0.2	155	0.33	0.03	11.2	0.017	<0.01
BL003	22-Oct-03	98	1.5	<0.04	0.045	<0.002	<0.02	<0.2	<0.001	45.7	25	<0.006	<0.002		0.008		0.2	173	2.39	<0.02	14.3	0.07	<0.01
BL003	19-Nov-03	100	3.65	<0.04	0.045	<0.002	<0.02	<0.2	<0.001	48.7	26	<0.006	<0.002	439	0.008		0.12	177	4.15	<0.02	13.5	0.079	<0.01
BL003	24-Mar-04	66	2.11	0.11	0.03	<0.02	<0.05	<0.2	<0.005	47.3	56	<0.005	<0.005	459	<0.005		0.15	163	2.58	<0.02	11.1	0.029	<0.005
BL003	20-Apr-04	93	4.7	<0.4	0.054	<0.0007	0.13	<0.2	<0.0005	51	37	0.0042	0.0021	415	0.0088		0.2	181	6.6	0.0045	13	0.096	0.0008
BL003	19-May-04	143	3.12	0.06	0.05	<0.02	0.06	<0.2	<0.005	70.3	43	<0.005	<0.005	590	0.012		0.21	236	4.42	<0.02	14.9	0.194	<0.005
BL003	29-Jun-04	145	1.39	<0.04	0.05	<0.02	0.05	<0.2	<0.005	84.6	41	<0.005	<0.005	660	<0.005		0.19	277	1.65	<0.02	16	0.075	0.023
BL003	28-Jul-04	138	0.6	<0.04	0.03	<0.02	0.06	<0.2	<0.005	61.4	42	<0.005	<0.005	570	<0.005		0.2	197	1	<0.02	10.8	0.048	<0.005
BL003	24-Aug-04	136	1.96	<0.04	0.05	<0.02	<0.05	<0.2	<0.005	54.5	16	<0.005	<0.005	411	0.006		0.24	201	2.39	<0.02	15.8	0.157	<0.005
BL003	14-Sep-04	77	1.58	<0.04	0.04	<0.02	<0.05	<0.2	<0.005	34	11	<0.005	<0.005	280	0.006		0.2	118	1.97	<0.02	8	0.073	<0.005
BL003	13-Oct-04	164	0.43	<0.04	0.05	<0.02	<0.05	<0.2	<0.005	118	41	<0.005	<0.005	778	<0.005		0.2	379	0.74	<0.02	20.5	0.052	<0.005
BL003	5-Apr-05	39	6.05	<0.07	0.038	<0.001	<0.03	<0.2	<0.002	16.4	19	<0.009	<0.003	190	<0.004	126	0.1	64	4.58	<0.01	5.56	0.044	<0.003
BL003	10-May-05	141	2.27	<0.07	0.053	<0.001	0.05	<0.2	<0.002	98.2	68	<0.009	<0.003	824	<0.004	70	0.2	323	2.65	<0.01	18.9	0.13	<0.003
BL003	21-Jun-05	132	2.17	0.1	0.062	<0.001	0.08	<0.2	<0.002	83.4	55	<0.009	<0.003	674	0.007	222	0.19	89	2.26	<0.01	16.6	0.163	<0.003
BL003	12-Jul-05	140	1.32	0.09	0.04	<0.001	0.1	<0.2	<0.002	71.8	52	<0.009	<0.003	639	<0.004	17	0.21	248	1.23	<0.01	16.6	0.068	<0.003
BL003	9-Aug-05	123	0.54	<0.7	0.034	<0.001	0.07	<0.2	<0.002	55.5	38	<0.009	<0.003	489	<0.004	35	0.18	200	0.6	<0.01	14.8	0.024	0.007
BL003	14-Sep-05	70	0.17	0.05	0.05	<0.001	0.09	<0.2	<0.002	94.2	40	<0.009	<0.003	768	0.006	6	0.14	309	0.2	<0.01	17.9	0.019	<0.003
BL003	12-Oct-05	85	1.09	<0.7	0.045	<0.001	0.06	<0.2	<0.002	84.8	44	<0.009	<0.003	657	0.005	52	0.09	276	1.33	<0.01	15.8	0.035	<0.003
BL003	8-Nov-05	94	1.05	<0.7	0.037	<0.001	<0.03	<0.2	<0.002	64	28	<0.009	<0.003	529	<0.004	62	0.18	221	0.98	<0.01	15	0.067	<0.003
BL003	25-Apr-06	119	0.46	<0.04	0.04	<0.001	0.05	<0.2	<0.0001		63	0.002	0.0007	670	0.003	30	0.18		0.91	0.002		0.09	<0.005
BL003	24-May-06	136	0.3	0.07	0.05	<0.001	0.05	<0.5	<0.0001	103	114	0.003	0.0006	972	0.002	50	<0.2	339	0.67	0.002	19.7	0.12	<0.005
BL003	27-Jun-06	131	0.34	0.19	0.04	<0.001	0.05	<0.2	<0.0001	67.9	56	0.003	0.0005	615	0.001	25	0.16	230	0.64	0.001	14.9	0.12	<0.005
BL003	25-Jul-06	120	0.21	0.08	0.02	<0.001	0.04	<0.2	<0.0001	58	51	<0.001	0.0002	521	0.001	12	0.15	203	0.25	<0.001	14.3	0.03	<0.005
BL003	29-Aug-06	119	0.25	0.06	0.03	<0.001	0.05	<0.2	<0.0001	54.3	56	0.001	<0.0002	564	0.001	83	0.17	190	0.28	<0.001	13.3	0.04	<0.005
BL003	27-Sep-06	108	0.63	0.06	0.03	<0.001	0.06	<0.2	<0.0001	72.4	55	0.002	0.0004	309	0.004	24	0.2	301	0.65	<0.001	17.3	0.05	<0.005
BL003	24-Oct-06	71	1.47	<0.04	0.03	<0.001	0.02	<0.2	<0.0001	32.2	10	0.001	0.0006	278	0.004	225	0.11	106	1.34	0.002	9.04	0.02	<0.005
BL003	28-Nov-06	105	0.52	0.1	0.03	<0.001	0.03		<0.0001	64.8	21	0.002	0.0005	488	0.003	102	<0.08	216	0.86	<0.001	13.3	0.05	<0.005
BL003	27-Mar-07	88	1.25	0.11	0.03	<0.001	0.03	<0.2	<0.0001		55	0.003	<0.0002	459	0.004	46	0.14		1.3	0.001		0.02	<0.005
BL003	25-Apr-07	115	0.65	0.11	0.04	<0.001	0.05	<0.2	<0.0001		74	0.003	0.0009	730	0.003	84	0.17		1.16	0.002		0.12	<0.005
BL003	28-May-07	144	0.44	0.07	0.06	<0.001	0.05	<0.2	<0.0001		68	0.002	0.0006	822	0.002	43	0.19		0.7	0.002		0.11	<0.005
BL003	25-Jun-07	130	0.5	0.06	0.07	<0.001	0.17	<0.2	<0.0001	69.5	48	0.003	0.0012	600	0.005	24	0.17	251	0.85	0.001	18.9	0.32	<0.005

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Nickel	Nitrate as N	Nitrite as N	pH	Phosphate	Phosphorus (Total)	Potassium	Silver	Sodium	Strontium	Sulphate	Thallium	Tin	Titanium	Total Coliform	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Solids	Total Suspended Solid	Uranium	Vanadium	Zinc
BL003	22-May-03	<0.09	0.5	<0.2	7.4	<0.2	0.16	3.63	<0.02	41.5	1.3	86	<0.1	<0.03	<0.7		457	2.3	496	39	<1.0	<0.03	<0.1
BL003	25-Jun-03	<0.05	<0.1	<0.05	7.53	<0.05	0.11	2.7	<0.02	70.4	3.23	90	<0.1	<0.05	<0.07		472	1.9	508	36	<0.1	<0.02	<0.2
BL003	23-Jul-03	<0.02	<0.1	<0.05	7.75	<0.05	0.16	3.4	<0.005	30.8	1.26	112	<0.1	<0.05	<0.05		521	2.2	536	15	<0.1	<0.006	<0.06
BL003	20-Aug-03	<0.02	<0.1	<0.05	7.65	<0.05	0.18	4.1	<0.005	32.3	1.19	76	<0.1	<0.05	<0.05		460	1.1	464	<5	<0.1	<0.006	0.09
BL003	24-Sep-03	<0.02	<0.2	<0.05	8.47	<0.2	0.07	2.8	<0.005	26.3	0.69	47	<0.1	<0.05	<0.05		539	0.48	544	5	<0.1	<0.006	<0.06
BL003	22-Oct-03	<0.02	<0.4	<0.2	7.35	<0.2	0.19	7.2	<0.005	16.6	0.51	67	<0.1	<0.05	<0.05		348	1.31	360	12	<0.1	<0.006	<0.06
BL003	19-Nov-03	<0.02	<0.4	<0.2	7.6	<0.2	0.22	4.9	<0.005	18.3	0.74	79	<0.1	<0.05	0.05		364	1.12	384	20	<0.1	0.006	<0.06
BL003	24-Mar-04	<0.005	0.5	<0.2	7.61	<0.2	0.12	2.4	<0.02	30.9	0.94	63	<0.1	<0.05	<0.1		344	1	348	15	<0.1	<0.005	<0.02
BL003	20-Apr-04	0.016	<0.4	<0.2	7.54	<0.2	0.23	3.8	<0.0003	24		66	<0.0005	0.0011	0.092		380	1.53	448	40		0.008	0.047
BL003	19-May-04	<0.005	0.5	<0.2	7.72	<0.2	0.3	3.6	<0.02	28.6	1.6	90	<0.1	<0.05	<0.1		408	0.84	520	33	<0.1	0.009	0.02
BL003	29-Jun-04	<0.005	<0.4	<0.2	7.99	<0.2	0.13	2.7	<0.02	24.2	1.82	132	<0.1	<0.05	<0.1		496	1.19	580	<5	<0.1	<0.005	<0.02
BL003	28-Jul-04	<0.005	<0.4	<0.2	7.78	<0.2	0.25	2.6	<0.02	24.6	1.35	89	<0.1	<0.05	<0.1		372	1.21	464	10	<0.1	<0.005	<0.02
BL003	24-Aug-04	<0.005	<0.4	<0.2	7.9	<0.2	0.2	4.7	<0.02	13.5	0.745	53	<0.1	<0.05	<0.1		344	2.2	480	16	<0.1	<0.005	<0.02
BL003	14-Sep-04	0.017	<0.4	<0.2	7.33	<0.2	0.23	4.2	<0.02	7.9	0.565	41	<0.1	<0.05	<0.1		244	0.7	284	25	<0.1	<0.005	<0.02
BL003	13-Oct-04	0.011	1	<0.1	7.88		0.1	4	<0.02	20.6	2.92	181	<0.1	<0.05	<0.1		616	1.18	708	8	<0.1	<0.005	<0.02
BL003	5-Apr-05	0.01	<0.4	<0.2	7.33	<0.2	0.18	3.07	<0.03	12.8	0.3	18	<0.02	<0.02	0.08	1990	156	0.79	248	18	<0.1	0.01	0.028
BL003	10-May-05	<0.01	<0.4	<0.2	7.84	<0.2	0.13	3.23	<0.03	35.7	2.64	188	<0.02	<0.02	0.04	326	556	0.81	644	44	<0.1	<0.01	0.013
BL003	21-Jun-05	<0.01	<0.4	<0.2	7.63	<0.2	0.26	4.73	<0.03	35.9	1.86	127	<0.02	<0.02	0.03	687	500	1.65	556	20	<0.1	<0.01	0.009
BL003	12-Jul-05	<0.01	<0.4	<0.2	7.97	<0.2	0.16	2.81	<0.03	28.8	1.53	107	<0.02	<0.02	<0.03	>2420	468	0.97	556	21	<0.1	<0.01	0.01
BL003	9-Aug-05	<0.01	<0.4	<0.2	8.28	<0.2	0.11	1.97	<0.03	22.3	1.07	66	<0.02	<0.02	<0.03	>2420	294	0.9	414	6	<0.1	<0.01	0.006
BL003	14-Sep-05	<0.01	<0.4	<0.2	8.23	<0.2	<0.05	3	<0.03	23.4	2.06	260	<0.02	<0.02	<0.03	1410	572	0.8	620	<5	<0.1	<0.01	0.005
BL003	12-Oct-05	<0.01	<0.4	<0.2	7.48	<0.2	0.17	4.29	<0.03	27.3	1.62	183	<0.02	<0.02	<0.03	>2420	516	1.2	496	<5	<0.1	<0.01	0.017
BL003	8-Nov-05	<0.01	<0.4	<0.2	7.62	<0.2	0.08	4.33	<0.03	20.8	1.17	132	<0.02	<0.02	<0.03	>2420	392	1.1	368	5	<0.1	<0.01	0.008
BL003	25-Apr-06	0.012	<0.4	<0.2	7.84	<0.2	0.16		<0.0001		1.44	125	<0.0001		0.002	551	<40	1.62	528	31		0.002	<0.01
BL003	24-May-06	0.008	<1	<0.5	8.04	<0.5	0.14	3.1	<0.0001	58.2	2.31	190	<0.0001		<0.01	1300	680	1.5	848	30		0.003	<0.01
BL003	27-Jun-06	<0.005	<0.4	<0.2	7.68	<0.2	0.12	2.5	<0.0001	27.5	1.18	86	<0.0001		<0.01	2595	380	1.18	492	16		0.003	<0.01
BL003	25-Jul-06	<0.005	<0.4	<0.2	8.14	<0.2	0.09	2.3	<0.0001	40.2	0.782	60	<0.0001		<0.01	>2420	340	0.72	376	11		0.003	<0.01
BL003	29-Aug-06	<0.005	<0.4	<0.2	7.87	<0.2	0.09	3.9	<0.0001	40.6	0.742	76	<0.0001		<0.01	>2420	368	0.9	384	8		0.002	<0.01
BL003	27-Sep-06	0.007	<0.4	<0.2	7.56	<0.2	0.16	6.5	<0.0001	38.6	1.17	108	<0.0001		0.03	>2420	436	1.42	504	6		0.002	<0.01
BL003	24-Oct-06	0.007	<0.4	<0.2	7.46	<0.2	0.28	4.8	<0.0001	9.4	0.563	44	<0.0001		<0.01	>2420	296	1.04	344	11		0.002	0.01
BL003	28-Nov-06	0.014	<0.4	<0.2	7.65		0.11	3.4	<0.0001	13.2	1.12	100	0.002		<0.01	>2420	392	1.34	420	20		0.002	<0.01
BL003	27-Mar-07	0.007	<0.4	<0.2	7.51	<0.2	0.17		<0.0001		0.714	54	<0.0001		0.07	774	354	1.31	380	12		0.004	<0.01
BL003	25-Apr-07	0.008	<0.4	<0.2	7.7	<0.2	0.15		<0.0001		1.47	120	0.0006		0.01	>2420	512	1.3	578	63		0.003	0.01
BL003	28-May-07	<0.005	<0.4	<0.2	7.73	<0.2	0.11		<0.0001		2.01	167	0.0003		0.01	>2420	660	1.3	694	<5		0.003	<0.01
BL003	25-Jun-07	0.016	<0.4	<0.2	7.94	<0.2	0.07	2.7	<0.0001	29.1	1.44	94	<0.0001		0.02	1990	445	0.8	450	13		0.005	<0.01

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Alkalinity	Aluminum	Ammonia as N	Barium	Beryllium	Boron	Bromide	Cadmium	Calcium	Chloride	Chromium	Cobalt	Conduc-tivity	Copper	E. coli	Fluoride	Hardness	Iron	Lead	Magnesium	Manganese	Molybdenum
FR001	22-May-03	113	1.7	<0.4	<0.1	<0.1	0.08	<0.2	<0.005	40.1	15	<0.02	<0.02	479	0.005		0.3	182	2.1	<0.1	18.7	0.06	<0.02
FR001	25-Jun-03	132	0.8	0.08	0.046	<0.008	0.16	<0.05	<0.005	102	16	<0.02	<0.007		<0.02		0.49	358	0.6	<0.01	27	0.053	<0.03
FR001	23-Jul-03	140	1.46	<0.04	0.061	<0.002	0.24	<0.05	<0.001	108	39	<0.006	<0.002		<0.006		0.63	458	0.94	<0.02	43.1	0.088	0.01
FR001	20-Aug-03	157	1.96	<0.04	0.064	<0.002	0.21	<0.05	<0.001	101	76	<0.006	<0.002		<0.006		0.54	369	1.61	<0.02	28.6	0.294	<0.01
FR001	24-Sep-03	134	0.4	<0.04	0.064	<0.002	0.16	<0.2	<0.001	245	26	<0.006	0.004		<0.006		0.5	780	0.45	<0.02	40.5	0.032	<0.01
FR001	22-Oct-03	169	0.13	0.07	0.058	<0.002	0.07	<0.2	<0.001	98.4	141	<0.006	<0.002		<0.006		0.3	338	0.84	<0.02	22.6	0.209	<0.01
FR001	19-Nov-03	122	3.42	<0.04	0.045	<0.002	<0.02	<0.2	<0.001	94.9	18	<0.006	0.002	684	<0.006		0.14	305	3.6	<0.02	16.5	0.051	<0.01
FR001	24-Mar-04	90	2.4	0.06	0.03	<0.02	0.08	<0.2	<0.005	97.9	29	<0.005	<0.005	620	<0.005		0.25	315	2.62	<0.02	17.2	0.025	<0.005
FR001	20-Apr-04	152	0.55	<0.4	0.041	<0.0007	0.24	<0.2	<0.0005	190	28	<0.0008	<0.0005	1110	0.0044		0.38	614	1.7	0.0012	34	0.045	0.0033
FR001	19-May-04	160	1.84	0.07	0.05	<0.02	0.18	<0.2	<0.005	104	34	<0.005	<0.005	899	0.01		0.53	427	2.01	<0.02	44.2	0.117	<0.005
FR001	29-Jun-04	128	0.67	<0.04	0.05	<0.02	0.15	<0.2	<0.005	102	17	<0.005	<0.005	834	<0.005		0.55	415	0.63	<0.02	39.3	0.035	<0.005
FR001	28-Jul-04	105	3.2	<0.04	0.05	<0.02	0.05	<0.2	<0.005	34.7	10	<0.005	<0.005	276	0.007		0.19	131	4.11	<0.02	10.9	0.102	<0.005
FR001	24-Aug-04	125	0.41	<0.04	0.06	<0.02	0.11	<0.2	<0.005	76	30	<0.005	<0.005	706	<0.005		0.47	330	0.34	<0.02	34.1	0.062	<0.005
FR001	14-Sep-04	103	2.15	<0.04	0.07	<0.02	0.16	<0.2	<0.005	92.1	11	<0.005	<0.005	772	<0.005		0.49	384	2.13	<0.02	37.6	0.076	0.007
FR001	13-Oct-04	90	1.83	<0.04	0.8	<0.02	0.2	<0.2	<0.005	126	14	<0.005	<0.005	1050	<0.005		0.66	527	1.31	<0.02	51.7	0.055	0.008
FR001	5-Apr-05	37	4.97	<0.07	0.033	<0.001	<0.03	<0.2	<0.002	11.8	14	<0.009	<0.003	146	<0.004	102	0.11	49	3.75	<0.01	4.7	0.036	<0.003
FR001	10-May-05	112	0.61	<0.07	0.045	<0.001	0.14	<0.2	<0.002	137	21	<0.009	<0.003	943	<0.004	18	0.44	495	0.43	<0.01	37	0.054	<0.003
FR001	21-Jun-05	132	1.27	0.07	0.065	<0.001	0.17	<0.2	<0.002	172	20	<0.009	<0.003	1050	<0.004	160	0.44	571	0.99	<0.01	34.5	0.051	<0.003
FR001	12-Jul-05	113	1.54	0.14	0.057	<0.001	0.08	<0.2	<0.002	75.5	12	0.01	<0.003	643	<0.004	687	0.56	306	2.19	<0.01	28.4	0.051	0.009
FR001	14-Sep-05	77	0.6	0.05	0.072	<0.001	0.2	<0.2	<0.002	123	7	<0.009	<0.003	907	0.005	299	0.49	498	0.57	<0.01	46.4	0.046	0.01
FR001	12-Oct-05	106	1.07	<0.07	0.06	<0.001	0.16	<0.2	<0.002	107	10	<0.009	<0.003	772	<0.004	99	0.56	423	1.08	<0.01	38	0.054	0.008
FR001	8-Nov-05	146	0.77	<0.07	0.043	<0.001	0.03	<0.2	<0.002	73.8	15	<0.009	<0.003	629	<0.004	2	0.51	291	0.63	<0.01	26	0.05	<0.003
FR001	25-Apr-06	159	0.32	<0.04	0.03	<0.001	0.11	<0.2	<0.0001		33	0.002	0.0004	662	<0.001	138	0.43		0.45	<0.001		0.04	<0.005
FR001	24-May-06	148	0.25	0.08	0.04	<0.001	0.2	<0.5	<0.0001	128	31	0.002	0.0004	1030	0.001	48	0.6	519	0.42	<0.001	48.7	0.08	<0.005
FR001	27-Jun-06	153	0.28	0.11	0.07	<0.001	0.24	<0.2	<0.0001	135	98	0.003	0.0004	1280	0.003	2190	0.55	523	0.4	<0.001	45.1	0.09	<0.005
FR001	25-Jul-06	159	0.26	0.26	0.09	<0.001	0.27	<0.2	<0.0001	249	58	0.002	0.0007	1510	0.002	>2420	0.56	869	0.47	<0.001	60.2	0.63	<0.005
FR001	29-Aug-06	145	0.46	0.04	0.07	<0.001	0.23	<0.2	<0.0001	135	61	0.001	0.0004	1150	0.003	1414	0.53	509	0.38	<0.001	41.9	0.05	<0.005
FR001	27-Sep-06	151	0.25	<0.04	0.05	<0.001	0.19	<0.2	<0.0001	142	18	0.001	0.0003	932	0.001	65	0.61	557	0.32	<0.001	49.3	0.07	0.006
FR001	24-Oct-06	87	0.73	<0.04	0.03	<0.001	0.06	<0.2	<0.0001	55.9	8	<0.001	0.0003	429	0.003	86	0.18	195	0.61	0.001	13.7	0.01	<0.005
FR001	28-Nov-06	178	0.14	0.09	0.16	<0.001	0.16		<0.0001	192	24	<0.001	0.0005	1230	0.005	19	<0.08	630	0.16	<0.001	36.7	0.03	<0.005
FR001	27-Mar-07	135	0.84	0.05	0.03	<0.001	0.09	<0.2	<0.0001		25	0.002	0.0004	798	0.002	2	0.26		1.09	<0.001		0.03	<0.005
FR001	25-Apr-07	141	0.85	0.08	0.04	<0.001	0.11	<0.2	<0.0001		31	0.003	0.0012	981	0.003	387	0.26		1.09	0.002		0.26	<0.005
FR001	28-May-07	158	0.5	0.05	0.04	<0.001	0.15	<0.2	<0.0001		16	<0.001	0.0004	639	0.001	365	0.39		0.42	<0.001		0.04	<0.005
FR001	25-Jun-07	146	0.18	0.03	0.04	<0.001	0.13	<0.2	<0.0001	75	14	<0.001	<0.0002	599	<0.001	206	0.36	290	0.14	<0.001	25	0.01	<0.005

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Nickel	Nitrate as N	Nitrite as N	pH	Phosphate	Phosphorus (Total)	Potassium	Silver	Sodium	Strontium	Sulphate	Thallium	Tin	Titanium	Total Coliform	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Solids	Total Suspended Solid	Uranium	Vanadium	Zinc
FR001	22-May-03	<0.09	<0.4	<0.2	7.57	<0.2	0.08	2.38	<0.02	10.4	2.3	106	<0.1	<0.3	<0.7		509	1.4	536	27	<1.0	<0.03	<0.1
FR001	25-Jun-03	<0.05	<0.1	<0.05	7.79	<0.05	0.04	2.7	<0.02	9.3	4.64	284	<0.1	<0.05	<0.07		920	0.9	936	16	<0.1	<0.02	<0.2
FR001	23-Jul-03	0.02	0.6	<0.05	7.83	<0.05	0.08	4.4	<0.005	24.8	5.84	371	<0.1	<0.05	<0.05		961	1.5	976	15	<0.1	<0.006	<0.06
FR001	20-Aug-03	<0.02	0.1	<0.05	7.43	<0.05	0.15	4	<0.005	41.5	5	262	<0.1	<0.05	<0.05		866	0.5	888	22	<0.1	<0.006	<0.06
FR001	24-Sep-03	<0.02	<0.4	<0.2	7.99	<0.2	0.04	4.1	<0.005	13.5	9.82	670	<0.1	<0.05	<0.05		1230	0.24	1250	13	<0.1	<0.006	<0.06
FR001	22-Oct-03	<0.02	<0.4	<0.2	7.5	<0.2	0.2	5.3	<0.005	87.9	3.27	169	<0.1	<0.05	<0.05		726	0.58	732	6	<0.1	<0.006	<0.06
FR001	19-Nov-03	<0.02	<0.4	<0.2	7.52	<0.2	0.22	4.8	<0.005	11.7	3.07	207	<0.1	<0.05	<0.05		585	0.79	624	40	<0.1	<0.006	<0.06
FR001	24-Mar-04	<0.005	<0.4	<0.2	7.88	<0.2	0.11	2.1	<0.02	15.3	3.15	176	<0.1	<0.05	<0.1		416	0.74	516	20	<0.1	<0.005	<0.02
FR001	20-Apr-04	0.0028	<0.4	<0.2	8.26	<0.2	0.03	2.5	<0.0003	14		428	<0.0005	0.001	0.011		840	0.27	884	8		0.0011	0.014
FR001	19-May-04	<0.005	0.6	<0.2	7.76	<0.2	0.13	3.8	<0.02	22.9	5.82	269	<0.1	<0.05	<0.1		668	0.52	762	29	<0.1	<0.005	<0.02
FR001	29-Jun-04	<0.005	<0.4	<0.2	7.89	<0.2	0.04	2.8	<0.02	8.8	5.61	301	<0.1	<0.05	<0.1		672	0.62	760	8	0.1	<0.005	<0.02
FR001	28-Jul-04	<0.005	<0.4	<0.2	7.49	<0.2	0.35	2.7	<0.02	8.5	0.754	21	<0.1	<0.05	<0.1		200	1.41	328	52	<0.1	<0.005	0.03
FR001	24-Aug-04	<0.005	<0.4	<0.2	7.72	<0.2	0.04	3.2	<0.02	23.6	4.03	196	<0.1	<0.05	<0.1		496	0.26	672	7	<0.1	<0.005	<0.02
FR001	14-Sep-04	<0.005	0.4	<0.2	7.77	<0.2	0.11	3.7	<0.02	6.8	4.66	286	<0.1	<0.05	<0.1		592	0.56	700	37	<0.1	<0.005	<0.02
FR001	13-Oct-04	<0.005	0.4	0.03	7.54		0.19	2.8	<0.02	7.1	7.04	463	<0.1	<0.05	<0.1		900	0.83	1120	29	<0.1	<0.005	<0.02
FR001	5-Apr-05	<0.01	<0.4	<0.2	7.5	<0.2	0.17	2.39	<0.03	<0.03	9.3	7	<0.02	<0.02	0.07	>2420	128	0.69	180	25	<0.1	<0.01	0.02
FR001	10-May-05	<0.01	<0.4	<0.2	8.71	<0.2	0.08	2.36	<0.03	10.7	6.47	388	<0.02	<0.02	<0.03	1300	668	0.31	742	9	<0.1	<0.01	0.005
FR001	21-Jun-05	<0.01	<0.4	<0.2	8.02	<0.2	0.07	2.69	<0.03	11.1	6.86	434	<0.02	<0.02	<0.03	>2420	580	0.2	960	21	<0.1	<0.01	0.004
FR001	12-Jul-05	<0.01	<0.4	<0.2	7.9	<0.2	0.06	2.42	<0.03	6.4	4.69	209	<0.02	<0.02	0.03	>2420	486	0.35	600	35	<0.1	<0.01	0.009
FR001	14-Sep-05	<0.01	<0.4	<0.2	7.8	<0.2	<0.05	2.93	<0.03	4.4	6.17	405	<0.02	<0.02	<0.03	>2420	738	0.2	768	10	<0.1	<0.01	0.007
FR001	12-Oct-05	<0.01	0.7	<0.2	7.76	<0.2	0.13	3.5	<0.03	7.3	4.48	294	<0.02	<0.02	<0.03	>2420	528	0.8	852	254	<0.1	<0.01	0.014
FR001	8-Nov-05	<0.01	<0.4	<0.2	7.61	<0.2	0.07	3.3	<0.03	10.2	3.87	167	<0.02	<0.02	<0.03	792	424	0.4	412	5	<0.1	<0.01	0.007
FR001	25-Apr-06	<0.005	<0.4	<0.2	8.16	<0.2	<0.05		<0.0001		3.76	144	<0.0001		<0.01	872	436	0.38	460	8		0.001	<0.01
FR001	24-May-06	<0.005	<1	<0.5	8.43	<0.5	0.08	3.2	<0.0001	18.1	7.14	388	<0.0001		<0.01	1733	800	0.23	960	6		0.002	<0.01
FR001	27-Jun-06	<0.005	<0.4	<0.2	7.66	<0.2	0.1	3	<0.0001	52.5	7.19	380	<0.0001		0.01	>9678	872	0.68	1100	8		0.002	0.01
FR001	25-Jul-06	0.007	<0.4	<0.2	7.69	<0.2	0.24	7.1	<0.0001	39.9	9.6	620	<0.0001		0.01	>2420	1190	1.26	1410	85		0.002	<0.01
FR001	29-Aug-06	<0.005	<0.4	<0.2	7.93	<0.2	0.06	4.7	<0.0001	51.1	6.37	380	<0.0001		0.02	>2420	828	0.53	896	7		0.002	0.04
FR001	27-Sep-06	<0.005	<0.4	<0.2	7.8	<0.2	0.11	5.2	<0.0001	13.3	5.6	329	<0.0001		0.01	>2420	688	0.55	860	6		0.001	<0.01
FR001	24-Oct-06	<0.005	<0.4	<0.2	7.51	<0.2	0.11	2.8	<0.0001	6.3	1.6	111	<0.0001		0.01	>2420	328	0.65	344	6		0.001	0.02
FR001	28-Nov-06	0.009	<0.4	<0.2	7.97		0.03	2.7	<0.0001	9.8	7.07	497	<0.0001		<0.01	1733	952	0.4	1010	16		<0.001	<0.01
FR001	27-Mar-07	<0.005	<0.4	<0.2	7.95	<0.2	0.08		<0.0001		3.62	238	<0.0001		0.05	582	504	0.65	508	28		0.004	<0.01
FR001	25-Apr-07	<0.005	<0.4	<0.2	7.73	<0.2	0.12		<0.0001		4.39	321	0.0007		0.02	>2420	778	0.9	796	59		0.002	0.01
FR001	28-May-07	<0.005	<0.4	<0.2	8.06	<0.2	0.06		<0.0001		3.73	156	0.0004		0.01	>2420	515	0.4	602	29		0.002	<0.01
FR001	25-Jun-07	<0.005	<0.4	<0.2	7.98	<0.2	<0.02	2.7	<0.0001	10.2	3.59	139	<0.0001		<0.01	>2420	411	0.3	430	<5		0.001	<0.01

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Alkalinity	Aluminum	Ammonia as N	Barium	Beryllium	Boron	Bromide	Cadmium	Calcium	Chloride	Chromium	Cobalt	Conduc-tivity	Copper	E. coli	Fluoride	Hardness	Iron	Lead	Magnesium	Manganese	Molybdenum
FR003	22-May-03	120	2.3	<0.4	<0.1	<0.1	0.06	<0.2	<0.005	31.9	91	<0.02	<0.02	626	0.007		0.2	142	2.6	<0.1	14.4	0.08	<0.02
FR003	25-Jun-03	189	0.65	0.08	0.02	<0.008	<0.08	0.08	<0.005	28	120	<0.02	<0.007		<0.02		0.4	100	5.1	<0.01	7.4	0.82	<0.03
FR003	23-Jul-03	128	0.82	0.1	0.037	<0.002	0.07	<0.05	<0.001	45	116	<0.006	<0.002		<0.006		0.22	173	0.76	<0.02	14.1	0.229	<0.01
FR003	20-Aug-03	218	0.58	<0.04	0.044	<0.002	0.14	<0.05	<0.001	83.6	110	<0.006	<0.002		<0.006		0.35	282	0.3	<0.02	17.9	0.124	<0.01
FR003	24-Sep-03	143	0.27	<0.04	0.087	<0.002	<0.02	<0.2	<0.001	159	71	<0.006	0.003		<0.006		0.4	530	0.81	<0.02	32.3	0.255	<0.01
FR003	22-Oct-03	190	0.32	<0.04	0.051	<0.002	0.21	<0.2	<0.001	272	30	0.004	<0.002		<0.006		0.5	811	0.43	<0.02	31.9	0.046	<0.01
FR003	19-Nov-03	168	1.64	<0.04	0.051	<0.002	<0.02	<0.2	<0.001	102	67	<0.006	0.002	891	<0.006		0.19	338	2.04	<0.02	20.4	0.215	<0.01
FR003	24-Mar-04	148	0.81	0.09	0.04	<0.02	0.08	<0.2	<0.005	126	146	<0.005	<0.005	1130	<0.005		0.25	421	1.15	<0.02	26	0.127	<0.005
FR003	20-Apr-04	172	0.44	<0.4	0.05	<0.0007	0.21	<0.2	<0.0005	150	97	0.0009	<0.0005	1160	0.0038		0.36	502	1.4	0.0013	31	0.13	0.0021
FR003	19-May-04	193	1.39	0.11	0.06	<0.02	0.1	<0.2	<0.005	85.5	207	0.006	<0.005	1290	0.011		0.37	351	2.23	<0.02	33.5	0.362	<0.005
FR003	29-Jun-04	149	0.66	<0.04	0.05	<0.02	0.13	<0.2	<0.005	95.1	57	0.016	<0.005	926	<0.005		0.42	383	1.01	<0.02	35.4	0.115	0.005
FR003	28-Jul-04	131	0.99	<0.04	0.05	<0.02	0.06	<0.2	<0.005	46	158	<0.005	<0.005	838	<0.005		0.25	174	1.38	<0.02	14.5	0.099	<0.005
FR003	24-Aug-04	141	0.49	0.05	0.03	<0.02	<0.05	<0.2	<0.005	63.8	31	<0.005	<0.005	528	<0.005		0.25	214	0.79	<0.02	13.4	0.034	<0.005
FR003	14-Sep-04	188	0.51	<0.04	0.06	<0.02	0.11	<0.2	<0.005	79.9	153	<0.005	<0.005	1090	<0.005		0.4	296	0.86	<0.02	23.6	0.117	<0.005
FR003	13-Oct-04	184	0.07	<0.04	0.06	<0.02	0.15	<0.2	<0.005	114	49	<0.005	<0.005	998	<0.005		0.48	437	0.2	<0.02	37.2	0.041	<0.005
FR003	5-Apr-05	72	2.69	<0.07	0.031	<0.001	<0.03	<0.2	<0.002	24.1	82	<0.009	<0.003	451	<0.004	199	0.13	94	2.12	<0.01	8.1	0.038	<0.003
FR003	10-May-05	138	0.48	<0.07	0.051	<0.001	0.13	<0.2	<0.002	129	50	<0.009	<0.003	1020	<0.004	26	0.44	473	0.55	<0.01	36.7	0.103	0.004
FR003	21-Jun-05	146	0.66	0.2	0.079	<0.001	0.15	<0.2	<0.002	155	52	<0.009	<0.003	1080	0.004	186	0.42	526	0.69	<0.01	34.5	0.103	<0.003
FR003	12-Jul-05	158	0.58	0.14	0.053	<0.001	0.04	<0.2	<0.002	78.9	45	<0.009	<0.003	738	<0.004	93	0.5	307	0.66	<0.01	26.8	0.158	0.003
FR003	9-Aug-05	246	0.21	<0.7	0.039	<0.001	0.09	<0.2	<0.002	83.4	31	<0.009	<0.003	679	<0.004	1410	0.45	292	0.46	<0.01	20.4	0.048	<0.003
FR003	14-Sep-05	252	0.11	0.06	0.06	<0.001	0.12	<0.2	<0.002	116	84	<0.009	<0.003	1010	0.006	88	0.49	405	0.16	<0.01	28.1	0.04	<0.003
FR003	12-Oct-05	196	0.67	<0.7	0.062	<0.001	0.09	<0.2	<0.002	94	140	<0.009	<0.003	1030	0.004	770	0.28	340	0.9	<0.01	25.6	0.082	<0.003
FR003	8-Nov-05	203	0.49	<0.07	0.054	<0.001	<0.03	<0.2	<0.002	84.1	95	<0.009	<0.003	915	<0.004	50	0.47	322	0.51	<0.01	27.4	0.066	<0.003
FR003	25-Apr-06	189	0.33	<0.04	0.04	<0.001	0.08	<0.2	<0.0001		182	0.004	0.0003	1120	0.001	71	0.36		0.39	<0.001		0.07	<0.005
FR003	24-May-06	206	0.08	0.11	0.04	<0.001	0.07	<0.5	<0.0001	82	160	0.003	0.0002	1080	0.001	17	0.5	304	0.23	0.001	24.3	0.06	<0.005
FR003	27-Jun-06	179	0.29	0.15	0.06	<0.001	0.08	<0.2	<0.0001	72.1	166	0.005	0.0005	1040	0.002	1302	0.28	267	0.62	0.002	21.2	0.3	<0.005
FR003	25-Jul-06	246	0.13	0.08	0.05	<0.001	0.1	<0.2	<0.0001	102	102	0.003	0.0002	915	0.001	387	0.45	354	0.22	0.001	24.2	0.1	<0.005
FR003	29-Aug-06	109	0.35	0.05	0.05	<0.001	0.11	<0.2	0.0001	72.8	76	0.003	0.0004	779	0.004	>2420	0.26	269	0.57	0.002	21.2	0.06	<0.005
FR003	27-Sep-06	206	0.98	<0.04	0.06	<0.001	0.09	<0.2	<0.0001	92.9	156	0.005	0.0004	1050	0.003	56	0.38	339	0.83	0.001	26.2	0.05	<0.005
FR003	24-Oct-06	110	0.87	0.05	0.03	<0.001	0.06	<0.2	0.0001	47.1	38	0.002	0.0003	479	0.003	64	0.2	154	0.66	0.001	13.4	0.02	<0.005
FR003	28-Nov-06	195	0.14	0.08	0.05	<0.001	0.14		0.0001	204	41	0.001	0.0004	1230	0.001	13	<0.08	637	0.17	<0.001	31.2	0.04	<0.005
FR003	27-Mar-07	141	0.97	0.06	0.04	<0.001	0.07	<0.2	<0.0001		138	0.003	<0.0002	982	0.002	4	0.25		0.8	0.001		0.04	<0.005
FR003	25-Apr-07	157	0.63	0.07	0.05	<0.001	0.09	<0.2	0.0002		111	0.003	0.0005	1110	0.003	72	0.28		0.58	0.001		0.11	<0.005
FR003	28-May-07	201	0.1	0.1	0.05	<0.001	0.13	<0.2	<0.0001		77	0.002	0.0003	995	0.001	42	0.38		0.17	<0.001		0.14	<0.005
FR003	25-Jun-07	185	0.07	0.06	0.04	<0.001	0.13	<0.2	<0.0001	95.1	73	0.002	0.0002	889	0.001	1410	0.4	381	0.13	<0.001	34.9	0.07	<0.005

TABLE 2.7.6
NPCA SURFACE WATER QUALITY DATA 2003-2007: BLACK CREEK & FRENCHMAN'S CREEK
(Units are in mg/L except for: Conductivity=uS/cm, E. coli & total coliform=CFU/100 Ml)

Site ID	Date	Nickel	Nitrate as N	Nitrite as N	pH	Phosphate	Phosphorus (Total)	Potassium	Silver	Sodium	Strontium	Sulphate	Thallium	Tin	Titanium	Total Coliform	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Solids	Total Suspended Solid	Uranium	Vanadium	Zinc
FR003	22-May-03	<0.09	<0.4	<0.2	7.61	<0.2	0.1	2.83	<0.02	59	1.4	46	<0.1	<0.03	<0.7		843	1.5	872	29	<1.0	<0.03	<0.1
FR003	25-Jun-03	<0.05	0.2	<0.05	7.64	<0.05	0.42	1.4	<0.02	33.2	0.21	164	<0.1	<0.05	<0.07		955	0.8	960	5	<0.1	<0.02	<0.2
FR003	23-Jul-03	<0.02	0.1	<0.05	7.6	0.14	0.23	3.4	<0.005	64.1	1.83	74	<0.1	<0.05	<0.05		519	1.8	532	13	<0.1	<0.006	<0.06
FR003	20-Aug-03	<0.02	0.7	<0.05	7.44	<0.05	0.11	4.4	<0.005	61.5	2.23	109	<0.1	<0.05	<0.05		706	0.8	712	6	<0.1	<0.006	<0.06
FR003	24-Sep-03	<0.02	<0.4	<0.2	7.85	<0.2	0.31	5.4	<0.005	50.2	6.19	396	<0.1	<0.05	<0.05		971	1.23	996	25	<0.1	<0.006	<0.06
FR003	22-Oct-03	<0.02	<0.4	<0.2	7.87	<0.2	0.04	3.7	<0.005	14.1	9.08	714	<0.1	<0.05	<0.05		1390	0.35	1400	8	<0.1	<0.006	<0.06
FR003	19-Nov-03	<0.02	<0.4	<0.2	7.63	<0.2	0.15	4.1	<0.005	45	3.44	194	<0.1	<0.05	<0.05		633	0.68	664	31	<0.1	<0.006	<0.06
FR003	24-Mar-04	<0.005	<0.4	<0.2	7.82	<0.2	0.06	2.2	<0.02	74.3	4.03	202	<0.1	<0.05	<0.1		700	0.7	776	14	<0.1	<0.005	<0.02
FR003	20-Apr-04	0.003	<0.4	<0.2	7.97	<0.2	0.05	2.6	<0.0003	59		297	<0.0005	0.0011	0.009		812	0.33	832	12		<0.045	0.017
FR003	19-May-04	<0.005	1	<0.2	7.69	<0.2	0.14	3.1	<0.02	104	4.15	160	<0.1	<0.05	<0.1		748	0.82	940	48	<0.1	<0.005	0.04
FR003	29-Jun-04	<0.005	0.6	<0.2	7.8	<0.2	0.06	2.5	<0.02	29.7	4.88	253	<0.1	<0.05	<0.1		664	1.34	832	20	<0.1	<0.005	0.04
FR003	28-Jul-04	<0.005	<0.4	<0.2	7.62	<0.2	0.22	2.9	<0.02	81.1	1.53	46	<0.1	<0.05	<0.1		452	1.37	588	25	<0.1	<0.005	0.02
FR003	24-Aug-04	<0.005	<0.4	<0.2	7.97	<0.2	0.15	3.8	<0.02	26.5	1.44	83	<0.1	<0.05	<0.1		356	1.5	532	9	<0.1	<0.005	<0.02
FR003	14-Sep-04	<0.005	0.7	<0.2	7.42	<0.2	0.09	4	<0.02	83.6	2.68	129	<0.1	<0.05	<0.1		688	0.56	716	26	<0.1	<0.005	0.04
FR003	13-Oct-04	<0.005	0.4	<0.02	7.61		0.1	2.9	<0.02	27.2	4.66	278	<0.1	<0.05	<0.1		748	0.42	868	<5	<0.1	<0.005	0.03
FR003	5-Apr-05	<0.01	<0.4	<0.2	7.72	<0.2	0.13	2.29	<0.03	45.5	0.651	21	<0.02	<0.02	0.04	1990	236	0.61	324	21	<0.1	<0.01	0.021
FR003	10-May-05	<0.01	<0.4	<0.2	8.08	<0.2	0.08	2.28	<0.03	25.1	6.13	353	<0.02	<0.02	<0.03	435	688	0.37	774	10	<0.1	<0.01	0.01
FR003	21-Jun-05	<0.01	<0.4	<0.2	7.83	<0.2	0.09	2.68	<0.03	30.2	6.28	372	<0.02	<0.02	<0.03	>2420	840	0.18	930	12	<0.1	<0.01	0.012
FR003	12-Jul-05	<0.01	<0.4	<0.2	7.59	<0.2	0.08	2.57	<0.03	23.8	3.83	164	<0.02	<0.02	<0.03	>2420	484	0.38	586	13	<0.1	<0.01	0.033
FR003	9-Aug-05	<0.01	<0.4	<0.2	7.66	<0.2	0.06	3.19	<0.03	17.7	2.32	75	<0.02	<0.02	<0.03	>2420	414	0.5	544	8	<0.1	<0.01	0.057
FR003	14-Sep-05	<0.01	0.5	<0.2	7.62	<0.2	<0.05	3.79	<0.03	46.4	3.47	146	<0.02	<0.02	<0.03	>2420	668	0.2	696	<5	<0.1	<0.01	0.061
FR003	12-Oct-05	<0.01	0.7	<0.2	7.62	<0.2	0.13	3.81	<0.03	77.8	2.81	135	<0.02	<0.02	<0.03	>2420	644	0.6	648	6	<0.1	<0.01	0.036
FR003	8-Nov-05	<0.01	<0.4	<0.2	7.71	<0.2	<0.05	3.78	<0.03	62.4	3.36	137	<0.02	<0.02	<0.03	1120	240	0.46	632	6	<0.1	<0.01	0.02
FR003	25-Apr-06	<0.005	<0.4	<0.2	8.11	<0.2	<0.05		<0.0001		3.43	112	<0.0001		0.01	1540	660	0.29	676	15		0.001	<0.01
FR003	24-May-06	<0.005	<1	<0.5	7.66	<0.5	0.06	2.6	<0.0001	77.2	2.92	103	<0.0001		<0.01	816	668	0.16	732	6		0.002	0.03
FR003	27-Jun-06	<0.005	<0.4	<0.2	7.61	<0.2	0.12	3.6	<0.0001	83.1	2.51	83	<0.0001		0.01	>9678	600	1.09	748	19		0.002	0.02
FR003	25-Jul-06	<0.005	0.6	<0.2	7.77	<0.2	<0.05	4.2	<0.0001	76.1	2.27	77	<0.0001		<0.01	>2420	576	0.42	604	8		0.002	0.02
FR003	29-Aug-06	<0.005	<0.4	<0.2	7.91	<0.2	0.09	3.8	<0.0001	56.1	3.08	164	<0.0001		<0.01	>2420	516	0.62	572	19		0.002	0.02
FR003	27-Sep-06	<0.005	0.4	<0.2	7.59	<0.2	0.11	4.9	<0.0001	90.4	2.41	92	<0.0001		0.05	>2420	740	0.78	712	6		0.003	0.03
FR003	24-Oct-06	<0.005	<0.4	<0.2	7.71	<0.2	0.12	3.2	<0.0001	28.9	1.21	70	<0.0001		0.02	>2420	352	0.67	340	8		0.002	0.01
FR003	28-Nov-06	0.009	<0.4	<0.2	7.94		0.04	2.4	<0.0001	21.6	6.6	430	<0.0001		<0.01	>2420	812	0.39	990	8		<0.001	<0.01
FR003	27-Mar-07	<0.005	<0.4	<0.2	7.93	<0.2	0.07		<0.0001		2.91	168	<0.0001		0.05	449	598	0.62	624	18		0.003	0.01
FR003	25-Apr-07	<0.005	<0.4	<0.2	7.75	<0.2	0.05		<0.0001		3.89	229	0.0005		0.02	>2420	688	0.7	684	21		0.002	0.02
FR003	28-May-07	<0.005	<0.4	<0.2	7.81	<0.2	0.02		<0.0001		4.54	191	0.0003		<0.01	>2420	725	0.4	686	<5		0.001	<0.01
FR003	25-Jun-07	<0.005	<0.4	<0.2	7.87	<0.2	<0.02	2.7	<0.0001	43.9	3.48	164	<0.0001		<0.01	>2420	590	0.5	612	<5		0.002	<0.01

A review of the NPCA water quality grab samples was conduced and several observations can be made regarding the data:

Black Creek

- Consistently high E. coli readings in the Black Creek at Station BL001, peaking with the January 2006 reading of 2908 CFU/100 ml, higher than the Provincial Water Quality Objective of 100 CFU/100 ml (MOE 1999).

- High E. coli readings (100-200 CFU/100 ml) at Station BL003, over the PWQO of 100 CFU/100 ml in four samples out of 20 (20%).

- Consistently elevated Total Phosphorous (TP) levels (over 10 x the Provincial Water Quality Objective, or PWQO of 0.03 mg/ℓ) at Station BL001 and BL003.

- Zinc concentrations meeting or exceeding the PWQO of 0.020 mg/ℓ were taken at BL001 four times over the sampling duration (2003-2007), and four times at BL003.

- Stations BL001 and BL003 routinely recorded Iron concentrations above the PQO of 0.3 mg/ℓ.

Frenchmans Creek

- Extremely high E. coli readings (>1000) at Frenchman's Creek in summer 2006 (June, July, August) at Station FR001 and FR003, over the PWQO of 100 CFU/100 ml.

- Consistently elevated Total Phosphorous (TP) levels (over 10 x the Provincial Water Quality Objective, or PWQO of 0.03 mg/ℓ) at Station FR001 and FR003.

- In addition to the routine exceedences of the PWQO for Total Phosphorus, there were notably high readings at Station FR003 in June, July, and September 2003 (0.42, 0.23, and 0.31 mg/ℓ respectively). This magnitude of concentration was not subsequently recorded in the 2004-2007 readings.

- Zinc concentrations meeting or exceeding the PWQO of 0.020 mg/ℓ were taken at FR001 seventeen times over the sampling duration (2003-2007).

- The highest zinc concentrations were recorded in July and August 2006 at FR003, reaching 0.061 mg/ℓ or 3 times the PWQO of 0.020 mg/ℓ.

- Stations FR001 and FR003 routinely recorded Iron concentrations above the PWQO of 0.3 mg/ℓ

- Station FR001 recorded Boron concentrations exceeding the PWQO level of 0.2 mg/ℓ June to September 2003, and again from June to August 2006.

2.7.3.3 NPCA Provincial Groundwater Monitoring Network (PGMN)

The NPCA is working in partnership with the Ministry of Environment to monitor the quality and quantity of groundwater (as well as hourly reporting of groundwater levels) on selected sites. There is one monitoring site in the study area at the Onondaga Escarpment (Well ID #W0000289, shown on Figure 20), and another monitoring site adjacent to the study area in the City of Niagara Falls (Well ID #W0000290, shown on Figure 20). As described previously, the water level hydrograph shows seasonal variations of up to two metres. The lowest water levels occur later on in the summer with recovery through the fall and early winter. The two metre seasonal variation would be greater than the majority of hydraulic gradients within the local to intermediate flow system setting. The chemical results indicate slightly mineralized water.

2.7.3.4 Mass Balance Modelling

A mass balance model has been developed in order to determine the impacts to water quality which would result from the proposed future development. This model has been based upon a spreadsheet analytical technique in order to obtain an estimate of annual loading from non-point sources for selected water quality parameters. While this information provides utility as a comparative tool for assessing impacts to in-stream water quality, which would be associated with proposed development and land use changes, the analyses are intended to provide a planning level estimate of the various pollutants and their sources. Instream concentrations and lethal levels of toxicity are not determined as part of this process.

The pollutants which have been evaluated have been based upon the following general and typical water quality indicators:

- Total Phosphorus
- Total Nitrogen
- Fecal Coliforms
- Total Suspended Solids
- Copper

The analytical approach is based upon the Event Mean Concentration (EMC) for each constituent and land use category. Typical annual rainfall values for the geographic area are combined with runoff coefficients based upon the prevailing soil types in order to obtain annual runoff volumes. The contaminant loading for existing land use has been summarized in Table 2.7.1 and for future land use without stormwater management has been compiled in Table 2.7.2. The results (ref. Table 2.7.3) indicate an increase in pollutant loading due to increased imperviousness (ref. Appendix ‘SW-C’, for details).

TABLE 2.7.1 SUMMARY OF ANNUAL CONTAMINANT LOADING (KG)[1] EXISTING LAND USE					
Watershed	**F.Col[2]**	**TP**	**TSS**	**Cu**	**TKN**
Black Creek	1.13E+11	7.12E-01	5.63E+02	1.51E-02	7.12E-01
Beaver Creek	1.46E+11	7.22E-01	5.57E+02	1.96E-02	7.22E-01
Miller Creek	6.28E+10	5.89E-01	4.83E+02	9.12E-03	5.89E-01
Baker Creek	4.65E+10	2.75E-01	2.40E+02	1.11E-02	2.75E-01
Kraft Drain	1.92E+11	4.81E-01	3.82E+02	4.03E-02	4.81E-01
Bertie Bay Drain / Hollister Drain	5.08E+11	1.08E+00	7.08E+02	8.98E-02	1.08E+00
Six Mile Creek F.E.	2.86E+11	6.79E-01	4.69E+02	4.05E-02	6.79E-01
Niagara River # 16	2.11E+11	7.01E-01	5.13E+02	2.89E-02	7.01E-01
Niagara River # 19	1.89E+11	4.75E-01	3.42E+02	2.86E-02	4.75E-01
Niagara River # 20	6.45E+11	8.03E-01	4.18E+02	8.89E-02	8.03E-01
Niagara River # 21	2.52E+11	4.04E-01	2.60E+02	3.85E-02	4.04E-01
Niagara River # 22	3.31E+11	4.84E-01	2.92E+02	4.86E-02	4.84E-01
Fort Erie	1.34E+12	1.63E+00	8.21E+02	1.83E-01	1.63E+00
Lake Shore	1.20E+12	1.46E+00	7.48E+02	1.64E-01	1.46E+00
Lake Erie	3.31E+11	4.84E-01	2.92E+02	4.86E-02	4.84E-01

[1] Annual Contaminant Loading values have been determined using the tables in Appendix ‘SW-C’
[2] Fecal Coliform Annual Contaminant Loading is specified in Counts/Yr

2.8 Rural Point and Non-Point Source Pollution

Importance:

- The impacts of agriculture on water quality are considered to be quite widespread and varying throughout the various watershed areas. There is a general lack of information on the significance of the amount and impact rural non-point source pollution

2.8.1 Background Information Collection

- A sample of a rural survey from a previous watershed plan was provided by NPCA, as well as the results of the 2005-2006 rural landowners’ survey for Fort Erie (ref. Appendix ‘E’).
- Digital and hardcopy historic mapping in the study area, for locating potential point source pollutants

2.8.2 Work Activities

- The limits of the existing mass balance analysis have been reviewed. Several point sources of pollution have been identified through a review of the available data, primarily historic and current topographic and aerial mapping. A visual comparison of the historic map editions from 1936 to 1990 was completed.
- Complemented by the landowner’s survey (mapping) and the NWQPS, an updated inventory has been prepared which documents potential sources of non-point and point source contamination.

2.8.3 Findings

The rural landowner survey results numbered 4 responses for the Town of Fort Erie and 8 responses for the City of Port Colborne. This was from a distribution of 31 and 53 surveys in the Town and City respectively. The top 4 concerns regarding their lands, from all respondents in the Niagara Peninsula, were: Government interference, erosion, water quality, and access to irrigation.

In terms of point and non-point source pollutants, two of the Fort Erie respondents considered "nitrate, phosphate, and bacteria levels" in surface water a "moderate problem", and in groundwater a "slight problem". The presence of pesticides in surface and groundwater and septic tank seepage, were considered a "serious problem" by 2 of the 4 Fort Erie respondents. Tillage, seeding, and crop rotation were the only BMP's listed as practiced. The survey did not ask respondents to locate or identify any point source pollutants.

In terms of point source pollutants, a number of potential sources have been identified, including:

- Sewage treatment plants (active and decommissioned)
- Sewage pumping stations
- Landfills (active and decommissioned)
- Auto wreckers
- Quarries
- Industrial areas
- Butcher/rendering operations
- Combined sewer overflows

These locations are identified on the Figures included in Section 6.

Typical non-point sources of pollution identified include: urban development, farming/agricultural livestock and pesticide and fertilizer use, golf course fertilizer and pesticide use, roads and railroads.

2.9 Lake Erie Shoreline

2.9.1 Background Information Collection

The following information has been collected and reviewed:

- Lake Erie Shoreline Management Plan (Sandwell/Philpott, 1999)
- Regional Municipality of Niagara aerial photography
- NPCA Shoreline, wave uprush and dynamic layers in GIS
- Assessment of Coastal Hazards, Erie Beach Development, Fort Erie (Shoreplan, 2003)
- Great Lakes Flood Levels and Water Related Hazards, Provincial Shoreline Management Program (MNR 1989)

The Lake Erie Shoreline Management Plan describes the study area as being located within a part of reach 9-2, reach 9-3 and reaches 10-1 to 10-10. The locations of these reaches are presented in Appendix 'WC-B'. Each of the reaches is described and categorized as to the type of shoreline and regulatory shoreline zone applicable to the reach. Although the Regulatory Shoreline Zones are similar in definition to the types of shoreline hazards defined under the technical guidelines prepared in support of the Provincial Policy Statement (PPS), the preparation of the Shoreline Management Plan (SMP) pre-dates the guidelines and therefore is not consistent with the PPS and guidelines. A summary of the hazards associated with each reach are provided in the Shoreline Management Plan.

A detailed assessment of erosion rates and flood hazards was completed for the Erie Beach Development project located within reach 10-10. The assessment concluded that the use of an erosion rate of 0.15 m /year along the north shore of Lake Erie was conservative and applicable in areas where the erosion rate is controlled by the erosion of the bedrock. The flood hazard was determined to extend up to an elevation 177.11 m.

2.9.2 Work Activities

The shoreline of the study area was visited on three occasions. An initial site reconnaissance by a coastal engineer was completed in November 2005. This was followed by a survey of four typical beach cross-sections also in November 2005. A final field assessment of the dynamic beaches and shoreline conditions was completed in early March 2006.

Locations of the sections surveyed in November 2005 and typical sections surveyed are presented in Appendix 'WC-B'. The sections are vertically exaggerated. Run up calculations during design high water levels were completed using depth limited wave conditions for the surveyed locations. The results indicate wave uprush elevations varying from 178.6 to 179.2 m.

2.9.3 Findings/Constraint Identification

Shoreline hazards, as defined by technical guidelines were determined and mapped. The three hazards are:

- Erosion Hazard
- Flood Hazard
- Dynamic Beach Hazard

The extent of erosion and flood hazards were determined for the entire Lake Erie shoreline within the study area. Dynamic beach hazards were determined for three areas that are under consideration for Dynamic Beach designations. The dynamic beach designation may be modified based on comments and feedback by agencies.

Erosion Hazard is defined as 100 times the average annual erosion plus a stable slope allowance. The technical guidelines suggest a default erosion rate of 0.3 m/year unless site specific erosion rate is available. Further, the technical guidelines propose a stable slope of 3 hor. : 1 vert. allowance is to be used, unless site specific investigations confirm the safe use of another slope with the appropriate factors of safety.

The review of the erosion data contained both in the SMP (Sandwell, Philpott, 1992) and the Erie Beach Development report (Shoreplan, 2003) indicates that the use of the default value contained in the technical guidelines would result in an overly conservative estimate of erosion. The following briefly describes the critical components of the erosion process and the controlling mechanism.

The Lake Erie shoreline of the study area consists of headlands and bays. The headlands are formed by rock outcrops. The bays in between consist mostly of cohesionless materials. The bays are dynamically stable. The overall erosion of the shoreline is control by erosion of the headlands. As the headlands erode, the beach shores in between erode and recede at the same rate. The erosion rate of limestone or dolomite-type shores, which form the bedrock outcrop, is very low. The reviewed reports and the references cited in them suggest that the average rate may be well less than 0.1 m/year. The SMP suggested 0.15 m/year is considered the upper limit of erosion or these bedrock outcrops.

There are no available reports dealing with the slope stability of the sandy banks within the study area. Therefore, the use of the default value of 3 horizontal:1 vertical to determine the is recommended. The sum of the 100 times the erosion rate and the stable slope allowance combine to produce the erosion allowance. The extent of the Erosion Hazard is presented in Figures 15-17.

Flood Hazard is defined in the technical guidelines as the limit of wave uprush during a design storm condition. A design storm condition is defined as a severe storm occurring at 1:100 year water level of 177.11 m. The technical guidelines allow for a wave uprush allowance of 15 meters, measured horizontally in cases where site specific wave uprush calculations are not available. Our review of the shore conditions indicates that variability of the backshore grades and conditions is considerable and use of this horizontal allowance is the most appropriate way to provide a conservative allowance for wave uprush. The extent of the Flood Hazard is presented in Figures 15-17.

Dynamic Beach hazard is applicable to beach shorelines. It is defined as the extent of the wave uprush plus a dynamic beach allowance of 30 metres to accommodate dynamic beach processes. On beaches that may be experiencing a gradual recession, an appropriate erosion allowance must be included. The dynamic beach allowance is designated as a line 60 metres behind the 1:100 year instantaneous water level. The sixty metre allowance includes a fifteen metre wave uprush allowance, fifteen metre erosion allowance and thirty metre dynamic beach allowance.

The locations of the erosion, flood and dynamic beach hazards are presented on Figures 15-17. This section provides a brief discussion of the outlined limits relative to the technical guidelines.

The use of 0.15 m/year recession rate on a watershed basis rather than the default value of 0.3 m may be open to discussion. The technical guidelines could be interpreted as allowing site specific erosion results only to replace the default value. However, the recommended value of 0.15 m/yr is considered to present a realistic and conservative erosion rate within a planning horizon.

The use of 15 metre wave uprush allowance is also considered realistic and conservative. Much of the shoreline contains some form of erosion protection works at the upper limit of the beach or backshore. In most area, the structures also represent the location of the design high water level (1:100 year instantaneous). Thus the run up during a design storm occurs on the structure and on lands above the structures. These lands above the structures tend to be highly landscaped. Thus their run up properties, such as slope, surface texture and porosity, vary considerably. Representing wave uprush by a typical section is not appropriate in such cases. The use of a 15 m horizontal allowance, as outlined in the technical guidelines, is more appropriate.

There are three locations where potential for backshore flooding has been identified. These are located in reach 9-2, 10-4 and 10-7. The potential for flooding to reach the outlined level will depend on the duration of the flood. The design flood level is reached only as a result of a substantial set up, which is short in duration. High set up levels generally lasts for several hours only. It is likely that the two smaller backshore flood areas in reaches 10-4 and 10-7 will flood. However, the large inland area in reach 9-2 may not. The potential flood area extends over 1 kilometre inland and is as much as 1 kilometre wide. An assessment of flood water inflow has not been completed, as it is beyond the scope of the watershed plan. Subsequent study would need to consider overland flow calculations through a relatively narrow opening behind the beach and then calculate flows spreading over a large, relatively flat area. The study would also need to consider the dynamic inflow head which would rise and fall over several hours.

The outlined dynamic beach hazards have two aspects to discuss: first, it could be argued that the entire shoreline in the study area is a dynamic beach. This includes the headlands. It has been observed that there are sufficient sand or gravel deposits at all sites visited to meet the basic definition of a dynamic beach provided in the technical guidelines, with respect to thickness and extent of the sand or gravel cover. This would be considered extreme and unrealistic definition of a dynamic beach. What is more critical in defining dynamic beach is the ability of the nearshore profile to respond to water level changes and wave conditions. The headlands and other areas where bedrock is exposed do not respond to these conditions and should not be classified as dynamic beaches. The second aspect of the dynamic beach designation is that the present use and conditions of the shore in the designated areas eliminates much of the dynamic processes and raises a question about the appropriateness of the application of the Dynamic Beach hazard at all. The toe of the sand dunes is mostly protected and therefore fixed in position by presence of seawalls and revetment. The surfaces of the dunes above the seawalls/revetment are generally landscaped, thus inhibiting any movement of sand. These result in a static system, are not able to respond to coastal processes. Therefore, designating this as a dynamic system may be viewed inappropriate. This second view may also be considered somewhat extreme.

A more appropriate definition of a dynamic beach hazard that recognizes the long time residential and recreational uses in the area and the real risks associated with these uses is needed. It is recommended that three dynamic beach areas identified on the figures in Appendix ‘WC-B’ should be designated as dynamic beaches. However, a consideration should be given to limiting the extent of dynamic beach hazard to the location of the shore protection structure, since this is where dynamic processes stop.

2.10 Land Use

Importance:

The Town of Fort Erie Official Plan documents approved future land uses. It has been thoroughly reviewed by the Region, Province, and NPCA, and has been verified in the context of ongoing planning initiatives, as well as potential recent impacts of the Greenbelt legislation and other relevant Provincial Policy and initiatives. While the study area is not within the Greenbelt, there is a recognized indirect impact to lands beyond the Greenbelt when development potentially increases on the lands adjacent to the Greenbelt.

2.10.1 Background Information Collection

- (Old) Official Plan, Town of Fort Erie, October 1995
- Official Plan, Town of Fort Erie, September 11, 2006
- Revised Town of Fort Erie Urban Land Needs Assessment, Town of Fort Erie, Community Planning and Development Services, September 2005
- City of Port Colborne and City of Niagara Falls Official Plan Land Use schedules
- Regional Municipality of Niagara Official Plan Land Use schedule

2.10.2 Work Activities

The Official Plan land uses have been mapped and layers created for comparison of existing and future imperviousness coverage, to be used as input to the study area hydrologic models.

2.10.3 Findings /Constraint Identification

Based on the analysis prepared by the Town in the Revised Urban Land Needs Assessment, the Town will have a surplus of urban land available for residential purposes within the 20-year time frame of the Official Plan. The Town's assessment determined that there is sufficient developable residential land available to support the next 32 years of the residential growth requirements.

The assessment concludes that there is no basis or justification to consider an Urban Boundary Expansion. The Official Plan land use plan (September 11, 2006), which is largely the same as the Land Use Schedule in Appendix 1 of the Urban Land Needs Assessment (2005), has been adopted as the future land use plan for the purpose of this study.

3. SUMMARY OF POLICIES, OBJECTIVES AND TARGETS

Policies (Acts, Regulations, Policies, Guidelines, Plans, Programs…) are the governing documents (legislative or otherwise) that are followed and used to guide practitioners in watershed planning. The Objectives are similar to goals, and are the overall end products that are proposed to be achieved, while following the governing policies. The targets are specifically defined to measure how well the objectives are being met.

In order to effectively evaluate various alternatives and management approaches, it is necessary to clearly articulate the governing policies on a Federal, Provincial and Municipal scale.

These have been summarized along with other local companion programs, to set Objectives and Targets, from such sources as: the Niagara River Remedial Action Plan (RAP), the Niagara Water Quality Protection Strategy (NWQPS), Lake Erie Lakewide Management Plan (LaMP), and Lake Erie Shoreline Management Plan. Clearly the watershed strategies developed as part of this plan need to be consistent with governing policy, hence all parties need to clearly understand the current requirements.

Policies, objectives and targets will evolve from the stakeholders' vision of their watershed and its health and services compared to the current condition and issues. It is suggested to develop both short term and long-term targets to help build momentum to long-term goals through shorter-term success.

The following table summarizes the various governing legislation, policy and guidelines relevant to the study:

TABLE 3.1.1:
SUMMARY OF ACTS AND GUIDELINES

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
Federal	Agricultural and Rural Development Act	Act	The Act provides for federal/provincial agreements (Section 3(b)(I)) to develop and conserve water supplies for agricultural and other rural development purposes.
	Canada Marine Act	Act	The Canada Marine Act's objective is to implement National Marine Policy, to attend to matters related to maritime trade and transport, to establish Port Authorities and to divest the federal government certain harbours and ports, to provide a high level of safety and environmental protection, to ensure that services are available at a reasonable cost, and to respond to local development priorities.
	Canada Shipping Act	Act	The Canada Shipping Act (Part XV), administered by Transport Canada, provides for the Governor in Council to make regulations with respect to prohibiting the discharge from ships of pollutants and prescribing substances and classes of substances that are pollutants.
	Canada Water Act	Act	An Act to provide for the management of the water resources of Canada, including research and the planning and implementation of programs relating to the conservation, development and utilization of water resources
	Canadian Environmental Assessment Act	Act	The Act requires federal departments, including Environment Canada, agencies, and crown corporations to conduct environmental assessments for proposed projects where the federal government is the proponent
	Canadian Environmental Protection Act (CEPA)(1999)	Act	To protect the environment, human life and health from the risks associated with toxic substances.

TABLE 3.1.1: SUMMARY OF ACTS AND GUIDELINES			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Federal	Department of the Environment Act	Act	Establishes the department of the Environment and sets forth the various powers and responsibilities of the minister.
	Federal Fisheries Act (I)	Act	Purpose is to protect fish habitat. The Act deals with the discharge of deleterious substances into waters used by fish, and any harmful alteration and disruption of fish habitat.
	Food and Drug Act	Act	This Act applies to all food, drugs, cosmetics and medical devices sold in Canada, whether manufactured in Canada or imported.
	Migratory Birds Convention Act (1994)(I)	Act	Protects migratory birds from indiscriminate harvesting; affects timing of construction or habitat clearing.
	Species at Risk Act	Act	Protection of species at risk.
	Pest Control Products Act	Act	An Act to regulate products used for the control of pests and the organic functions of plants and animals.
	National Round Table on the Environment and the Economy Act	Act	An Act to establish the National Round Table on the Environment and the Economy.
	Pesticide Residue Compensation Act	Act	An Act to provide compensation to farmers whose agricultural products are contaminated by pesticide residue.
	Species at Risk	Act	Protects wildlife species at risk, including species-specific recovery plans.
	Canada/Ontario Agreement Respecting Great Lakes Basin Ecosystems.	Guideline	Since 1971, Canada-Ontario Agreements Respecting the Great Lakes Basin Ecosystem have guided the Parties in their work to improve the environmental quality of the Basin.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended "safe limits" for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and ground waters and not to estuarine and marine waters.
	Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended "safe limits" for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and ground waters and not to estuarine and marine waters.
	Guidelines for Canadian Drinking Water Quality	Guideline	To provide a national guideline for the protection of drinking water.
	Guidelines for Canadian Recreational Water	Guideline	To provide a national guideline for the protection of recreational waters used for primary contact recreation such as swimming, windsurfing and water skiing and for secondary contact recreation activities including boating and fishing.
	ISO 1400/EMS	Guideline	ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing co-operation in the spheres of intellectual, scientific, technological and economic activity.
	A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (2004, EC/CWS, OMNR, OME) (D)	Guidelines	Watershed-based suggested guidelines for rehabilitation of forest, wetlands, riparian habitat. Intended de-listing of Areas of Concern.
	Cleanup Fund	Program	Initiated in 1990 as part of the federal Great Lakes Action Plan, the Cleanup Fund represents a significant part of Canada's commitment to restore the Great Lakes Basin Ecosystem as outlined in the 1987 Protocol to the Great Lakes Water Quality Agreement between Canada and the United States (GLWQA).
Provincial	Bill 127, Ontario Water Resources Amendment Act (Water Source Protection), 2002	Act	The Bill amends the Ontario Water Resources Act in regard to the availability and conservation of Ontario water resources. Specifically, the Bill requires the Director to consider the Ministry of Environment's statement of environmental values when making any decision under the Act. The Bill also requires that municipalities and conservation authorities are notified of applications to take water that, if granted, may affect their water sources or supplies.

TABLE 3.1.1: SUMMARY OF ACTS AND GUIDELINES			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Clean Water Act (2006)	Act	To protect the quantity and quality of water in aquifers, rivers and lakes, through development of collaborative locally-driven, science-based protection plans.
	Drainage Act	Act	Provides for the regulation of drainage practices in Ontario.
	Endangered Species Act (1990)	Act	Provides for the conservation, protection, restoration and propagation of species of flora and fauna in Ontario that are threatened with extinction.
	Environmental Assessment Act (199)	Act	The purpose of this Act is to provide for the protection, conservation and wise management of the environment.
	Environmental Protection Act	Act	The purpose of this Act is to provide for the protection and conservation of the natural environment. R.S.O. 1990, c. E.19, s.3.
	Farming and Food Protection Act (1998)	Act	The Act is intended to ensure that farmers can carry out normal farm practices without fear of nuisance complaints or unnecessarily restrictive by-laws.
	Fish and Wildlife Conservation Act (1997)	Act	The new Fish and Wildlife Conservation Act came into force as of January 1, 1999. The Act enables the Ministry of Natural Resources (MNR) to provide sound management of the province's fish and wildlife well into the next century. It replaces the Game and Fish Act, that last underwent major changes in 1980.
	Lakes and Rivers Improvement Act (1990)	Act	The Lakes and Rivers Improvement Act gives the Ministry of Natural Resources the mandate to manage water-related activities, particularly in the areas outside the jurisdiction of Conservation Authorities.
	Municipal Act	Act	The Municipal Act sets forth regulations in regard to the structuring of municipalities in Ontario.
	Niagara Parks Commission (MOT)	Act	The Niagara Parks Act enables the Niagara Parks Commission to regulate the use of the parks, providing for protection and preservation of the Property of the Commissioner.
	Nutrient Management Act (OMAF) (2002)	Act	As part of the Ontario government's Clean Water Strategy, the Nutrient Management Act provides for province-wide standards to address the effects of agricultural practices on the environment, especially as they relate to land-applied materials containing nutrients.
	Ontario Water Resources Act	Act	The Ontario Water Resource Act deals with the powers and obligations of the Ontario Clean Water Agency, as well as an assigned provincial officer, who monitors and investigates any potential problems with regards to water quality or supply. There are also extensive sections on Wells, Water Works, and Sewage works involving their operation, creation and other aspects.
	Pesticides Act	Act	The Ontario Pesticides Act establishes a classification system for pesticides and regulates the licensing of vendors and persons employed as applicators of pesticides, the storage and disposal of pesticides, and the requirements for notification of pesticide use.
	Places to Grow Act (2005)	Act	To enable decisions about growth to be made in ways that sustain a robust economy, strong communities, healthy environment and a culture of conservation.
	Provincial Planning Act (D)	Act	The purposes of this Act is to promote sustainable economic development in a healthy natural environment
	Public Lands Act	Act	
	Safe Drinking Water Act (MOE) (2002)	Act	As recommended by Commissioner O'Connor, the government has passed a Safe Drinking Water Act, which expands on existing policy and practice and introduces new features to protect drinking water in Ontario. Its purpose is the protection of human health through the control and regulation of drinking-water systems and drinking-water testing and provides legislative authority to implement 50 of the 93 recommendations made in Commissioner O'Connor's Part Two Report.
	Environmental Bill of Rights (EBR)	Bill of Rights	On February 15, 1994, the Environmental Bill of Rights (EBR) took effect and the people of Ontario received an important new tool to help them protect and restore the natural environment. While the Government of Ontario retains the primary responsibility for environmental protection, the EBR provides every resident with formal rights to play a more effective role.

TABLE 3.1.1: SUMMARY OF ACTS AND GUIDELINES			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Model NMP By-law	By-Law	Model By-law to Incorporate the Nutrient Management Plan (NMP) Requirements into a Municipal By-law Pursuant to the Municipal Act (July 23, 1999).
	Fish Habitat Types with Management Rationale – Niagara Regional Municipality (MNR) (2000)	Guideline	The report is designed to provide fisheries habitat and management information for assisting with resource management decisions.
	Guidelines for Evaluating Construction Activities Impacting on Water Resources (MOE) (1995)	Guideline	These guidelines were developed to protect the receiving environment according to the physical, the chemical and the biological quality of the material being dredged.
	Guidelines for Use at Contaminated Sites in Ontario (MOE) (1997)	Guideline	The purpose is to provide a guideline for use by property owners who are cleaning up or redeveloping a contaminated site.
	Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land (MOE/OMAFRA) 1996	Guideline	Purpose is to provide guidelines on the application of biosolids on agricultural land.
	Incorporation of the Reasonable Use concept into MOE Groundwater Management Activities (1994)	Guideline	This guideline establishes the basis for the reasonable use of groundwater on property adjacent to sources of contaminants and for determining the levels of contaminants acceptable to the ministry.
	Ontario Drinking Water Standards (MOE) (2001)	Guideline	The purpose of the standards is to protect public health through the provision of safe drinking water.
	Provincial Water Quality Objectives (MOE) (1994)	Guideline	To provide objectives for the protection of aquatic life.
	Significant Wildlife Habitat Technical Guide (MNR) (2000)	Guideline	Significant Wildlife Habitat has been identified as one of the natural heritage feature areas under the Provincial Policy Statement
	Protection and Management of Aquatic Sediment Quality in Ontario (MOE) (1993)	Guideline	The purpose of the sediment quality guideline is to protect the aquatic environment by setting safe levels for metals, nutrients and organic compounds.
	Technical Guideline for Private Wells: Water Supply Assessment (MOE) (1996)	Guideline	Guidance manual for the development of private wells.
	Technical Guideline for On-site Sewage Systems (MOE)	Guideline	Guidance manual for assessing the proposed impacts on on-site sewage systems on groundwater.
	Integrating Water Management Objectives into Municipal Planning Documents (MOE) (1993)	Policy	Policy manual on the integration of watershed management practices into municipal planning documents.
	Subwatershed Planning (MOE) (1993)	Policy	Technical manual on conducting subwatershed planning in Ontario.
	Watershed Management on a Watershed Basis (MOE) (1993)	Policy	Policy manual on watershed management practices.
	Provincial Policy Statement	Policy	Provincial Policy Statement was issued under Section 3 of the Planning Act and came into effect in 2005.
	Ontario Drinking Water Protection Regulation	Regulation	In August 2000, the Government of Ontario announced a new Drinking Water Protection Regulation (Ontario Regulation 459/00) to ensure the safety of Ontario's drinking water. The regulation issued under the Ontario Water Resources Act was a part of the comprehensive Operation Clean Water action plan. This regulation put the Ontario Drinking Water Standards into law, updating and strengthening the Ontario Drinking Water Objectives.
	Ontario's New Drinking Water Protection Regulation for Smaller Waterworks Serving Designated Facilities O. Reg. 505/01	Regulation	The Regulation is Part of the New Drinking Water Regulations administered through the Ministry of the Environment.
Regional	Regional Municipalities Act (1990)	Act	Purpose is to put forth the structuring and governance of municipalities in support of the Municipal Act.
	Regional Municipality of Niagara Act (1990)	Act	Purpose is to put forth the structuring and governance of municipalities in support of the Regional Municipalities Act and the Municipal Act.
	Regional Municipality of Niagara Model Site Alteration By-law	By-Law	To assist in the protection of sensitive lands and agricultural areas (can be adopted by the local municipalities under the Municipal Act).

TABLE 3.1.1: SUMMARY OF ACTS AND GUIDELINES			
Level of Government	**Level of Government**	**Level of Government**	**Level of Government**
Regional	Regional Municipality of Niagara Tree Cutting By-Law	By-Law	The Tree Conservation By-Law is designed to support and encourage good forestry management and weed out those in the industry responsible for poor logging practices. The By-Law regulates tree cutting in woodlots. It does not prohibit it. Landowners are free to cut trees in their woodlots provided that they do not violate good forestry practice.
	Regional Municipality of Niagara EIS Guidelines (2001)	Guideline	Guidelines for the conduct of EIS projects in the Region. To standardize and put forward the requirements for EIS completion and review.
	Regional Municipality of Niagara Policy Plan (2005)	Policy	The Regional Plan, therefore, is essentially a means of guiding short range public and private actions on a region wide scale according to long range considerations of the public interest, and is intended to assist in the creation of conditions within which the private market and public authorities can function most effectively.
Municipal	Town of Fort Erie Site Alteration By-law 201-96	By-Law	To protect lands from unauthorized alteration, which may damage the existing and future land and environment.
	Municipal EIS Guidelines (D)	Guideline	Purpose is to set forth guidelines for conducting Environmental Impact Statements as part of the review of social, economic and environmental impacts of proposed projects in order to protect natural heritage features.
	Municipal Official Plans (D)	Policy	Municipal planning strategies, and associated land use bylaws, are the primary tools used by municipalities for land use planning. As a statement of Council's policies and priorities, a strategy establishes a framework for addressing how a community will respond to opportunities and challenges for orderly growth and development. And while opinions on municipal planning strategies are many and varied, most would agree they are necessary.
Conservation Authority	Conservation Authorities Act	Act	Conservation Authorities, created in 1946 by an Act of the Provincial Legislature, are mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs.
	Land Use Policies for Valleylands, Stream Corridors and Floodplains (NPCA) (2002)	Policy	Purpose is to identify valleys and/or valley systems and stream corridors, to further its objectives relating to flooding and erosion, and the maintenance of natural environmental integrity, including the conservation of land.
	Shoreline Management Program - Plan Input and Review Guidelines (NPCA) (1988)	Program	Purpose is to set forth a management program for addressing erosion problems along shorelines in the Niagara Conservation Authority lands.
	Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses – Ont. Reg 155/06 (NPCA) (2006)	Regulation	Generic Regulation allows the NPCA to prohibit or regulate development in or adjacent to Shorelines, wetlands, floodplains, watercourses, valleys, dynamic beaches and hazard lands.
Binational Canada/USA	Lake Erie Lakewide Management Plan (LaMP)	Plan	Initiated in 2000, the plan is revisited every two years. A review of the "Significant Ongoing and Emerging Issues" has been completed, and there are no specific policies to deal with the shoreline in the Fort Erie area, however there are general ecosystem objectives and indicators.
	Niagara River Toxics Management Plan	Plan	Reports on the status of 18 NRTMP "priority pollutants"

3.1 Policy

The Town of Fort Erie, Niagara Peninsula Conservation Authority (NPCA), Ministry of Natural Resources, Department of Fisheries and Oceans, Ministry of the Environment, and Niagara Parks Commission, each have criteria and guidelines pertaining to management of watershed resources.

The Provincial Policy Statement (2005) includes policies that allow the agencies to "protect, improve or restore the quality and quantity of water by using the watershed as an ecologically meaningful scale for land use planning"

The following outlines the basic policy of each agency as it applies to the various watershed disciplines considered by this study:

3.1.1 Hydrogeology

The NPCA legislative mandate as set out in Section 20 of the Conservation Authorities Act is to establish and undertake programs designed to further the conservation, restoration, development and management of natural resources. However, the primary water management focus has generally been surface water management and flooding prevention.

The Provincial Policy Statement (2005) issued under the authority of the Planning Act directs conservation authorities to in future place greater emphasis on groundwater resource management. It indicates that "Planning authorities shall protect, improve or restore the quality and quantity of water by:…identifying…groundwater features …protect, improve or restore vulnerable…groundwater…and sensitive groundwater features …" In this regard, protection of natural recharge and discharge features are extremely important.

The Ministry of Natural Resources has responsibilities under the Federal Fisheries Act and the Federal Fish Habitat Management Policy. The Federal Fisheries Act requires that stream flows be maintained at levels that will not affect fish habitat while the Federal Fish Management Policy requires no net loss of fish habitat. As such, any development that has the potential to alter groundwater and surface water relationships (i.e. baseflow and water quality) in a manner that impacts fish habitat would require the preparation of plans designed to mitigate these effects. In the case of baseflow maintenance, due to the inter-relationship between groundwater and surface water, at-source infiltration is generally encouraged provided the water is of suitable quality.

The Ministry of the Environment provides protection and conservation of the natural environment (including groundwater) through various statues and regulations, most notably the Ontario Water Resources Act, the Environmental Assessment Act and the Environmental Protection Act (EPA). In particular, these Acts and associated Regulations, Policies and Guidelines provide for protection of impacts to groundwater quality by both regulated (i.e. landfills, septic systems) and unregulated (i.e. spills) contaminant sources. In addition impacts to groundwater quantity are regulated, primarily through the Permit to Take Water program (Reg. 387/04). The Town of Fort Erie are however responsible for approvals of single lot septic systems receiving less than 10,000 L/day (under EPA transfer of responsibilities to the Building Code Act).

Under the Health Protection and Promotion Act, the Ministry of Health, Public Health Branch has "Safe Water" as one of its "Mandatory Health Programs and Services Guidelines" (December 1997). The stated goal is "To reduce the incidence of water-borne illness in the population". The mandate of the Public Health Laboratory is to provide free microbiological analyses and interpretation of the results.

The Clean Water Protection Act 2006 was passed to secure primarily municipal drinking water supplies at the source of the water and is commonly referred to as Source Water Protection. The existing guidelines and technical supporting documents are in a draft stage but technical studies have begun. Within the Fort Erie Creeks Watershed Plan Area these studies currently include the (i) Tier 1 Water Budget and the (ii) Intake Protection Zone study for the Rosehill municipal surface water treatment plant. With respect to groundwater the Tier 1 Water Budget will be delineating high volume and significant recharge areas and evaluating the stress state of water resources in the WSPA (due for completion by end of 2008). Also to be completed in 2008 will be a preliminary Groundwater Vulnerability Study of highly vulnerable groundwater areas.

3.1.2 Flooding and Erosion

The NPCA mandate under the Conservation Authorities Act permits the Authority to regulate designated areas based on flood potential (risk), erosion, hazard potential and resource protection. The intent of the regulation is to reduce risk to life and property damage by assessing the technical feasibility of proposals based on examination of hydrologic and hydraulic effects. The Authority also administers the Provincial Floodplain Policy issued under Section 3 of the Planning Act. This responsibility is delegated to the Conservation Authority from the Ministry of Natural Resources.

Under the new Generic Regulations (May 2006) the NPCA may prohibit or regulate development in the following areas:

(a) adjacent or close to the shoreline of the Great Lakes-St. Lawrence River System or to inland lakes that may be affected by flooding, erosion or dynamic beaches, including the area from the furthest offshore extent of the Authority's boundary to the furthest landward extent of the aggregate of the following distances:

- *(i) the 100 year flood level, plus the appropriate allowance for wave uprush shown in the column headed "100 Year Flood Limit" found in Table 3 of the document entitled "Lake Ontario Shoreline Management Plan", January 1994*
- *(ii) the 100 year flood level, plus the appropriate allowance for wave uprush shown in the column headed "100 Year Flood Limit" found in Section 3.2 of the document entitled "Lake Erie Shoreline Management Plan", June 1992*
- *(iii) the predicted long term stable slope projected from the existing stable toe of the slope or from the predicted location of the toe of the slope as that location may have shifted as a result of shoreline erosion over a 100-year period,*
- *(iv) where a dynamic beach is associated with the waterfront lands, the appropriate allowance inland to accommodate dynamic beach movement shown in Section 4.4 of the document entitled "Lake Ontario Shoreline Management Plan", January 1994, and*
- *(v) where a dynamic beach is associated with the waterfront lands, the appropriate allowance inland to accommodate dynamic beach movement shown in Section 3.8.2 iii) of the document entitled "Lake Erie Shoreline Management Plan", June 1992;*

(b) River or stream valleys that have depressional features associated with a river or stream, whether or not they contain a watercourse, the limits of which are determined in accordance with the following rules:

- *(i) where the river or stream valley is apparent and has stable slopes, the valley extends from the stable top of bank, plus 15 metres, to a similar point on the opposite side,*
- *(ii) where the river or stream valley is apparent and has unstable slopes, the valley extends from the predicted long term stable slope projected from the existing stable slope or, if the toe of the slope is unstable, from the predicted location of the toe of the slope as a result of stream erosion over a projected 100-year period, plus 15 metres, to a similar point on the opposite side,*
- *(iii) where the river or stream valley is not apparent, the valley extends the greater of,*
  - *(A) the distance from a point outside the edge of the maximum extent of the flood plain under the applicable flood event standard, to a similar point on the opposite side, and*
  - *(B) the distance of a predicted meander belt of a watercourse, expanded as required to convey the flood flows under the applicable flood standard, to a similar point on the opposite side;*

(c) hazardous lands;

(d) wetlands; or

(e) other areas where development could interfere with the hydrologic function of a wetland, including areas up to 120 metres of all provincially significant wetlands and wetlands greater than 2 hectares in size, and areas within 30 metres of wetlands less than 2 hectares in size, but not including those where development has been approved pursuant to an application made under the Planning Act or other public planning or regulatory process.

The Black Creek, Beaver Creek, Baker Creek, Frenchman's Creek, Miller Creek, Six Mile Creek and Kraft Drain are regulated based on the flood produced by the Regional Storm (100 year). The study area is regulated by a "one zone" policy, with no development allowed within the regulated area.

The Town of Fort Erie's storm drainage policies have been defined in a report: "Town of Fort Erie, Storm Drainage Master Plan", by Kerry T. Howe Engineering Ltd. April, 1993. The AES design storms for Port Colborne have been recommended for use in the Town of Fort Erie, and accordingly the design criteria for minor and major storms has been defined.

The Niagara Parks Commission has a legislated mandate for the Niagara River corridor, Niagara gorge, and environmental matters within their jurisdiction. The NPC will have regard to this document however, *"the use of lands owned by the NPC is regulated under the provisions of the Niagara Parks Act R.S.O. 199, cN3. The provisions of this plan shall not apply to the lands of the Niagara Parks Commission so long as those lands are owned by the Niagara Parks Commission and are used for the purposes of the Niagara Parks Commission"*.

3.1.3 Stream Morphology

It is NPCA policy to protect stream morphological and fluvial character (ref. Section 2(b) Generic Regulations, May 2006). Further, for stream corridor delineation from a planning perspective, the determination of an appropriate meander belt width is recommended.

At the Provincial level, natural hazard lands are covered under Section 3 of the Provincial Policy Statement. Specific guidelines regarding stream morphology are also found in the Ministry of Natural Resources “Natural Channel Systems” and “Technical Guide, River and Stream Systems: Erosion Hazard Limit”, 2001.

3.1.4 Aquatic Habitat and Fisheries

The most encompassing legislation addressing aquatic habitat and fisheries is the Policy for the Protection of Fish Habitat (Department of Fisheries and Oceans; 1986), under the auspices of the Federal Fisheries Act. The policy is based on the guiding principle of "no net loss of the productive capacity of fish habitat" and "net gain" of habitat where feasible. No habitat which is required for the support of any aspect of a fishery or its productivity (feeding, nursery, spawning, migratory or general living habitat) can be destroyed, altered or otherwise deleteriously affected without permission of the Minister, subject to substantial fine and/or imprisonment penalties.

Any assessment of a fishery resource and the constraints that the presence of a fishery resource has upon development activity, must frame the assessment within the federal and provincial legislation designed to protect the fishery resource and species at risk. Federal protection of all fish habitat is provided under the Fisheries Act. Federal protection for species at risk is provided under the Species At Risk Act, for species listed in Schedule 1 of the Act. Provincial protection of species at risk is provided under the Planning Act.

The Fisheries Act defines fish as: “parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals”.

The Fisheries Act defines fish habitat as: “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes”.

The Fisheries Act states “no person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat (Section 35(1))” unless authorized by the Minister of Fisheries and Oceans, or under regulations made by the Governor in Council under this Act (Section 35(2)). As well, “no person shall deposit or permit the deposit of any deleterious substance into water frequented by fish” (Section 36(3)). Stemming from the Fisheries Act, the Department of Fisheries and Oceans (1986) Policy for the Management of Fish Habitat has the objective of creating a net gain of habitat for Canada’s Fisheries resources. The guiding principle to realize this end is “no net loss” which requires that if the productive capacity of a fish habitat is reduced, then a compensating increase in fish production must be made to occur. The hierarchy of preferences for applying this principle to development, or other activities, is as follows:

1. Maintain, without disruption, the natural productive capacity of fish habitats through relocation, redesign or mitigation.

2. If the former proves impossible or impractical, then compensation by either creating new habitat, or by increasing the productive capacity of existing habitat, will be considered. It should be noted, however, that compensation may not be acceptable in some cases where the habitats in question are deemed especially important or sensitive. It should also be noted that an Authorization under the Fisheries Act triggers the Canadian Environmental Assessment Act, so that screening under this Act also becomes necessary.

The presence of fish species classed as “Vulnerable” elevates the fish habitat to MNR “Type 1" habitat, and triggers provincial protection of habitat under the Planning Act. Under Section 3 of the Planning Act the province requires that, in exercising any authority that affects planning matters, planning authorities "shall have regard to" policy statements issued under the Act. Under Section 2.3.1 of the Provincial Policy Statement it is stated that “Development and site alteration will not be permitted in significant portions of the habitat of endangered and threatened species”. Coldwater fish habitat is also considered “Type 1", which requires the highest degree of protection.

Administration of the policy at the local level has been delegated to the NPCA through a Level II Agreement with DFO. Typically, NPCA reviews the implications of the policy in conjunction with applications under the Lakes and Rivers Improvement Act, as well as through subdivision approval, Environmental Assessment and other relevant processes. The NPCA’s responsibilities include determination of whether or not potential habitat impacts can be mitigated to an acceptable level. If it is deemed that impacts cannot be mitigated, and the proposal involves compensation, applications to the Minister of Fisheries for approval of the relevant habitat impacts must be made, in conjunction with an acceptable plan for compensation of the proposed habitat impact/loss.

The Ministry of Natural Resources (Vineland Office) has classified fish habitat in all the main watercourse channels in the Niagara Region (ref. “Fish Habitat Types with Management Rationale, Niagara Regional Municipality”, MNR, February 25, 2000). The fish communities/habitat definitions in this document are as follows (ref. Appendix ‘NH-A’ for full definitions).

Type 1: areas that limit the overall productive capacity (i.e. if these areas are harmfully altered the productive capacity of the area would be reduced). Sensitive fish species (part or all of their life cycle) and/or habitats are present (including springs, seeps, upwelling areas, seasonally inundated spawning habitats, refugia, nursery areas, over-wintering areas, and ephemeral pools). These areas require a high degree of protection, however may also be enhanced with care, and can achieve a high potential for habitat compensation.

Type 2: this habitat is important but below its productive capacity and is ideal for enhancement or restoration projects. Sensitive species may or may not be present part or all of the time. Fish community is below potential due to habitat related issues, however may be increased if the limiting factors are reversed.

Type 3: areas with low productive capacity, where common species may or may not be present, and no sensitive species and/or specialized habitat are present (incidental exceptions of fish presence may occur in some locations, e.g. the Welland Shipping Canal). Areas can negatively affect downstream, down-drift or connected fish habitats, and should not be considered for compensation opportunities.

This classification in intended to guide the management and treatment of watercourses, whether confronted by development, land use changes, or opportunities for enhancement.

In the course of any project that has the potential to impact upon a watercourse, an appropriately detailed site-specific study will be required to address the concerns of DFO, MNR and the CA.

The Department of Fisheries and Oceans has classified the legal drains within the Fort Erie Creeks watershed according to their official drain typing, defined as follows (the DFO should be contacted to obtain the most current classification of specific drains in Fort Erie).

Table 3.1.2
DFO DRAIN CLASSIFICATION

Type	Flow	Temperature	Species	Time Since Last Clean Out	Authorization
A	Permanent	Cold/Cool/ Unknown	No Trout Or Salmon	N/A	Class A
B	Permanent	Warm	Top Predators (Bass, Pike, Muskie, Crappie)	Less Than 10 Years	Class B
C	Permanent	Warm	Baitfish	N/A	Class C
D	Permanent	Cold/Cool/ Unknown	Trout and/or Salmon	N/A	Project Specific
E	Permanent	Warm	Top Predators (Bass, Pike, Muskie, Crappie)		Project Specific
F	Intermittent	N/A	N/A	N/A	Conditional (See Below)

Class Authorization A:

<u>Authorized Activities:</u> brushing of side slope; bottom cleanout; debris cleanout. <u>Specific Terms and Conditions:</u> width:depth ratio not increased; shade producing side unaltered; specific timing restrictions; sediment control; work in water only when flows are not elevated; replanting of bank vegetation.

Class Authorization B:

<u>Authorized Activities:</u> brushing of side slope; bottom cleanout; debris cleanout.
<u>Specific Terms and Conditions:</u> specific timing restrictions; vegetation can be removed from either bank, but must be replanted; width:depth ratio can be increased, but channel must be as deep as possible; sediment control; work in water only when flows are not elevated; replanting of bank vegetation.

Class Authorization C:

Authorized Activities: brushing of side slope; bottom cleanout; debris cleanout; full clean out. Specific Terms and Conditions: vegetation removal allowed on either bank, but must be replanted; bends in channel must be stabilized; specific timing restrictions; sediment control; work in water only when flows are not elevated.

Project Specific Evaluations: D & E:

Drain types D and E are sensitive to maintenance activities. This however does not necessarily mean that work cannot proceed in these drains. These projects will be evaluated on a project by project basis to determine if the effects of maintenance can be mitigated. In some cases, a project specific authorization under the Fisheries Act may be required.

F Drains:

F drains are intermittent systems and therefore a harmful alteration, disruption or destruction of fish habitat will not occur in these systems for cleanout work provided the following conditions are met: work is done in the dry; all disturbed soils are stabilized upon completion of work.

Class Authorization Adaptability:

All conditions can be adapted to suit regional biological differences as well as the needs of the drainage superintendents. Therefore a Class C authorization in Wingham could have different terms and conditions than a Class C authorization in Fonthill.

MNR setback guidelines are 30 m from the top of bank for Critical Habitats, and 15 m for both Important and Marginal Habitats (Ian Barrett, Fisheries Biologist, NPCA. pers. comm., February 28, 2006). Where no top-of-bank is delineated, some definable standard such as the waterline of a two-year return flow event is suggested (Ian Barrett, Fisheries Biologist, NPCA, pers. comm.. with Study Team, February 28, 2006).

Erosion, flooding and water quality guidelines and policies noted previously also set objectives to protect fish and aquatic habitat, through water quality treatment objectives, requirements for erosion and sediment controls, and mitigation of impacts to stream morphology.

3.1.5 Water Quality

The MNR and the MOE have developed technical guidelines for the control of stormwater from new development (ref. Stormwater Management Practices Design Manual, MOE, March 2003). These guidelines encompass Best Management Practices for the control of water quality, erosion and hydrogeologic aspects of stormwater management. They provide direction in the preparation and review of planning documents and proposals, as well as master drainage and stormwater management plans, to ensure that stormwater quality is appropriately addressed in stormwater management system design.

The principles advanced in the documentation include a focus on: various stormwater quality treatment levels for various types of receiving watercourse habitats, use of at-source controls, conveyance controls, and end-of-pipe controls, management of volumes, water quality treatment performance and volume requirements.

Based on the fisheries assessment of the study area of the Fort Erie Creeks, habitat protection has been advocated in accordance with type assessment of the creeks as a combination of Type 1, Type 2 and Type 3 Habitat

Enhanced protection should be used where Type 1 habitat exists, or would be impacted by end-of-pipe discharges. Normal protection should be used where Type 1 habitat and conditions for enhanced protection do not exist. Basic protection may only be used when the receiving aquatic habitat can be demonstrated to be insensitive to stormwater impacts and has little potential for future rehabilitation (MOE 2003).

The Enhanced Habitat Protection criteria has been designed to attain suspended solids (and other pollutants) long-term average removal which exceeds 80% removal efficiency. Normal protection corresponds to end-of-pipe storage volumes required for the long-term average removal of 70% suspended solids; basic corresponds to 60%.

In terms of general water quality, the Provincial government has recently increased the scope and number of legislative vehicles for the protection of water quality. The three most recent are the Clean Water Act (2006), the Safe Drinking Water Act (2002) and the Nutrient Management Act (2002). These supplement the many other tools such as the Pest Control Products Act and the Agricultural and Rural Development Act, and Guidelines for Drinking Water Quality.

These and other Acts, Policies, and Guidelines are administered by all levels of Government, with the objective of protecting water quality through the prevention, elimination, or mitigation of both point-source and non-point source pollutants that enter the water cycle.

Niagara Water Quality Protection Strategy

The Strategy was developed to protect, restore, and manage the Niagara area’s water resources. The Region is overseeing the implementation of the strategy, together with the Niagara Peninsula Conservation Authority and the Municipalities, as well as other Provincial and Federal government stakeholders, and numerous public interest groups.

3.1.6 Terrestrial Natural Heritage

Table 3.1.3 outlines the strategies and policies – federal, provincial, regional and local; government and non-government - most relevant to the natural heritage strategy. A recurrent theme is priority to protection of existing natural areas. Protection includes a reduction of agricultural and urban impacts. Other common themes are the importance of enhancement to increase biodiversity, the value of replication of natural functioning, and the need for awareness-raising and stewardship partnerships.

TABLE 3.1.3: SUMMARY OF POLICIES, STRATEGIES AND PLANS RELEVANT TO THE NATURAL HERITAGE STRATEGY		
Policy/Strategy Source	**Policy/Strategy Title**	**Relevance**
Environment Canada and US Environmental Protection Agency	Lake Erie Lake-wide Management Plan (LaMP)	LaMP advocates a return to natural landscapes, where possible, as the best way to restore the lake. Management strategies include: natural area protection, minor restoration, and strong mitigation of agricultural and urban effects; enhance native biodiversity and ecological integrity using targets; use resources sustainability; prevent exotic invasives. The Habitat Strategy priorities are protection, then restoration, then rehabilitation. The guiding principles are: watershed scale; pre-European settlement as the baseline; integration of land and water management; protection of significant areas linked by corridors; restoration focus on restoring processes and function, address aquatic threats – dams, diversions, invasives; address emerging issues, incl. shoreline habitat protection related to climate change, via monitoring, research
Environment Canada with partners	Great Lakes Wetlands Conservation Action Plan	Strategies include: increase public awareness; develop wetland database and understanding; secure wetlands; restore and enhance wetlands; strengthen legislation, policies, local planning; improve coordination; evaluate progress.
Environment Canada with partners	A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (2004)	Watershed-based suggested minimum guidelines for rehabilitation of forest, wetlands, riparian habitat. Towards de-listing of Areas of Concern
Government of Canada	Species at Risk Act	Requires protection of wildlife species at risk. Includes species-specific recovery plans that may affect land use planning.
Government of Canada	Fisheries Act	Protects fish habitat from unauthorized disruption with a goal to increase habitat capacity. The act applies to adjoining terrestrial systems where their functions affect fish habitat.
Province of Ontario	Endangered Species Act	Prohibits interference with habitat of listed species
Province of Ontario	Fish and Wildlife Conservation Act	Empowers MNR to manage fish and wildlife species and protect species at risk
Province of Ontario	Planning Act	Provincial Policy Statement (PPS) prohibits development in significant wetlands and habitat of endangered and threatened species. It protects significant woodlands, valleylands, wildlife habitat and ANSIs from negative impacts of development and site alteration. It requires diversity, connectivity and ecological functions of natural areas be maintained, restored and improved.
Ontario Ministry of Infrastructure Renewal	Places to Grow Plan	Protects the natural system: natural heritage, surface water features, ground water features, linkages. Intensifies growth in urban areas.
Ontario Ministry of Natural Resources	Ontario Biodiversity Strategy	Goals include to protect biodiversity and to use natural heritage sustainably, capturing its benefits. Strategic directions include: engage Ontarians; promote stewardship, work together, integrate biodiversity conservation into land use planning, prevention over cure, improve understanding.
Ontario Ministry of the Environment, Niagara Region and Niagara Peninsula Conservation Authority	Niagara Water Quality Protection Strategy	Recognizes both the importance of water in maintaining natural heritage and the vital role of natural heritage in protecting water. Key strategies are: raise community awareness of natural heritage value and citizen roles; beneficiaries of natural heritage values contribute to protection; protection have priority over enhancement and restoration; replicate natural system functioning where possible
Niagara Peninsula Conservation Authority, Ontario Ministry of the Environment, Environment Canada	Niagara River Area of Concern Remedial Action Plan	A plan to reduce toxic chemical, nutrient and bacteria loadings; improve sediment quality, benthic health and groundwater quality; protect habitat; reduce agricultural non point sources; sustain recreational amenities and extend education. Environment Canada (2004a) has developed minimum guidelines for wetland, riparian and forest habitat rehabilitation towards de-listing areas of concern
Niagara Peninsula Conservation Authority	Conservation Authorities Act and Generic Regulations	Any proposed development of restoration works affecting a watercourse, floodplain, shoreline or wetland will require a permit from Niagara Peninsula Conservation Authority.
Regional Municipality of Niagara	Official Plan	Healthy Landscape principles of: ecosystem health and sustainability, prevention through planning, protection plus restore, stewardship plus regulation, address cumulative impacts. Objectives add cooperation, maintain Niagara's distinct character. Policies add ecosystem approach (interrelationships, effects on neighbours, long term effects), monitoring to adapt, shoreline access and naturalization. Targets are: 30% forest, 10% wetland, 30 m buffer along 70% of first to third order streams. Mapped Core Natural Heritage System – Environmental Protection Areas (EPA) meet provincial PPS significance criteria; Environmental Conservation Areas (ECA) include regionally significant areas. Local natural heritage inventories incorporated into municipal OPs can override.
Town of Fort Erie	Proposed Draft Official Plan	Environment goals and objectives include enhanced natural heritage, efficient use of urban land and conservation of rural landscape, protection of features and functions, shoreline preservation. In support of general goals to maintain unique character and efficient growth patterns. Targets of 30% woodland, 10% wetland. EPA's and ECA's slightly refined from Region's map, adding Locally Significant Areas, some trimming of ECAs in settlement areas.

TABLE 3.1.3: SUMMARY OF POLICIES, STRATEGIES AND PLANS RELEVANT TO THE NATURAL HERITAGE STRATEGY		
Policy/Strategy Source	**Policy/Strategy Title**	**Relevance**
City of Port Colborne	Draft Official Plan	A strategic direction is strengthening and integrating natural, cultural and heritage resources. Strategic planning policies encourage conservation including restoration. Policies protect Environmental Areas (woodlots, wetlands, ANSI's, habitat of species at risk, dynamic beach, watershed-scale corridors) with limited permitted uses and with requirements for sensitive designs, EIS's and buffers. An associated Natural Environment Issues and Options Background Paper (Dillon et al) sets the key issues as percentage and quality of natural cover balanced with other community needs. Suggested objectives include: natural area protection and enhancement, strategies in cooperation with and compatible with agriculture, stewardship partnerships, meet PPS, set targets, protect from nearby uses, link and distribute, improve patches, monitor. It presents 3 options for degrees of protection proposing that the choice be based on the community vision.
Carolinian Canada	The Big Picture	Toward re-establishing an ecologically viable natural heritage system, maps significant core natural areas for protection and options for restoration, enhancement and corridors. Goals include 30% natural, proportions of systems similar to pre-settlement, corridor linkages.
LandCare Niagara	Natural Heritage Framework	Identifies three major natural heritage areas: Niagara River to QEW corridor; Beaver Creek corridor and Humberstone Marsh; plus general linkage zones and rights-of-way.

3.2 Objectives

General

To paraphrase the MOEE/MNR in "Water Management on A Watershed Basis" (1993), the general objective is "to produce a watershed plan developed in consultation with appropriate government agencies, and other stakeholders to manage water, land/water interactions, aquatic life and aquatic resources in order to protect and improve the health of the watershed ecosystem as land uses change".

Specific Goals from Local Initiatives:

Niagara Water Quality Protection Strategy

The NWQPS (2003) identified the need to manage watersheds in such a manner as to "sustain healthy rural and urban communities in harmony with a natural environment, rich in species diversity".

Niagara River Remedial Action Plan

The Niagara River Redial Action Plan (RAP), started in 1993, identified an Area of Concern (AOC) which covers a large portion of the Fort Erie Creeks Watershed Plan study area. The Stage I Report (Environmental conditions and Problem Definition) was published in 1993, and the Stage II Implementation Annex, which outlined the numerous objectives/recommendations of the RAP, as well as the Agencies responsible for implementation, a schedule, and projected costs, was published in 2005.

In 2004, a ten-year review of the Stage II Report was initiated, to reflect the changing criteria and status of some of the impairments. This resulted in a new list of 12 Recommendations (replacing the 37 Stage II recommendations from 1995):

TABLE 3.1.4 CURRENT NIAGARA RIVER REMEDIAL ACTION PLAN RECOMMENDATIONS	
Category	**Recommendations**
Water Quality – Municipal	*Implement municipal storm and waste water quality improvement projects through infrastructure upgrades, optimization, pollution prevention and control planning initiatives.*
Water Quality – Rural	*Identify priority target areas for water quality and habitat improvement and encourage landowner participation through funding incentives, education, and outreach.*
Sediment Quality	*Implement the sediment remediation actions identified through the management plans for contaminated sediment sites in the AOC.*
Biota/Habitat/Land Use	*Support the implementation of municipal natural heritage strategies within the Niagara River AOC.*
Human Health	*While fish consumption advisories are necessary, adequately communicate and encourage the use of: (1) the government's "Guide to Eating Ontario Sport Fish" and (2) any advisories to protect human consumers from consumption of snapping turtle.*
Surveillance & Monitoring	*Establish and support a monitoring plan for the RAP.*
Outreach & Education	*Develop and deliver education and community programs that address matters of interest to the RAP or that support RAP implementation.*
General	*Provincial and federal governments continue an integrated ecosystem approach to management for its agencies.*
	All levels of government continue providing resources for RAP initiatives and make projects in Great Lakes AOCs a priority for infrastructure funding.
	The Niagara River RAP endorse and encourage the process of multi-sectoral liaison committees as the vehicle to facilitate the satisfactory remediation of water quality in the Niagara River AOC.
	That the NPCA maintain its G.I.S. restoration database as a tool in determining priority areas for remediation within the watershed and collaborate with NWS in G.I.S. information management.
	Continue to protect natural habitat on both sides of the Niagara River as one ecosystem and seek opportunities for international cooperation.

Town of Fort Erie Official Plan

The Town of Fort Erie Official Plan (adopted by Town Council September 11, 2006) states the goal for the environment is "To provide present and future residents of the Town with a high quality living environment that protects and enhances natural heritage features, minimizes pollution of water, air, and land resources and ensures good community planning and design". The Official Plan lists a further six objectives:

a) *"Tog encourage the efficient use of land resources in the Town and to encourage the continuation of viable agricultural operations and conservation of the rural landscape.*

b) *To identify Natural Hazard Areas for the protection of life and property.*

c) *To ensure urban development is attractive and appropriately considers the protection of natural heritage features and functions from the site specific to watershed levels.*

d) *To encourage early recognition and regulation of existing and potentially incompatible uses resulting from adverse environmental effects, including sound, vibration and gas odour.*

e) *To ensure the preservation of Lake Erie, the Niagara River and their shorelines as major environmental resources, consistent with the recreational potential and the needs of the resident and tourist population.*

f) *To recognize the importance of the Niagara River as one of forty-three Areas of Concern in the Great Lakes Basin identified by the federal and provincial governments in cooperation with the International Joint Commission."*

Friends of Fort Erie Creeks

The Friends of Fort Erie Creeks is an active local interest group, whose objectives include the annual monitoring of the creeks for water quality, fisheries, and erosion. The group also manages local restoration and clean-up projects. One other objective is to co-ordinate research and summer student employment programs in the study area.

Goals Developed Through Public Consultation

Three goals or vision statements were developed at the first workshop, held in April 2006. These goals were further broken down into a long-list of issues at the second workshop, held in October 2006. The goals or objectives developed by the Public were:

1. *That our community learns how to maintain the natural features of our watershed and continues to work together to enhance and appreciate its value for seven generations.*
2. *Attractive, healthy, functioning natural areas (creeks, shoreline, natural heritage features) become the focal point for land use planning, integrating opportunities managed human access.*
3. *Better maintained creeks, with less debris jams, a marsh at creek outlets to trap sediment, grassed buffers, enhanced water and land values, undoing years of abuse, and nature/development/farming in harmony.*

Through the consultation with the Public, the following objectives were recorded:

1. Protect, Enhance and Restore Watercourses/Wetlands/Woodlots
2. Manage Urban Runoff from Existing and Future Development Areas
3. Address Impacts from Point and Non-Point Source Contaminants
4. Preserve and Enhance the quality and quantity of groundwater.
5. Protect the Lake Erie and Niagara River shorelines.
6. Integrate rural and agricultural land uses with the ecosystem.

3.2.1 Hydrogeology

- Develop the Study Area in a manner that maintains and/or enhances groundwater recharge and prevents groundwater level declines and reductions in baseflow. Ensure that future baseflow maintains permanent and seasonal fish habitat where the groundwater function exists.

- Minimize the potential negative impacts arising from land use practices and/or development (i.e. pesticides, herbicides, and fertilizers; septic systems, stormwater infiltration, leaky underground storage tanks) which represents a threat to groundwater quality for water wells and ultimately stream water quality.

- Provide guidelines to carry out Phased Hydrogeologic Studies for development applications. These studies would confirm and refine the hydrogeologic sensitivity of the development setting within the context of the type of development and potential impacts to groundwater quantity and quality.

- Carry out water well surveys in areas of high density development (i.e. 5 or more units on less than 2 acres lots and/or the areas can be refined at the outset of the study) on private wells and septic systems to assess potential aquifer contamination, water well integrity and management options.

3.2.2 Flooding

- Mitigate or eliminate currently flood prone areas.

- Control future development flows so that flood potential throughout the watershed, and in particular in the identified flood damage centres do not increase.

- Manage flooding concerns in a manner that maintains fish habitat and any other natural resources or features.

3.2.3 Erosion

- Mitigate potential erosion impacts through control of peak flow rates and runoff volumes from the development area through implementation of erosion control storage.

- Manage stream bank erosion in a manner which maintains fish habitat and any other natural resources or features.

- Where necessary, address severe erosion through "natural" stabilization measures.

3.2.4 Stream Morphology

- Encourage protection of well-defined watercourse features including those watercourses which periodically are dry.

- Where appropriate and feasible; restore sinuosity, maintain and protect physical habitat attributes (pool, riffles, etc.); maintain diversity and fluvial processes; prevent increases in erosion and deposition.

- Characterize each reach in the study area and, based on the morphological attributes of each channel reach, determine the physical and biological health of the watercourses.

3.2.5 Aquatic Habitat and Fisheries

- Minimize thermal impacts of development on the Fort Erie Creeks and their tributaries.

- Ensure that no net loss of productive capacity of the existing fish habitat occurs, and incorporate enhancement where feasible.

- Prevent installation of barriers to movement permanently or seasonally where upstream habitat exists and remove existing barriers where possible.

- Maintain associated floodplain and riparian habitat linkages to the stream habitat.

3.2.6 Surface Water Quality

- Control quality of stormwater runoff from future developed surfaces so that existing stream and groundwater quality is maintained.

- Utilize source control management techniques wherever feasible to maintain hydrogeologic functions of the study area.

- Identify other potential contaminant sources in the watershed (historical and current).

3.2.7 Terrestrial Natural Heritage

Objectives for natural heritage (ref. Table 3.2.1) are advanced to meet the requirements and main objectives of the policies and strategies listed in Tables 3.1.1 and 3.1.3, as well as those identified by the public.

TABLE 3.2.1:
OBJECTIVES FOR TERRESTRIAL NATURAL HERITAGE: FORT ERIE WATERSHEDS

Theme	Objective
Ecological Health	Maintain and improve the natural heritage system including its natural features, areas, diversity and connectivity while protecting the area's significant species, specialized or threatened habitats and distinct character.
Ecological Services	Protect and restore natural ecosystems that perform important ecological services contributing to the economic, social and ecological health of the area
Public Awareness	Promote community participation and awareness of a: the value and distinctiveness of its natural heritage and functioning; and b) the plan's stewardship opportunities for citizens to maintain, improve and monitor natural heritage.
Flexibility	Build in flexibility for landowner options and for future knowledge and issues
Compatibility	Comply with existing policies, strategies and plans (see Table 3.1.3) with priority to PPS and Region's and Towns' OP's
Update	Maintain relevancy through current information

3.3 Targets

3.3.1 Storm Drainage System

Town of Fort Erie standards require that the design of each subdivision include provisions for a minor system (i.e. storm sewer) which is sized for the 5 year return period event as well as major system overland flow routes. Major and minor system capacity on streets and overland flow routes must be provided to a minimum of the 100 year return event peak flows.

Drainage areas greater than 40 to 80 hectares may require dedicated overland flow routes in addition to that provided through area roadways.

Storm drainage systems must be designed with consideration of upstream development in accordance with the Official Plan.

- Maintain pre-development flow duration exceedance characteristics.
- Future development should control peak flow rates to existing levels for the 1:2 year to 1:100 year design events inclusively. Erosion control facilities should be installed in the study area, and should be considered on a subwatershed basis.

3.3.2 Creek Erosion

Erosion impact mitigation has been proposed to be addressed through incorporation of extended detention storage within stormwater management facilities. The volume of extended detention storage has been based on the requirements to detain site runoff resulting from a four hour, 25 mm rainfall event as recommended in the stormwater management planning manual (ref. MOE, 2003). This volumetric criterion has been evaluated in the context of specific recommendations in the Watershed Plan. Future local study would be needed to further refine this approach.

3.3.3 Water Quality

The Ministry of the Environment Stormwater Management Practices Planning and Design Manual outlines storage requirements for water quality treatment for each type of stormwater management technique. Fisheries habitat constraints indicate that between a Level 1 and Level 3 Habitat protection level would be required.

Due to the recreational swimming uses of Lake Erie and Niagara River, the Town requires the effluent to have less than 100 fecal coliforms per 100 ml except for four occurrences annually (Town of Fort Erie, Storm Drainage Master Plan, by Kerry T. Howe Engineering Ltd. May 1994).

3.3.4 Terrestrial Natural Heritage

Objective 1: Maintain and improve the natural heritage system including its natural features, areas, diversity and connectivity while protecting the area's significant species, specialized or threatened habitats and distinct character.

Targets:

- Environment Canada-based minimum guidelines for wetland, forest, interior forest and riparian cover
- Development directed away from natural features and areas
- Corridors in draft OP's of the Towns of Fort Erie and Port Colborne, the Region's OP and LandCare Niagara, linking with neighbouring watersheds
- Functional natural landscapes in proportion to original
- Enhancement for accessible opportunities in immature successional areas where the slough mosaic has been levelled
- Restoration that replicates the functioning of original natural landscapes
- Priority of globally significant communities

Objective 2: Protect and restore natural ecosystems that perform important ecological services contributing to the economic, social and ecological health of the area.

Targets:

- Priority to long-term protection: of globally provincially, regionally and locally significant natural features, functions and areas
- Methods to: minimize nuisance wildlife and invasive exotics; maintain wetlands while also maintaining drains; minimize off-site impacts on natural areas; use natural heritage sustainability
- Restoration area options important for water protection that avoid prime farmland.
- Compact urban areas, efficient growth patterns, green infrastructure encouraged.
- Encourage options for rural income based on sustainable natural heritage use.

Objective 3: Promote community participation and awareness of a) the value and distinctiveness of its natural heritage and functioning; and b) the plan's stewardship opportunities for citizens to maintain, improve and monitor natural heritage.

Targets:

- User-friendly subwatershed-based summaries of ecosystem functioning, issues and possible actions.
- Promotion of agency-private-NGO partnerships, information sharing, cost sharing among beneficiaries and actions towards common goals.
- Suggestions for increasing passive recreational public access to natural areas and shorelines.

Objective 4: Build in flexibility for landowner options and for future knowledge and issues.

Targets:

- Priority to protection
- Outline of a strategy to monitor natural ecosystem functioning and cumulative impacts: participatory, scientifically valid, inexpensive, long term, compatible with regional monitoring systems; produces highly accessible and meaningful output
- Options for enhancement and restoration areas

Objective 5: Comply with existing policies, strategies and plans

Targets:

- Objectives and targets of documents in Table 3.1.3 fulfilled
- Support for all regulatory requirements.

Objective 6: Maintain relevancy through current information

Targets:

- Knowledge gaps flagged
- Response to long term issues such as climate change and peak oil (point, some experts predict as soon, when oil production will start to decline rapidly and prices start to soar, once easily accessible fields are depleted.)
- Encourage adaptation to monitoring findings, new knowledge and new issues.

4. IMPACT ASSESSMENT

As outlined in Section 2, the Watershed Plan is not intended to prescribe land uses or specific locations for development, as this planning process is being completed by the Town of Fort Erie, through an updated Official Plan process. Rather it is the intent that this Watershed Plan complement land use planning and allow for an integration of the Watershed Plan findings with the Official Plan, through the definition of constraints and management opportunities.

This report section specifically provides insight as to the impact of proposed development on the important resources in the Watershed Plan study area, in terms of the quantity of runoff (baseflow, flooding and erosion), quality of runoff, the natural heritage system, and the watercourse systems.

Through the exercise of conducting the impact assessment, each of the sub-disciplines has generated a set of key issues, or constraint areas where mitigation protection or restoration efforts will be required. A graphical depiction of the issues for the entire study area is shown on Drawing 1 as a complement to this assessment.

4.1 Water Quantity

4.1.1 Groundwater and Baseflow

The primary impacts to quantity and quality within the groundwater flow systems are caused by a (1) a reduction in recharge by reducing the ground surface permeability for infiltration, (2) groundwater pumping, and (3) introduction of contaminants (i.e. pesticides, herbicides, and fertilizers; septic systems, stormwater infiltration, leaky underground storage tanks). In addition to impacting the local water wells, the subsequent groundwater discharge to local streams and wetlands may be impacted. At this time there is no definitive data or observations which would indicate any significant impacts to the local groundwater flow systems. Areas where there are higher densities of private wells and septic systems (i.e. southern part of Six Mile Creek and Bertie Bay Drains) are more prone to local contamination relating to nitrogen species and bacteria. These conditions may be very local to the aquifer or the site specific well. Potential impacts resulting from future land use change should be analyzed through site specific studies at the design stage.

4.1.2 Flooding

Hydrologic processes are central to many of the natural functions and features within the study area, hence maintaining or enhancing hydrologic functions as land uses change is important to preserve existing resources. Significant alterations to subwatershed hydrologic response may negatively impact on the receiving system, in terms of increased flood potential, reduced baseflows and alterations to channel forming processes, as well as the aquatic systems which are supported.

The purpose of the hydrologic modeling has been to evaluate the impact of development on the hydrologic processes within the subwatershed areas and to determine potential methods to manage impacts, specifically:

- *Baseflow flow*
- *peak flow rates and flood potential*
- *in-stream erosion potential*

A Future Land Use hydrologic model has been developed based on the proposed urban development within Subwatershed Areas. The impervious coverage for future conditions has been based on the Town of Fort Erie Official Plan (September 11, 2006).

The hydrology of the entire study area has been estimated using SWMHYMO for existing land use and for future land uses. The hydrological model and its parameters have been discussed in Section 2. Table 4.1.1 summarizes the frequency flows for existing land use for the various subwatersheds at key points of interest (ref. Figure 8 for nodal locations).

TABLE 4.1.1:
FREQUENCY FLOWS (m3/s)
EXISTING LAND USE

Location		Node	Frequency (year)					
			2	**5**	**10**	**25**	**50**	**100**
Black Creek								
Tributary 1	At outlet to Niagara River		9.62	29.31	46.11	70.20	89.88	110.53
Tributary 1	At QEW - Conf of Black and Beaver	BLK-19	9.04	28.03	44.31	67.70	86.88	106.93
Tributary 1	Before Conf. with Beaver	BLK-18	6.74	19.12	29.11	43.28	54.93	66.91
Tributary 1	Before Snyder Drain	BLK-16	5.93	17.15	26.16	39.02	49.56	60.38
Tributary 1	After Conf. With Tr. 2	BLK14	5.67	16.46	25.10	37.48	47.58	57.96
Tributary 1	Before Conf. With Tr. 2	BLK13	1.38	3.60	5.37	7.84	9.84	11.90
Tributary 1	After Blk101	BLK11	0.69	1.79	2.65	3.85	4.82	5.83
Tributary 1	Headwater	BLK100	0.38	0.92	1.35	1.94	2.40	2.87
Tributary 2	Before Conf. With Tr. 1 (Flow Gauge)	BLK25	4.29	12.87	19.75	29.65	37.75	46.08
Tributary 2	Add BLK301	BLK31	4.18	12.42	19.26	29.15	37.16	45.47
Tributary 2	Before Conf. With March Dr (Tr3)	BLK-24	1.85	5.85	9.20	14.05	17.99	22.03
Tributary 2	Headwater	BLK-23	1.39	4.65	7.38	11.93	14.63	17.96
Tributary 2	Headwater	BLK-22	0.79	2.79	4.55	7.16	9.29	11.48
Tributary 3	Conf of Tr.4, Tr.5 with Tr.3	MAD-11	1.24	3.46	5.31	7.95	10.08	12.31
Tributary 3	Tr.6 in Tr. 3	MAD-13	2.21	6.27	9.71	14.62	18.55	22.70
Tributary 4	Tr.4	MAD-10	0.89	2.58	4.01	6.08	7.76	9.52
Tributary 5	Tr.5	RTD-10	0.44	1.16	1.74	2.55	3.19	3.86
Tributary 6	Conf. With Schihl Drain	STJ-11	1.21	3.30	4.97	7.33	9.19	11.14
Tributary 6	Headwater	STJ-10+STJ102	0.73	1.99	3.02	4.49	5.63	6.85
Tributary 7	Headwater	SCH100+SCH101	0.53	1.39	2.09	3.07	3.85	4.65
Beaver Creek								
Tributary 1	before conf. With Black Cr	BEV 29.1 + BEV 211	2.44	8.92	15.26	24.64	32.48	40.66
Tributary 1		BEV-29	1.90	6.80	11.87	19.32	25.54	32.31
Tributary 1	After Conf. With Tr. 2	BEV-27	1.87	6.02	9.90	16.16	21.03	26.53

TABLE 4.1.1: FREQUENCY FLOWS (m3/s) EXISTING LAND USE								
Location		**Node**	**Frequency (year)**					
			2	**5**	**10**	**25**	**50**	**100**
Tributary 1		BEV-17	1.55	4.95	8.05	12.38	16.09	19.88
Tributary 1		BEV-16	1.33	4.01	6.30	9.62	12.38	15.21
Tributary 1		BEV-14	1.25	3.66	5.69	8.63	11.07	13.55
Tributary 1	Tr.1 Headwater	BEV-13	0.89	2.29	3.44	5.12	6.50	7.93
Tributary 2	Before Conf with Tr. 1	BEV-26	1.65	5.22	8.71	13.72	17.87	22.29
Tributary 2		BEV-23	1.41	3.83	6.09	8.90	11.33	13.90
Tributary 2		BEV-21	1.34	3.70	5.81	8.58	10.89	13.40
Tributary 2	Tr.2 Headwater	BEV-20	0.71	1.85	2.77	4.05	5.07	6.12
Six Mile Creek								
Mann Drain	Mann Drain Tr. 3	MAN 101	1.06	2.28	2.58	4.46	6.04	8.13
Mann Drain	Mann Drain Tr. 4	MAN 100	0.77	2.15	3.29	4.89	6.17	7.5
Mann Drain	Mann Drain Tr. 3	MAN-10	1.52	4.36	5.82	9.32	12.14	15.31
Six Mile Creek	Six Mile Cr. Tr. 1	SIX-40	0.96	2.38	3.52	5.11	6.38	7.68
Six Mile Creek	Six Mile Cr. Tr. 2	SIX-11	0.77	2.45	3.89	5.96	7.65	9.40
Six Mile Creek	Conf. Of Tr.1 and Tr. 2	SIX-22	2.50	7.07	10.91	16.36	20.77	25.36
Six Mile Creek	Six Mile Cr. Tr. 1 and Mann Drain	SIX-14	4.82	13.15	20.10	30.46	38.81	47.40
Miller Creek								
Miller Creek	Headwaters	MIL 100	0.92	2.49	3.76	5.54	6.98	8.46
Miller Creek		MIL-11	1.18	3.35	5.12	7.63	9.68	11.80
Miller Creek	At outlet	MIL-12	1.69	4.42	6.61	9.69	12.17	14.71
Kraft Drain								
Tributary 1	Headwater	KRD 100	0.19	0.53	0.90	1.56	2.29	3.05
Tributary 1	Headwater	KRD 102	0.58	1.64	3.03	5.30	7.33	9.67
Tributary 2	Headwater	KRD 103	0.37	1.02	1.57	2.34	2.96	3.60
Tributary 3	Headwater	KRD-12	0.71	1.92	3.24	5.31	7.10	9.23
At Outlet	Confluence of all Tributaries	KRD-13	1.25	3.49	5.73	9.10	12.10	15.51
Baker Creek								
Baker Creek	Headwaters	BAK-10	0.49	1.34	2.03	3.01	3.79	4.60
Baker Creek	Conf. With Dr. Cobb Drain	Outlet	0.83	2.12	3.14	4.62	5.81	7.07

In order to assess the potential impacts of future development on peak flows, the Draft Official Plan has been reviewed (ref. March 2006). Most of the future development in the Town of Fort Erie would proceed as ‘Greenfield’ development. The Official Plan also suggests the re-designation of certain residential designations to urban designations with an Environmental Conservation overlay designation. Since the Official Plan is in a draft form, a land use plan with conservatively high imperviousness has been used for further analyses. Overall, future imperviousness, within the study area, would increase from 5.8 % (+/-) at present to 10 % (+/-) (ref. Table 4.1.2).

TABLE 4.1.2: PROPOSED INCREASE IN IMPERVIOUS AREA BY CATCHMENT				
Watershed / Subcatchment	Drainage Area (km2)	Impervious Area (km2)		Increase in % Imperviousness
		Existing	Future	
BLK 205	2.99	0.75	1.36	21%
BEV 202	0.66	0.28	0.35	11%
BEV 2020	0.43	0.00	0.05	13%
BEV 203	0.56	0.17	0.27	19%
MIL 100	4.45	0.16	1.20	24%
MIL 101	2.06	0.00	0.35	17%
BAK 200	1.20	0.01	0.21	17%
KRD 100	0.67	0.05	0.41	55%
KRD 101	1.15	0.34	0.49	13%
KRD 102	1.64	0.06	0.41	22%
KRD 103	2.09	0.02	0.28	13%
BER 102	0.89	0.01	0.12	13%
MAN 102	0.75	0.00	0.14	19%
SIX 102	1.33	0.00	0.15	12%
SIX 103	2.21	0.00	0.35	16%
SIX 400	3.40	0.14	0.63	15%

The future land use mapping by the Town has been used to develop the hydrologic model input parameters and accordingly a SWMHYMO model has been developed. The frequency flows have been summarized in Table 4.1.3, and the increase in 100 year peak flows, at the outlet of each watershed, have been summarized in Table 4.1.4.

TABLE 4.1.3: FREQUENCY FLOWS (m^3/s) FUTURE LAND USE								
Location		Node	Frequency (year)					
			2	5	10	25	50	100
Black Creek								
Tributary 1	At outlet to Niagara River	BLK-20	10.63	30.90	48.10	72.58	92.59	113.40
Tributary 1	At QEW - Conf of Black and Beaver	BLK-19	10.08	29.68	46.35	70.13	89.63	109.84
Tributary 1	Before Conf. with Beaver	BLK-18	7.48	19.91	30.01	44.33	56.08	68.10
Tributary 1	Before Snyder Drain	BLK-16	6.61	17.82	26.92	39.90	50.12	61.38
Tributary 1	After Conf. With Tr. 2	BLK14	6.29	17.06	25.80	38.28	48.44	58.86
Tributary 1	Before Conf. With Tr. 2	BLK13	1.48	3.75	5.55	8.06	10.08	12.17
Tributary 1	After Blk101	BLK11	0.73	1.86	2.74	3.96	4.94	5.96
Tributary 1	Headwater	BLK100	0.38	0.92	1.35	1.94	2.40	2.87
Tributary 2	Before Conf. With Tr. 1 (Flow Gauge)	BLK25	4.83	13.32	20.26	30.23	38.37	46.71
Tributary 2	Add BLK301	BLK31	4.52	12.97	19.88	29.84	37.91	46.25
Tributary 2	Before Conf. With March Dr (Tr3)	BLK-24	2.15	6.37	9.81	14.74	18.76	22.84
Tributary 2	Headwater	BLK-23	1.68	5.15	7.97	12.04	15.36	18.73
Tributary 2	Headwater	BLK-22	0.97	3.16	4.94	7.59	9.76	11.98
Tributary 3	Conf of Tr.4, Tr.5 with Tr.3	MAD-11	1.24	3.46	5.31	7.95	10.08	12.31
Tributary 3	Tr.6 in Tr. 3	MAD-13	2.22	6.29	9.73	14.65	18.57	22.72
Tributary 4	Tr.4	MAD-10	0.89	2.58	4.01	6.08	7.76	9.52
Tributary 5	Tr.5	RTD-10	0.44	1.16	1.74	2.55	3.19	3.86
Tributary 6	Conf. With Schihl Drain	STJ-11	1.22	3.31	4.98	7.35	9.21	11.16
Tributary 6	Headwater	STJ-10+STJ102	0.74	2.00	3.04	4.51	5.65	6.87

TABLE 4.1.3: FREQUENCY FLOWS (m^3/s) FUTURE LAND USE								
Location		**Node**	**Frequency (year)**					
			2	**5**	**10**	**25**	**50**	**100**
Tributary 7	Headwater	SCH100+SCH101	0.53	1.39	2.09	3.07	3.85	4.66
Beaver Creek								
Tributary 1	before conf. With Black Cr	BEV 29.1 + BEV 211	2.77	9.82	16.44	26.10	34.14	42.52
Tributary 1		BEV-29	2.27	7.68	13.20	20.92	27.39	34.28
Tributary 1	After Conf. With Tr. 2	BEV-27	2.20	6.72	11.23	17.39	22.69	28.15
Tributary 1		BEV-17	1.73	5.45	8.66	13.25	16.97	20.88
Tributary 1		BEV-16	1.57	4.39	6.86	10.33	13.12	15.99
Tributary 1		BEV-14	1.45	4.05	6.27	9.36	11.85	14.39
Tributary 1	Tr.1 Headwater	BEV-13	1.05	2.65	3.93	5.79	7.23	8.76
Tributary 2	Before Conf with Tr. 1	BEV-26	2.00	5.99	9.99	15.07	19.53	23.99
Tributary 2		BEV-23	1.63	4.24	6.55	9.68	12.13	15.17
Tributary 2		BEV-21	1.45	3.91	6.08	8.83	11.29	13.77
Tributary 2	Tr.2 Headwater	BEV-20	0.76	1.92	2.85	4.13	5.16	6.21
Six Mile Creek								
Mann Drain	Mann Drain Tr. 3	MAN 101	1.06	2.28	2.58	4.46	6.04	8.13
Mann Drain	Mann Drain Tr. 4	MAN 100	1.17	2.84	4.14	5.91	7.29	8.70
Mann Drain	Mann Drain Tr. 3	MAN-10	1.92	5.06	6.64	10.35	13.27	16.55
Six Mile Creek	Six Mile Cr. Tr. 1	SIX-40	1.14	2.76	4.02	5.75	7.11	8.50
Six Mile Creek	Six Mile Cr. Tr. 2	SIX-11	0.77	2.45	3.89	5.96	7.65	9.40
Six Mile Creek	Conf. Of Tr.1 and Tr. 2	SIX-22	2.95	7.94	12.02	17.75	22.35	27.09
Six Mile Creek	Six Mile Cr. Tr. 1 and Mann Drain	SIX-14	5.94	15.21	22.73	33.68	42.42	51.33
Miller Creek								
Miller Creek	Headwaters	MIL 100	2.06	4.26	6.75	10.71	14.97	18.63
Miller Creek		MIL-11	2.40	5.48	8.36	12.69	16.09	19.68
Miller Creek	At outlet	MIL-12	2.22	5.45	8.32	12.43	15.93	19.36
Kraft Drain								
Tributary 1	Headwater	KRD 100	0.76	1.82	2.85	4.15	5.27	6.49
Tributary 1	Headwater	KRD 102	1.33	2.42	3.93	6.61	8.96	11.73
Tributary 2	Headwater	KRD 103	0.41	1.10	1.67	2.46	3.09	3.75
Tributary 3	Headwater	KRD-12	1.41	3.67	5.77	8.65	11.04	13.87
At Outlet	Confluence of all Tributaries	KRD-13	2.09	5.42	8.27	12.65	16.44	20.74
Baker Creek								
Baker Creek	Headwaters	Bak-10	0.56	1.47	2.20	3.20	4.01	4.84
Baker Creek	Conf. With Dr. Cobb Drain	Outlet	1.06	2.50	3.61	5.17	6.43	7.75

TABLE 4.1.4: 100 YEAR PEAK FLOW COMPARISON AT SUBWATERSHED OUTLET					
Subwatershed	Area (ha)	Existing Peak Flow	Future Peak Flow (m^3/s)	Increase in Peak Flow (m3/s)	
		(m^3/s)	(m^3/s)	(m^3/s)	(%)
Black Creek (At Confluence with Beaver Creek)	6374	66.91	68.1	1.19	2%
Beaver Creek (At Confluence with Black Creek)	3777	40.66	42.52	1.86	5%
Black Creek at Outlet	10656	110.53	113.4	2.87	3%
Six Mile Creek E.F	1805	47.4	51.33	3.93	8%
Miller Creek	901	14.71	19.36	4.65	32%
Baker Creek	431	7.07	7.75	0.68	10%
Kraft Drain	555	15.51	20.74	5.23	34%

The results indicate that the 100 year flows would marginally increase in Black Creek and Beaver Creek, while they would significantly increase in the Six Mile Creek, Miller Creek, Baker Creek and Kraft Drain, due to the planned urbanization in these watersheds (without stormwater management). Table 4.1.5 provides the difference in peak flows at the subcatchments where the catchment scale percentage imperviousness has increased 10% or more (ref. Drawing 1).

TABLE 4.1.5: CHANGE IN PEAK FLOWS (m3/s)							
Watershed / Subcatchment	Drainage Area	Frequency / Land Use					
		5 Year			100 Year		
	(km2)	Existing	Future	Difference	Existing	Future	Difference
BLK 205	2.99	3.72	6.06	63%	17.80	24.30	37%
BEV 202	0.66	2.27	2.84	25%	8.98	10.18	13%
BEV 2020	0.43	0.38	0.42	11%	1.58	1.65	4%
BEV 203	0.56	1.40	2.16	54%	6.28	8.63	37%
MIL 100	4.45	2.78	5.50	98%	9.20	25.94	182%
MIL 101	2.06	1.43	1.87	31%	5.22	6.05	16%
BAK 200	1.20	0.93	1.03	11%	2.53	2.68	6%
KRD 100	0.67	0.71	2.68	277%	4.31	9.14	113%
KRD 101	1.15	2.18	2.98	37%	9.82	12.00	22%
KRD 102	1.64	1.64	2.42	48%	9.67	11.73	21%
KRD 103	2.09	1.02	1.10	8%	3.60	3.75	3%
BER 102	0.89	0.68	0.80	18%	2.74	3.20	17%
MAN 102	0.75	0.44	0.76	73%	1.75	2.37	35%
SIX 102	1.33	0.82	1.17	43%	3.26	3.93	21%
SIX 103	2.21	0.65	1.04	60%	2.82	3.63	29%
SIX 400	3.40	2.39	2.77	16%	7.71	8.53	11%

Furthermore, the floodplain mapping has been delineated using existing land use mapping, and has been reviewed for potential flooding for existing residences and/or businesses. A total of 124 structures (houses, outbuildings, culverts, bridges, and roads) have been identified as potential damage centres or flood vulnerable areas, where existing structures are situated within the 100 year (Regulatory) floodplain (ref. Drawing 1):

A complete listing of all structures identified is shown in Table 4.1.6.

TABLE 4.1.6: FORT ERIE CREEKS WATERSHED PLAN POTENTIAL 100 YEAR FLOOD DAMAGE LOCATIONS							
Watershed	**Damage Location**	**NPCA Floodline Map**	**Location**	**Infrastructure Flooded: Structures**	**Infrastructure Flooded: Culverts, Roads**	**Flood Frequency**	**Existing 100 Yr Flood Depth (m)**
BLK	1	1	West side of Creek at Switch Rd.	3 Structures		100	0.1 - 1.0
BLK	2	1,2	East side of Creek at Switch Rd.	17 Structures	Switch Road	25-100	0.1 - 1.0
BLK	3	2	Glenny Drain	3 Structures		100	<0.3
BLK	4	2	South of Townline Road	2 Structures		25	0.3 - 0.6
BLK	6	4	West of Netherby Road	20 Structures (Trailers)	Black Creek Trail	25-100	0.3 - 0.6
BLK	11	5	Winger Road	1 Structure	Culvert 26, East Main Street	25	0.5
BLK	12	6	Stevensville Road	4 Structures		50	0.5
BLK	13	8	House Road	1 Structure	House Road, College Road	100	0.1 - 0.3
BLK	15	8	College Road	1 Structure	Culvert 35	100	0.1 - 0.3
BLK	16	9	Netherby Road	3 Structures	Culvert	100	0.1 - 0.3
BLK	22	17	East of Point Abino Road	3 Structures		25-100	0.1 - 0.3
BVR	1	3	College Rd.	3 Structures (Golf Course)	College Road	25-50	0.25 - 0.8
BVR	2	22	Eagle Street	1 Structure	Culvert	100	0.1 - 0.3
FRC	1	3	Thompson Road	rear of auto yard		100	0.1-1.5
FRC	2	3	Industrial Drive	6 structures		100	0.1-1.5
FRC	3	5	Sunset Drive	1 structure	Culvert 12 (NPCA 2004)	100	0.1
KRD	4	2	Limit of Study	3 Structures		25	0.3
SIX	3	1	North of Thunder Bay Road	16 Structures	Shirley Rd, Neva/Poplar/Bethune Ave	25	0.3
SIX	5	2	NE Corner Dominion Rd. & Centralia Ave.	2 Structures		50	0.3
SIX	8	4	Centralia Avenue North		Culvert 82	10	
SIX	9	5	Bernard Avenue	2 Structures	Culvert 83	25	0.3
SIX	10	5	Bernard Avenue / Nigh Road	6 Structures	Culvert 84 / 85	5	0.3
SIX	11	6	Burleigh Road		Culvert 86 B	50	
SIX	12	6	Dominion Road		Culvert 86 A	25	
SIX	13	6	NW Corner Dominion Rd. & Burleigh Rd.	25 Structures		5	0.1 - 1.0
TOTAL	**25**			**124 structures**	**11 culverts, 10 roads**		

4.1.3 Erosion

As part of the geomorphological investigation, field reconnaissance of the main channels within the study area was completed. During the field reconnaissance, both the RSAT and RGA assessment tools were used to evaluate the quality and relative stability of each reach for each creek. The RSAT and RGA scores were tabulated and linked to their qualitative ranking and compiled (ref. Appendix 'WC-A'). This data was then used to identify the most sensitive or unstable reaches in the Town of Erie study area and used to prioritize restoration efforts. During this assessment, erosion areas were mapped and photographed (ref. Appendix 'WC-A').

Overall, there were minor amounts of erosion visible throughout the study area. However, there were a few significant areas of erosion. The prominent areas of erosion that were found within the study area were on Black Creek and Beaver Creek. Reaches BLC-11 to BLC-15 on Black Creek exhibited crib wall failure, trampled banks due to farm animals and general basal scour erosion, due to lack of riparian zones or due to wood debris jams. The upper reaches on Beaver Creek also showed significant basal scour erosion and bedrock exposure (BVC-14).

There were several other localized sites that were affected by bank and bed erosion. Reach FRC-9 on Frenchman's Creek exhibited severe bank erosion and bed incision (i.e. exposed bedrock throughout the site) because of the channel setting and the flash floods that it receives from upstream sources. Reach MLC-7 on Miller Creek had severe basal scour erosion and a watermain was situated well above the channel bed (ref. Appendix 'WC-A'). In several sections of Kraft Drain there was significant bank scour due to large debris jams. There was also a large knickpoint found on Reach KFD-4, indicating that the channel flow was constrained. The first figure, "Reaches Exhibiting Significant Erosion in Fort Erie", in Appendix 'WC-B', illustrates the location of the erosion areas.

<u>Monitoring Analysis</u>

Generally, all stable creek systems erode (e.g., eroding banks, bed scour). Erosion is a natural process that helps deliver sediment to the system. Sediment supply, transport, and deposition is necessary to help the creek system dissipate stream energy and maintain a balance between flow and channel form. However, when this process is disturbed, channel erosion and other geomorphic processes are augmented. Therefore the channel is in adjustment. In order to measure the rate of erosion and understand the geomorphic processes occurring in the Fort Erie study area, a monitoring program was established. This consisted of the establishment of permanent channel cross-sections sampling sites and erosion pins to measure the rate of adjustment.

In order to monitor changes taking place in the channels, one monitoring cross-section was established at each of the sites where detailed field work was completed and one on Beaver Creek. Each of the monitoring sites was resurveyed on June 22, 2006 and the cross-sectional area was overlain onto the original November/December, 2005 plot (ref. Appendix 'WC-C'). The overlay provides a visual representation of what, if any, changes have occurred between the monitoring dates. Although a comparison of 2005 and 2006 transects provides an indication of channel change that has occurred between these dates, it is important to recognize that they do not necessarily reflect absolute change. That is, scour and fill processes will cause an intra-annual variation of bed elevations within alluvial channels.

The overlay figures in Appendix 'WC-C' show that, overall, there has been some change in cross-sectional configuration. Frenchman's Creek, Miller Creek and Black Creek have experienced minor bed scour and bank erosion was prominent for Black Creek and Frenchman's Creek.

There was minimal to no change in cross-sectional shape for Six Mile Creek. Aggradation was observed at the centre of the channel and on the left bank for Beaver Creek.

Erosion pins provide information regarding rates of bank erosion. Bank erosion rates are a product of channel migration and channel widening. Erosion pins were installed along the length of each detailed field site in combination with the control cross-sections (ref. Appendix 'WC-C'). The exposed length of erosion pins was measured once during the study period after their installation. Appendix 'WC-C' displays the annual rate of change (in meters) of each of the erosion pins.

The highest rates of erosion were occurring within Frenchman's Creek and Beaver Creek. Three erosion pins were installed within Bridgewater's Golf Course on Frenchman's Creek. Two out of the three erosion pins had an erosion rate of 0.10 m/yr. The third erosion pin was a control pin; therefore, it exhibited no net change. The large erosion rates for the reach located in Bridgewater Golf Course may be indicative of the surrounding land use. Typically in a golf course, the vegetative buffer zone is small, therefore there is not enough root structure support to hold the banks together. However, the vegetative buffer zone within this golf club is well established, therefore a better explanation of the erosion occurring within this reach is due to events occurring upstream of this reach.

The large change in cross-sectional area and erosion pin results for Beaver Creek is indicative of the general setting. Reach BVC-2 is a marsh area that is always fluctuating.

There was very little change in erosion pins for Six Mile Creek as confirmed by the no net change in cross-sectional shape. For Black Creek and Miller Creek, there was minor erosion for each of the banks.

<u>Erosion Thresholds</u>

Erosion thresholds were determined at each of the sites where detailed field work was completed. Erosion thresholds determine the magnitude of flows required to potentially erode and transport sediment. Therefore, these thresholds provide acceptable limits that prevent an increase in channel erosion and deposition beyond the natural rates. These results have been applied to assist with determining recommended locations for stormwater management within the Fort Erie area (ref. Section 5).

The collection of detailed field information was pertinent to modeling erosion thresholds. The calculations performed to determine critical discharge for bed materials were based on formulas for critical shear stress. Critical discharge is the minimum amount of discharge required to erode the channel bed and banks. Selection of appropriate thresholds was, in part, dictated by indicators of active processes (e.g. widening or entrenchment), and channel substrate.

For Black Creek, Miller's Creek, and Six Mile Creek, shear stress equations for cohesive materials were applied to the bed material (Chow, 1959). For, Frenchman's Creek shear stress equations for non-cohesive materials were used (Fischenich, 2001). The erosion thresholds were based on the threshold for the D50 (median grain size), which is the general practice. These thresholds were based on tables provided in Chow (1959) and Fischenich (2001).

As many of the models are based on a simplified cross-sectional geometry, several channel cross-sections were extracted from each detailed site for threshold analysis. The depth and the corresponding simplified geometry were used to produce a meaningful threshold. In all cases, a comparison between the flow competence and bankfull velocity indicates that the bed is fully mobilized around bankfull flows. This implies that sediment can be entrained below bankfull flows and that any increase in discharge within these systems will lead to increased transport and would likely exacerbate channel erosion. Table 4.1.7 provides both bankfull characteristics and erosion threshold parameters.

TABLE 4.1.7:
CHANNEL THRESHOLDS FOR EACH OF THE DETAILED SITES ASSESSED WITH THE STUDY AREA.

Parameter	Black Creek	Six Mile Creek	Millers Creek	Frenchmen's Bay
Average Bankfull Width (m)	16.10	17.23	5.60	6.11
Average Bankfull Depth (m)	0.90	0.75	0.52	0.42
Bankfull Gradient (%)	0.18	0.27	0.35	0.27
Bed Material D50 (mm)	0.0048	0.0043	0.047	7.76
Bed Material D84 (mm)	7.8	15.8	11.3	67.6
Manning's n at Bankfull	0.022	0.025	0.025	0.035
Average Bankfull Velocity (ms-1)	1.79	1.71	1.51	0.83
Average Bankfull Discharge (m3s-1)	13.30	14.39	9.81	2.03
Flow competence (ms-1) @ D50	0.017	0.016	0.048	0.507
Flow competence (ms-1) @ D84	0.508	0.703	0.603	1.37
Tractive Force at Bankfull (Nm-2)	15.89	19.93	17.68	11.04
Critical Shear (Nm-2) (D84)	5.68	11.51	8.23	5.89
Stream Power per Unit Width (Wm-2)	30.30	36.92	30.62	9.11
Critical Velocity (ms-1)	0.62	0.55	0.52	0.25
Critical Depth (m)	0.43	0.30	0.24	0.22
Critical Flow (m3s-1)	2.27	1.06	0.40	0.19
Method	Chow (1959)	Chow (1959)	Chow (1959)	Fischenich (2001)

The erosion thresholds are required to assess the impact of development on the watercourse systems.

An inventory of the reaches has been prepared to identify which reaches are nearing or above the erosion threshold. Any increase in peak flow or duration of the runoff hydrograph could potentially increase the erosion in these reaches. These reaches have been identified for protection (ref. Drawing 1) and future detailed erosion study.

The most erosion-prone reaches have been identified on Drawing 1. Several of the reaches are located downstream of existing and proposed development. Erosion control targets for new development can be determined by integrating the hydrology, hydraulics and stream morphology assessments, in future stages of supporting studies for development.

Meander Belt Widths

A meander belt width defines the area that a watercourse currently occupies or can be expected to occupy in the future. Meander belt width delineation is commonly used as a planning tool in order to protect private property and structures from erosion due to fluvial action or geotechnical instability (Parish Geomorphic Ltd., 2001a). Within a subwatershed context, studies require the general identification of meander belt widths to facilitate the planning process (ref. Appendix 'WC-D').

For the purposes of this study, meander belt widths were measured using digital mapping. The belt widths are approximate values and should be subjected to refinement during the secondary planning stage. For unconfined channels, limits of the meander belt are defined by parallel lines drawn tangential to the outside bends of the laterally extreme meanders of the planform for each reach. Several channels within the study area were straightened; therefore, a surrogate method was used to define the meander belt width. The surrogate method was developed by Parish Geomorphic Ltd., for Toronto Region Conservation (Parish Geomorphic Ltd., 2001a) and the Province of Ontario's natural channel initiative program in support of the technical requirements of the Provincial Policy Statement. The policy states when there is no historical evidence of the natural planform configuration for the altered channel, then it is appropriate to estimate the meander belt width for the study area in another manner. Specifically, if the adjoining downstream reach is characterized by the same controls and modifying influences of planform as the altered study reach, then the planform of the downstream reach can be assumed to represent the planform of the previously altered channel. This method was applied for the following reaches: BLC-21, BLC-25, BLC-28, BLC-ST-10, BLC-ST-12, BVC-3, SMC-9, BBD-1, MND-1, MND-5, MLC-2, HWB-1 and FRC-10.

Table 1 and the Meander Belt Width figure in Appendix 'WC-D', display the belt widths for the assessed reaches in each of the watersheds. Generally, the belt widths for the study area increased in the downstream direction as streams widened and increased their sinuosity, creating better-developed flood plains and increasing sediment storage.

4.2 Water Quality

A mass balance model has been developed in order to determine the impacts to water quality which would result from the proposed future development. This model has been based upon a spreadsheet analytical technique in order to obtain an estimate of annual loading from non-point sources for selected water quality parameters. While this information provides utility as a comparative tool for assessing impacts to in-stream water quality, which would be associated with proposed development and land use changes, the analyses are intended to provide a planning level estimate of the various pollutants and their sources. Instream concentrations and lethal levels of toxicity are not determined as part of this process.

The pollutants which have been evaluated has been based upon the following general and typical water quality indicators:

- Total Phosphorus
- Total Nitrogen
- Fecal Coliforms
- Total Suspended Solids
- Copper

The analytical approach is based upon the Event Mean Concentration (EMC) for each constituent and land use category. Typical annual rainfall values for the geographic area are combined with runoff coefficients based upon the prevailing soil types in order to obtain annual runoff volumes. The contaminant loading for existing land use has been summarized in Table 4.2.1 and for future land use without stormwater management has been compiled in Table 4.2.2. The results (ref. Table 4.2.3) indicate an increase in pollutant loading due to increased imperviousness (ref. Appendix 'SW-C', for details).

TABLE: 4.2.1:
SUMMARY OF ANNUAL CONTAMINANT LOADING (KG)[1]
EXISTING LAND USE

Watershed	F.Col[2]	TP	TSS	Cu	TKN
Black Creek	1.13E+11	7.12E-01	5.63E+02	1.51E-02	7.12E-01
Beaver Creek	1.46E+11	7.22E-01	5.57E+02	1.96E-02	7.22E-01
Miller Creek	6.28E+10	5.89E-01	4.83E+02	9.12E-03	5.89E-01
Baker Creek	4.65E+10	2.75E-01	2.40E+02	1.11E-02	2.75E-01
Kraft Drain	1.92E+11	4.81E-01	3.82E+02	4.03E-02	4.81E-01
Bertie Bay Drain / Hollister Drain	5.08E+11	1.08E+00	7.08E+02	8.98E-02	1.08E+00
Six Mile Creek	2.86E+11	6.79E-01	4.69E+02	4.05E-02	6.79E-01
Niagara River # 16	2.11E+11	7.01E-01	5.13E+02	2.89E-02	7.01E-01
Niagara River # 19	1.89E+11	4.75E-01	3.42E+02	2.86E-02	4.75E-01
Niagara River # 20	6.45E+11	8.03E-01	4.18E+02	8.89E-02	8.03E-01
Niagara River # 21	2.52E+11	4.04E-01	2.60E+02	3.85E-02	4.04E-01
Niagara River # 22	3.31E+11	4.84E-01	2.92E+02	4.86E-02	4.84E-01
Fort Erie	1.34E+12	1.63E+00	8.21E+02	1.83E-01	1.63E+00
Lake Shore	1.20E+12	1.46E+00	7.48E+02	1.64E-01	1.46E+00
Lake Erie	3.31E+11	4.84E-01	2.92E+02	4.86E-02	4.84E-01

1 Annual Contaminant Loading values have been determined using the tables located in Appendix 'SW-C'
2 Fecal Coliform Annual Contaminant Loading is specified in Counts/Yr

TABLE 4.22: SUMMARY OF ANNUAL CONTAMINANT LOADING (KG)[1] FUTURE LAND USE					
Watershed	F.Col[2]	TP	TSS	Cu	TKN
Black Creek	1.19E+11	7.17E-01	5.62E+02	1.56E-02	7.17E-01
Beaver Creek	1.72E+11	7.86E-01	5.98E+02	2.55E-02	7.86E-01
Miller Creek	1.22E+11	6.99E-01	5.43E+02	3.08E-02	6.99E-01
Baker Creek	5.99E+10	5.07E-01	4.17E+02	9.41E-03	5.07E-01
Kraft Drain	5.67E+11	7.50E-01	4.15E+02	8.00E-02	7.50E-01
Bertie Bay Drain / Hollister Drain	6.48E+11	1.17E+00	7.21E+02	1.12E-01	1.17E+00
Six Mile Creek F.E.	3.84E+11	1.14E+00	8.01E+02	8.60E-02	1.14E+00
Niagara River # 16	7.91E+11	1.35E+00	8.14E+02	1.06E-01	1.35E+00
Niagara River # 19	1.68E+11	9.72E-01	7.57E+02	6.97E-02	9.72E-01
Niagara River # 20	6.45E+11	8.03E-01	4.18E+02	8.89E-02	8.03E-01
Niagara River # 21	5.14E+11	1.10E+00	7.15E+02	6.79E-02	1.10E+00
Niagara River # 22	3.40E+11	5.80E-01	3.61E+02	5.57E-02	5.80E-01
Fort Erie	1.34E+12	1.63E+00	8.21E+02	1.83E-01	1.63E+00
Lake Shore	1.19E+12	1.45E+00	7.32E+02	1.63E-01	1.45E+00
Lake Erie	3.87E+11	1.04E+00	7.23E+02	8.81E-02	1.04E+00

1 Annual Contaminant Loading values have been determined using the tables located in Appendix 'SW-C'
2 Fecal Coliform Annual Contaminant Loading is specified in Counts/Yr

TABLE 4.2.3: % INCREASE IN ANNUAL CONTAMINANT LOADING DUE TO PLANNED LAND USE CHANGES					
Watershed	F.Col[1]	TP	TSS	Cu	TKN
Black Creek	6%	1%	0%	3%	1%
Beaver Creek	18%	9%	7%	30%	9%
Miller Creek	94%	19%	12%	237%	19%
Baker Creek	29%	85%	74%	-15%	85%
Kraft Drain	196%	56%	8%	98%	56%
Bertie Bay Drain / Hollister Drain	28%	8%	2%	24%	8%
Six Mile Creek F.E.	34%	67%	71%	112%	67%
Niagara River # 16	274%	93%	59%	267%	93%
Niagara River # 19	-11%	105%	121%	144%	105%
Niagara River # 20	0%	0%	0%	0%	0%
Niagara River # 21	104%	172%	175%	76%	172%
Niagara River # 22	3%	20%	24%	15%	20%

1 Fecal Coliform Annual Contaminant Loading is specified in Counts/Yr

The results suggest that even a small alteration in urbanization could significantly increase the contaminant loadings, without proper stormwater management.

4.3 Terrestrial Natural Heritage System

Impacts on terrestrial natural are discussed both for direct losses to development if the Fort Erie Official Plan is fully implemented and for the effects of other current and projected human influences on natural area and function.

A comparison of the Fort Erie Official Plan designations with the location of provincially, regionally and locally significant natural areas (LSA's) (ref. Figure NH 5) provided an indication of the potential direct impact of development on significant natural areas.

Provincial (Environmental Protection Areas or EPA's) and regional significance ratings (Environmental Conservation Areas or ECA's) are as designated by the Regional Municipality of Niagara (December, 2005); local significance is as designated by the Fort Erie Natural Areas Inventory (Dougan and Assoc., 2003) and applied to the Settlement Area only.

The results are presented by subwatershed in Table 4.3.1. For the Regional ECA category, the table distinguishes those areas protected by Fort Erie's ECA designation and policy that requires an assessment to ensure lack of major impact. All LSA's have been subject to more study than the ECA's; any development in or adjacent to an LSA requires an Environmental Impact Study that demonstrates lack of impact on the LSA's identified features and functions. The comparison was at a regional analysis scale rather than at the site level; the complexity of the OP digital layers restricted analysis to a qualitative visual review of the overlay.

The Town of Fort Erie Official Plan protects almost all of the significant natural areas either completely in the case of Environmental Protection Areas or, for Environmental Conservation Areas and Locally Significant Areas, by a requirement for an Environmental Impact Statement.

It should be noted that ECA's (including LSA's) identified in the Town of Fort Erie or Regional Municipality of Niagara are not completely protected features. Development may be permitted, provided the required expectations are met. In general, the amount of development allowed will depend on the significance of the feature, its makeup of features and functions, and on the magnitude of development. Some intrusion may be allowed, through justification with the EIS process, if the impacts are judged to be low enough. The EIS process remains a form of protection of the features and functions, while allowing the boundary to be finalized.

In summary:

- Provincially significant areas (Environmental Protection Areas on the Regional OP) are all designated protected except for a few very small parcels. In total area, the Town's Environmental Protection designation currently covers more area than the Region's, due in part to the fact that the Town placed 15 m either side of the Black, Beaver, Baker, Miller, Frenchman's, Kraft, and Six Mile watercourses to allow for the 100 year floodplain (the Town now has the final floodplain areas incorporated in their Official Plan). Also, the Region's Official Plan does not have the recently generated floodlines.

- Almost all Regionally significant areas (Environmental Conservation Areas in the Regional OP) are classified as Environmental Conservation in the Fort Erie OP and of these almost all are within non-development zones (i.e. Agriculture, Rural, Open Space). Several of the areas not classified ECA by the Town are also in non-development zones. A few ECA's are in development zones (i.e. Urban or Rural Residential, Commercial Industrial-Business Park, Extractive, Institutional) where proposals will trigger an assessment to document impacts.

- The Locally Significant Areas are protected either completely if under Environmental Protection Area designation or will trigger an Environmental Impact Study requirement.

Several Special Policy Areas include significant natural areas but also require their protection by meeting Natural Heritage policies.

The relatively large area of Regional Environmental Conservation Area zoned Open Space in the Niagara River Shore, south-east of the mouth of Miller Creek is also part of the important Niagara River corridor. The retention of natural cover would help maintain its role in that corridor.

Most of the Fort Erie Official Plan's proposed relatively small urban infill incursions into the Region's Environmental Conservation Areas are likely suggested as appropriate trade-offs to encourage infill and to retain the larger, more important, natural areas.

Future development is rated of Low to Moderate concern, assuming full compliance with Fort Erie and the Regional Municipality of Niagara's Official Plans.

The analysis is qualitative and regional, using regional data. Wetland revisions are on-going (Dave Heyworth, pers. comm.). Precise, up-to-date area figures would require use of the most recent and detailed data.

The Port Colborne Draft Official Plan shows no development planned for the study area with the exception of the hamlet of Sherkston. There the hamlet designation abuts a Regionally-designated Environmental Protection Area (provincial significance). Adequate buffers and application of Regional environmental policies would help mitigate possible effects.

Factors affecting natural areas extend beyond direct loss from development. Issues affecting the ecological functioning of natural areas can be classified by:

a) those related to the location, features, functioning and form of the natural areas themselves;
b) others that result from effects of nearby or upstream land uses; and
c) those that result from broader–scale influences.

Table 4.3.2 presents contributing factors for each of the three human influence classes. For each factor, the table outlines its cause, mitigation options, effects on natural area and biodiversity and effects on natural areas' ecological services - particularly on natural areas' water protection roles.

It should be noted that the mitigation listed in Table 4.3.2 should be considered voluntary, and a stewardship approach that involves the public. It should not be misconstrued as mandatory, and in being so, interfering with the continuation and expansion of agricultural activities.

The relative severity of the effects is rated. Also rated is the relative spatial extent of the influencing factor in the study area (none or very localized is Low, throughout but scattered/limited or extensive in only a small area is Moderate; throughout and extensive is High). Despite its global scope, climate change is included because its projected impacts on the hydrological cycle and biota make it a local problem with which conservation authorities and municipalities must deal (de Loë and Berg, 2006). Consideration of climate change effects will permit earlier, more effective and more efficient adaptation.

TABLE 4.3.1:
POTENTIAL INCURSIONS OF FUTURE DEVELOPMENT ON SIGNIFICANT NATURAL AREAS[1]: BROAD-SCALE[2] ANALYSIS BY SUBWATERSHED

	Provincially Significant Natural Areas With Potential Incursions According to Fort Erie OP	Regionally Significant Areas With Potential Incursions According to Fort Erie OP But Covered by Fort Erie OP Environmental Conservation Area Policy	Regional Significant Areas Not Protected by Fort Erie OP Environmental Conservation Area Policy	Locally Significant Areas (in Settlement Area) With Potential Incursions According to Fort Erie OP
Baker	An area in proposed golf course	Parts of the proposed golf course (Special Policy Area 5)	Parts of the proposed golf course (Special Policy Area 5) and small Open Space area	Parts of the proposed golf course (Special Policy Area 5)
Beaver	None	Small parts along creek valley that golf course - Open Space. A very small area to urban infill. A small area on the Frenchman's subwatershed boundary to Extractive.	Small parts along creek valley that are either golf course - Open Space or Agriculture. A very small area to urban infill. An area on the Miller subwatershed boundary to Extractive. A few narrow treed hedgerows	None
Bertie Bay + L. Erie 1	None	Some areas to residential – urban and rural	A few small areas along lakeshore	Some areas to residential- urban and rural
Black	None	Areas to Industrial-Business and to Urban and Rural Residential in Stevensville. Very small area to Urban Residential in Douglastown	Small areas along creek that Agriculture and in Douglastown and Stevensville, Open Space or urban infill	Areas to Industrial-Business and to Urban and Rural Residential in Stevensville. Very small area to Urban Residential in Douglastown
Fort Erie	None	Small area in industrial-business park and Institutional	None	Small are to Institutional
Frenchman's Creek	None	Some to Open Space at golf courses, and very small bits to Fort Erie Industrial Park (Special Policy Area 3) and Urban Entertainment Area (Special Policy Area 1). An area on the Beaver subwatershed boundary to Extractive. Some areas to Urban Residential and Industrial – Business Park	Some to Open Space at golf courses, and very small bits to Fort Erie Industrial Park (Special Policy Area 3) and Urban Entertainment Area (Special Policy Area 1).	Some areas to residential and Industrial – Business Park
Kraft Drain	Several hectares to Commercial and several to residential	Areas to Urban Residential infill and small area to Commercial	Small area to urban infill	Area in north end to Commercial. Areas to residential infill
Lakeshore	Very small area to Urban Residential	Some area to Urban Residential and a very small area to Commercial	Small areas to urban infill and Open Space	Some to Urban Residential
Miller	None	An area to Industrial-Business Park	An area on the Beaver subwatershed boundary to Extractive	An area to Industrial-Business Park (different one from Regional Significant Area incursion)
Niagara R. Shore	None	A small area to Industrial-Business Park. Possibly a very small area in the proposed golf course	Some area to Open Space	None
Six Mile Creek	A few hectares to Rural Residential and to Urban Residential	A few small areas to Urban Residential and Rural Residential	A few very small parcels to Urban infill	Some area to Rural Residential, a very small area to Urban Residential

1. Provincial and Regional significance is as designated by the Regional Municipality of Niagara's Core Natural Heritage Map (2005); Local Significance is as designated by Natural Areas Inventory: Town of Fort Erie Settlement Areas (Dougan and Associates, 2003).
2. The overlay was at a regional analysis scale rather than at the site level; the complexity of the OP digital layers restricted analysis to a qualitative visual review of the overlay.

TABLE 4.3.2: TERRESTRIAL NATURAL HERITAGE ISSUES' CONTRIBUTING FACTORS: THEIR CAUSES, MITIGATION, SEVERITY, AND EXTENT						
Contributing Factor Classes	**Contributing Factors**	**Cause**	**Mitigation**	**Effects on Natural Heritage** **Severity H=High M=Moderate L=Low**	**Effects on Ecological Services** **Severity H=High M=Moderate L=Low**	**Relative Extent Throughout Study Area**
Form and Function	Difficult delineation of wetlands: moving target for planners	Nature of flat landscape & numerous slough mosaic wetlands. Lack of central database for all agencies	Flag "possible" wetlands - all rural - and treat as ECAs Target wetland delineation refinements. Create a central database for NPCA watershed natural resource planning	M Assume most significant wetlands already evaluated. More concern in settlement areas where development more likely	L All subwatersheds but Fort Erie have >10% wetland cover counting only those already evaluated. Fort Erie subwatershed has no "possible" wetland.	H
	Fragmented habitat	Scattered residential rather than hamlet-focused development. Other intrusive land uses (e.g., wreckers, industry) Roads	New roads should try to avoid cutting through natural areas. If unavoidable, do environmental studies to direct mitigation. Discourage development in natural areas in favour of infill in built-up areas. Apply Fort Erie OP	M Worse in rural areas since urban already affected by proximity of development. Urban also should encourage infill to avoid rural sprawl.	L Minor effect.	H
	Age representation skewed to immature	Soil limitations and poor agricultural economy with some land speculation led to many abandoned areas.	Time + managed disturbance where natural disturbances are suppressed.	M Reduced representation of age classes within the watershed tends to create a more homogeneous system at the landscape level.	L Helps CO2 uptake though less aesthetically pleasing Water protection services (e.g., soil stabilization, flood moderation) are maintained.	H
	Original slough mosaic levelled away	Agriculture requires more uniform micro-topography for effective drainage and crop management. As areas are abandoned, they retain the levelled landscape.	In restoration areas and young shrub areas, create shallow irregular slough and ridge pattern before planting. Plant variety of native species appropriate to micro-topography - by hand but can be low density. Set hydrologic targets that development must meet	H Greatly reduces biodiversity by eliminating micro-habitat diversity – a major component of diversity in this landscape.	H Greatly reduces the hydrologic storage capacity of the landscape, reducing flood moderation and capacity to improve water quality. These roles will be even more important if climate change brings more extreme storm events	H
	Altered watercourses change natural drainage	Drains are necessary for viable agriculture on the wet clay soils. Maintenance is necessary to avoid flooding.	Restore slough pattern avoiding direct drain connection. In abandoned areas where surface drain system feeding the municipal drain, block the surface drains and widen some into closed off wetland sloughs. Drain naturalization when not harming agriculture. Investigate feasibility of niche crops adapted to wet soils, e.g., willow for ethanol	M Drains shift communities to drier ones. This is not severe because natural sloughs are isolated from drains and drier, mesic communities are slightly underrepresented compared to original. The drains deliver sediment & flood peaks to floodplain wetlands.	M Drains reduce water storage and contaminant uptake associated with wetlands and sloughs. Where the slough mosaic remains, the effect is less. The impacts are greater where slough mosaic is levelled or non-lacustrine (not part of natural slough mosaic landform)	M

TABLE 4.3.2: TERRESTRIAL NATURAL HERITAGE ISSUES' CONTRIBUTING FACTORS: THEIR CAUSES, MITIGATION, SEVERITY, AND EXTENT						
Contributing Factor Classes	**Contributing Factors**	**Cause**	**Mitigation**	**Effects on Natural Heritage** **Severity H=High M=Moderate L=Low**	**Effects on Ecological Services** **Severity H=High M=Moderate L=Low**	**Relative Extent Throughout Study Area**
	Lack of riparian buffer	Landowners maximizing land area under crops, cattle access or other land uses to help economic returns.	Plant buffers or allow to regenerate naturally. Downstream beneficiaries compensate owners	M Riparian buffers can be corridor linkages and habitat.	H Buffers are important for reducing non-point source pollution.	M
	Broken, incomplete habitat corridors	Intervening non-natural land uses. Lack of a corridor plan for planners and landowners to consult.	Referral to the proposed corridors when new plans or restoration opportunities arise. Manage rail and utility corridors for habitat. Restore and enhance corridors through open space.	M The relatively high natural area extent provides some opportunities for species migration.	L	M
	Beaver flooding inappropriate land uses	Unavoidable conflict of native wildlife and humans. Flat wet landscape with some natural area habitat	Act as soon as problem appears Protective material on trees Beaver baffles at culverts Consult OMNR for advice.	L Some trees cut but natural phenomenon	L	L
Other Land Uses	Current urban development	Growth in area with good climate, transportation access, some farmland	Retrofit with green roofs, street trees Develop trail systems	M Removed natural areas but not a fast urban growth area. Pets and people alter biota in nearby natural areas.	M Removed ecological services but not a fast urban growth area.	M
	Spreading imperviousness	Development adds impermeable surfaces	Encourage green roofs, urban trees	H Alters downstream floodplain hydrology and habitat conditions	M Downstream areas still function but less effectively; removes functioning of paved areas	L
	QEW and other existing roads	Population Car society Border location NAFTA	Reduce use of road salt, especially in priority areas, using recommendations of the Region's Salt Vulnerability Study now underway	M Pervasive point source chloride that affects sensitive biota. Likely no more than most of southern Ontario.	L Blocks some drainage but in slough mosaic landscape context not serious	M
	Possible future roads	Population Car society Border location NAFTA	Include rail transit options. Route to miss natural areas Consider if expensive gas will reduce need	Depends on route	Depends on route Blocks some drainage but in slough mosaic landscape context possibly not serious	L
	Agricultural runoff	Industrial agriculture Lack of stream/drain buffers Nutrient management problems Poor farm economy Clay soil	Better buffers Higher food prices Urban financial support for rural water protection Private land stewardship	H Over-enriches floodplain & lake ecosystems, reducing diversity. Sediment blocks light to aquatic systems and fills/alters wetlands	M Reduced wetland quantity and quality functions as sediment fills. Rotting algae deters beach use.	M

TABLE 4.3.2: TERRESTRIAL NATURAL HERITAGE ISSUES' CONTRIBUTING FACTORS: THEIR CAUSES, MITIGATION, SEVERITY, AND EXTENT						
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	Lakeshore development	Prime recreation, cottage & estate sites close to big cities. Improved L. Erie water quality	Boardwalks, walkway access only & info signs at public access. Restoration targeted at large lot owners. Proactive planning for reduced lake levels & exposed coastal corridor. Wind power generation might help pay to protect shore	H Globally rare communities and endangered Fowlers Toad.	M Losing possible wind power sites	M
	Golf courses – new and existing	Land available close to population centres. Older demographics.	Ecologically-aware planning to maintain best natural areas, minimize chemical use and include water retention areas.	M Removes some natural areas and potentially contaminates remaining on site or adjacent.	M Reshapes land to encourage drainage	L
	Potential Leakage from current/past Landfills (3), chemical plants/foundries (3), junkyards (6)	Old landfills had less regulation Accidental releases	Capture any runoff from landfills Plan for accidents See Section 3.2	Likely L depending on overland runoff Clay soils likely good base.		L
Broader-Scale Influences	Exotic species and pests and diseases	Global economy and goods transport Releases due to lack of awareness Poor regulations and difficult to enforce	Public education re issues & identification Better regulations and enforcement Promote and use native plants Work with nurseries to phase out invasives Locate priority management areas & circulate suitable action programs Reduce other stressors to allow system to repel pests effectively	H Potential to displace native plants especially in disturbed areas. Study area is adjacent to border and Great Lakes	L	H
	Long-range air pollution	Fossil fuel economy Downwind of industrial Ohio River Valley USA & Nanticoke, ON	Promote alternative fuels Support coal-fired generation plant at Nanticoke conversion or decommissioning	M Affects some plants	L	H
	Climate change	Fossil fuel economy	Promote alternative fuels Reduce energy use More local economy	M Wetlands on flat clay plains vulnerable	M As wetland dries flood storage capacity remains if wetland not converted	H
	Lack of public awareness	Lack of access to natural areas Lack of outdoor education Focus on technological solutions Lack of sense of place	More options for public access to natural areas Locally relevant brief accessible info on natural area values and public's role Celebrations for local natural features	H	H	H

Summary

The factors that scored a High severity of effect and a High relative extent were:

- Original slough mosaic levelled and related functions lost,
- Exotic Species (e.g., pests, diseases), and
- Lack of public awareness.

The latter two are very broad level issues not exclusive to the Fort Erie Creeks watershed area. They do or will, however, affect the watershed significantly. Although obviously requiring broad-scale response far beyond the study area, local actions can have a major effect on how well the area improves public awareness and controls exotic species.

Other factors of significant concern (with one High and two Moderate ratings) include:

- Lack of riparian buffers,
- Agricultural runoff
- Lakeshore development, and
- Climate change.

Tables 4.3.3 and 4.3.4 rate each subwatershed's relative extent for factors with High or Moderate effect severity. The Lows were not scored because in some cases Low indicated complete absence of the factor. The Fort Erie subwatershed was not included since it is has a very low coverage of natural area. Broader-scale influences were not rated by subwatershed, since all subwatersheds are affected similarly. The extent of potential issues related to wetland delineation was based on proportion of settlement area subwatersheds that are forested areas on 100% poorly drained soil but not MNR-evaluated wetlands.

Black Creek subwatershed has both the most issues represented and the most with High extents. The tables will provide guidance for initial considerations with respect to watershed-specific mitigation plans.

TABLE 4.3.3:
HIGH SEVERITY NATURAL HERITAGE ISSUES: EXTENT BY SUBWATERSHED

Subwatershed	Levelled Slough Mosaic	Lack of Riparian Buffers	Spreading Imperviousness	Agricultural Runoff	Shoreline Development
Baker	H		M		
Beaver	M	M	M	H	
Bertie Bay + L. Erie 1	H		M		M
Black	H	H	M	H	
Frenchman's	M			M	
Kraft	H		H		M
Lakeshore	M				M
Miller	H		H	M	
Niagara R. Shore	M				
Six Mile	M		H	M	M

TABLE 4.3.4: MODERATE SEVERITY NATURAL HERITAGE ISSUES: EXTENT BY SUBWATERSHED								
Subwatershed	**Possible Unevaluated Wetlands in Settlement Area**	**Natural Area Fragmentation**	**Immaturity of Natural Areas**	**Artificial Waterways Changing Natural Drainage**	**Broken Corridors**	**Current Development Affecting Natural Areas**	**Roads and QEW**	**Golf Courses**
Baker	M			M	M		M	M
Beaver		H		M	M		M	M
Bertie Bay + L. Erie 1	M	M	M	H	M	H	M	
Black		H		H	M	M	H	M
Frenchman's						M	H	M
Kraft	M		M	H		M	M	
Lakeshore	H	M	M			H	M	
Miller							H	
Niagara R. Shore	M	M	M			M	M	
Six Mile		M	M	H		H	M	M

The watershed's wetlands are possibly among the most vulnerable to climate change in the Canadian Lake Ontario basin (Snell and Astolfo, 2006). The slough-associated inland wetlands are maintained by precipitation. Many are already near the wetland-upland threshold, a feature that contributes to the difficulties in boundary delineation. The level landscape suggests that a small change in water level will have a broad effect. Predicted increases in evapotranspiration will tend to dry the sloughs and lower soil water content. Where the slough mosaic remains, sloughs will retain their flood moderation values but biota will suffer stress. Drier conditions may also result in more clay fracturing and local groundwater recharge, boosting the value of terrestrial ecosystems for contaminant filtering prior to recharge. More extreme storms and droughts will stress floodplain wetlands both with highly variable water volumes and with extra sediment, as diffuse source erosion increases (Bruce, Dickinson and Lean, 2006). Declining lake levels would dry out backwaters and alter coastal habitat. The possibility of a newly exposed coastal corridor, combined with increased pressures for shoreline recreation to escape urban heat has major planning implications (Snell, E., L. Mortsch and M. Galloway. 2006).

4.4 Aquatic Resources

The key processes/functions/characteristics of watercourses, which influence their biota, are baseflow, hydrology, channel form, water temperature, water chemistry, riparian vegetation, and barriers to fish movement and migration. The overall impact on aquatic resources is determined by the cumulative effects of impacts on those factors.

The relatively flat topography of the study area, with elevations near that of the surrounding Niagara River and Lake Erie water levels, has resulted in generally slow-flowing watercourses with few barriers to fish migration. As a consequence of the low gradients and the fine-grained soils, dominated by silt and clay, within the study area, the watercourses rarely contain coarser substrates, such as cobble or gravel. There is little groundwater discharge within the study area, with the result that flow rates are low, except as a consequence of precipitation events or snowmelt. The similarity in watercourse attributes, imposed by the landscape, is striking. Most of the variation in aquatic habitat observed within the study area is a function of whether water is present throughout the year or seasonally, stream size (width and depth), riparian and instream vegetation, and the degree to which the watercourses have been altered by past attempts to maximize available agricultural land. The assessment of impacts, and the determination of appropriate mitigation measures, is limited to this reduced set of environmental variables (i.e. presence of flow, stream size, riparian vegetation and historical impacts), in conjunction with the local aquatic community.

4.5 Watercourse Systems

The following is a detailed account of the geomorphic processes that have been documented for the respective fluvial systems occurring within the subwatersheds (ref. Figure 'WS-2' for reach locations).

Miller Creek

The headwaters for Miller Creek originate south of Petit Road and extend north, flowing into the Niagara River. The majority of the watercourse was situated in a very thick deciduous forest with shrub buffers. However, there were a small number of residential homes backing on to the creek in the downstream section closest to the Niagara Parkway.

Large portions of Miller Creek contained substantial amounts of in-stream emergent plant species and tall grasses. Channel bed substrate consisted of a combination of silt and unconsolidated clay material creating a very mucky environment. At the time of the assessment, water flow was minimal, however indication of high and stagnant water levels were noted as a major impact in much of the area.

General geomorphic assessments revealed extensive signs of planimetric form adjustment, channel widening, and aggradation. The bankfull widths varied from 1.5 m – 5 m and the bankfull width varied from 0.3 m – 0.8 m. The channel was relatively well-defined and lacked any bed morphology. The low-lying topography resulted in several chute formations of the floodplain.

Topography, combined with clay substrate, were the most significant factors affecting Miller Creek. Low gradients and slow drainage contributed to wide-spread flooding. Woody areas created many obstructive organic debris jams which in turn, hindered channel flow. As a result, much of Miller Creek lacks bank definition and is considered to have limited channel stability.

Beaver Creek

Through a desktop analysis, twenty-six reaches were delineated within the Beaver Creek subwatershed area. The headwaters originate south of Michener Road in Ridgeway and extend north to confluence with Black Creek at the Queen Elizabeth Highway. Generally, the channel bankfull widths ranged from 1 m to 5 m however, as it flowed north to the confluence with Black Creek, the channel width was greater than 20 m.

The riparian buffers generally consisted of thick shrubs, tall grasses, and herbaceous species; however, there were areas where the riparian zone consisted of manicured lawn up to the waters edge (i.e. Ridgeway and at I.C.C. Golf and Country Club). The dominant surrounding land use was agricultural, with pockets of residential and recreational areas.

Similar to other Fort Erie Creeks, this watercourse was significantly affected by the low-lying topography and geology of the area. The upstream portions were characterized by poor bank definition, low bed relief, multiple thread channels, clay/silt bed material, major channel widening and aggradation. Basal scour was the predominant form of erosion evident in the Beaver Creek subwatershed. In Reach BVC-14, exposed parent bedrock was found. As a result of topography and geology, large areas experience massive flooding and water logging which contribute to an increased accumulation of woody debris that inadvertently obstructs flow patterns creating large marsh environments.

Black Creek

Black Creek was the longest and most heterogeneous watercourse found in the Fort Erie watershed. This watercourse contains a north and south tributary that confluences with the main stem in the Stevensville area. In total, there were forty-nine reaches delineated in the Black Creek subwatershed system. The main stem originates in the south-eastern portion of Fort Erie, close to Halloway Bay Road, and extends north to the confluence with the Niagara River. The north tributary begins south of Netherby Road and east of House Road. South tributary branches generally begin in the Stevensville Road and Bowen Road area. Surrounding land use, for the most part, was agricultural, yet there were some areas of residential zoning located in Stevensville, Douglastown, and Black Creek.

North and South Tributaries

The north tributary differed greatly from the southern tributary in that it predominantly flowed through agricultural land with thick cut-grass (sp. Leersia) located both in-stream and as a riparian buffer. The south tributary was similar to various other areas within the Fort Erie area which consisted of low-lying topography, wide-spread marsh and saturated floodplain, and poor bank definition. Within the southern tributary, Reach BLC-ST-9 exhibited significant alteration due to residential development such as straightening, on-line pool, and water taking. General geomorphic assessments for both the tributaries revealed signs of planimetric form adjustment, channel widening, and aggradation, especially closer to the Stevensville area. Reaches located in the Stevensville area were characterized by several sections of erosion and incision as a result of fallen trees and large organic and urban debris jams.

Main Black Creek

Much of the main branch of Black Creek was characterized by low-lying topography, abundant in-stream vegetation, floodplain marsh areas, and poor bank definition. The occurrence of large organic debris and overbank deposition was frequently observed indicating persistent flooding and flashy discharge patterns. Comparable to many other areas of Fort Erie, the topography and geology played a significant role in bank erosion, drainage, and woody debris jams that were documented during the geomorphic assessments. Physical channel characteristics varied gradually as Black Creek flowed towards the Niagara River. Similar to Reach BVC-14 of Beaver Creek, Reach BLC-26 exhibited erosion and channel widening. Areas of exposed bedrock and major basal scour were observed throughout this reach.

Riparian conditions differed from the upper to the lower sections of the main branch of Black Creek. The upper section was composed of agricultural zones, with small to absent riparian buffer zones. Livestock trampling and channel straightening were noted in several agricultural areas especially in Reach BLC-24 through Reach BLC-30. Further downstream, the riparian conditions improved with thick shrub and deciduous species. As the channel bankfull width increased downstream, so did residential development. The channel banks were composed of manicured lawns and hardened bank structures (i.e. rip-rap).

Frenchman's Creek

Through desktop analysis, a total of fifteen reaches were determined for this watercourse. The headwaters of Frenchman's Creek originate east of Ridgemount Road and north of Bertie Street (Note that upstream of Sunset Drive, is classified as a Municipal Drain). A large portion of the watercourse was situated in thick deciduous forest with shrub buffers however, as it flowed downstream into the urban areas, a reduction in riparian zones was observed resulting in increased basal erosion (specifically surrounding golf course areas).

The majority of the upstream sections, Reaches FRC-11 to FRC-15, were located in low-lying topography within mixed deciduous forest. Bankfull widths in this area ranged from 1 m to 6 m. Throughout the upper reaches of Frenchman's Creek, large organic debris jams have caused bank erosion.

The middle portion of Frenchman's Creek, Reaches FRC-6 to FRC-10, exhibited various impacts by urban activities such as road realignments, golf course activities, and industrial development. Channel aggradation and widening were the most significant processes observed in this area. Large organic and urban debris jams combined with major siltation and lack of bed morphology were observed in these reaches.

Reaches FRC-4, FRC-5, and FRC-9, were located in the areas of the Bridgewater Golf and Country Club and the Rio Vista Golf and Country Club. Exposed bedrock, large algae blooms, basal erosion, exposed irrigation pipes, and aggradation in pool areas were found throughout these reaches. Runoff from urbanized areas upstream may be one of the reasons that this area exhibited extensive erosion including the incision of the channel bed into its parent bedrock.

The lower reaches (Reaches FRC-1 to FRC-5) flow through an area with isolated pockets of residential development and displayed typical geomorphic characteristics of a channel setting. The bankfull widths were approximately 10 m and the bed substrate was composed of silt and clay. Due to the typical low-gradient setting, aggradation was pronounced and channel widening was prominent because of the large organic debris jams.

Six Mile Creek

In general, Six Mile Creek was one of the more stable watercourses assessed in the Fort Erie region. A total of eleven reaches were defined for this subwatershed with headwaters originating at Highway #3/Garrison Road and flowing south until reaching Lake Erie.

The majority of the channel reaches had low-lying areas, with limited bank definition, and clay/silt bed material. The dominant geomorphic processes were aggradation and planimetric adjustment. In Reach SMC-4, close to Dominion Road, an agricultural field was fenced off from the channel as part of the Niagara Peninsula Conservation Authority initiatives to restore and preserve area creeks from livestock and other consequences of agricultural activities.

In the downstream section, closest to Lake Erie, channel bankfull widths increased and resembled areas close to the Niagara River. Reach SMC-2 and SMC-1 have been straightened at Thunder Bay Road and few residential properties were observed in this area.

Baker Creek

Baker Creek was the smallest of the watercourses in the Fort Erie watershed. Located north of the Queen Elizabeth Highway, this creek travels a short distance before it flows into the Niagara River. Only three reaches were delineated within the Baker Creek subwatershed area.

The headwater section was located in a well forested area north of College Road. Reach BKC-3 possessed little bank definition, low gradient, and showed evidence of planimetric form adjustment. As the channel flowed towards the Niagara River, it gained some bank definition and began to exhibit significant signs of channel widening and aggradation. Similar to other areas of Fort Erie, the frequent occurrence of large woody debris jams combined with geology drastically hindered drainage and flow patterns resulting in large flooded areas (especially noted in Reach BKC-2). Furthermore, Reach BKC-2 has been significantly impacted by ATV trails and hydro easement property altering channel thalweg and limiting riparian buffer area.

The remaining area of Baker Creek increases in bankfull width from 1 m to 10 m as it approaches the Niagara River. Reach BKC-1 resembled Miller Creek, in regards to its backwater setting and residential development. Road culverts at Schweigler Road in BKC-1 were the only form of channel disturbance noted in this section of Baker Creek.

Kraft Drain

Although surrounding land use was residential, the majority of Kraft Drain was located in an extremely pristine area of Fort Erie. Channel riparian conditions consisted of thick mixed forest, shrub, and tall grasses. A general geomorphic assessment of Kraft Drain revealed extensive signs of channel widening and aggradation, specifically in Reach KFD-3, KFD-2, and KFD-1. As a result, large sections of Reach KFD-1 were armoured by residential owners in the immediate area in an effort to increase bank stability. Several areas of exposed tree roots, leaning and fallen trees, large organic debris jams, and siltation in pools were observed throughout much of Kraft Drain. Bankfull widths for Reach KFD-1 to KFD-3 ranged between 2 m to 6 m. In Reach KFD-4, the channel bankfull decreased and ranged from 0.25 m to 1 m. In addition, this reach lacked bank definition and an approximately 1 meter deep knick point was noted. Reach KFD-5, was significantly straightened from Dominion Road to Nigh Road due to residential development of that area.

Mann Drain

Mann Drain was the largest of these three drainage systems. Similar to the rest of the Fort Erie creeks, this system was significantly affected by low-lying topography and characterized by poor bank definition, low bed relief, and siltation in pools. In Reach MND-1, the Niagara Peninsula Conservation Authority, in conjunction with the Ontario Government, Wetland Habitat Fund, and the Friends of Fort Erie Creeks, established a Water Quality Improvement Project to restore stream bank conditions and minimize the effects of livestock activities on watercourses. The remaining reaches flowed through large floodplain areas and consisted of profuse in-stream emergent vegetation and multiple thread channels. A general geomorphic assessment of Mann Drain revealed extensive signs of planimetric form adjustment, aggradation, and some minor areas of channel widening such as fallen and leaning trees, exposed roots, and organic debris.

Bertie Bay Drain

Bertie Bay Drain was a small watercourse that lacked bank definition as it flowed through thick mixed deciduous forest. Large areas of flooding were apparent throughout the reaches as a result of low-lying topography and gradient. In addition, much of the Bertie Bay Drain area was covered by woody debris indicating wide-spread flooding during increased water flows.

Creek Summary

The main fluvial geomorphological purpose of all watercourses is the efficient movement of water and sediment through the system. This function entails both conveyance and storage of sediment and water that is critical to the healthy functioning of the stream. Many of the streams in Fort Erie are transitional and are adjusting from one type of stream to another. This explains the large quantity of poorly defined banks and multiple thread channels found in the watershed. As a result of topography and geology, large areas are experiencing flooding. This contributes to increased accumulation of woody debris that inadvertently obstructs flow patterns, thereby contributing to the transitional and adjustment state of many of the reaches.

Drain Evaluation

Overall, most of the tributaries entering the main channels have been straightened as drains. Since, straightened reaches do not constitute a natural channel planform; the channel will work towards regaining a natural planform to ensure that water and sediment are transported efficiently downstream while minimizing energy expenditure. Natural readjustments of the channel planform occur through processes such as bank erosion, increasing the sediment load of the channel (i.e. Miller Creek, Black Creek Drain, Kraft Drain etc). Erosion in straightened channel reaches can be expected and, indeed, does occur in all watersheds within this study. This in turn is affecting the natural reaches located within the study area.

As a result of the altered planform, many of the drains within the study area have required remediation work to alleviate flooding and the accumulation of sediment. For example, in a 1928 report for Mann Drain, recommendations were made for a cleanout of the drain from the outlet into Six Mile Creek to remove stumps and other debris. In February 2005, there was a clearing and grubbing of a 12 m path along the Mann Drain, including existing clearing of channel cross-section. For Frenchman's Creek, throughout the 1990's there was a concern that the drain (the upper reaches above Sunset Drive) was silting up due to upstream activities. In April 2000, a clean-up initiative of the drain occurred. For Miller Creek, a report conducted by Blake Erwin recommended the excavation of the drain and the re-shaping of the side slope to be 1.5 horizontal to 1 vertical to accommodate the flows. For Black Creek Drain, an engineering report in 1952 recommended the deepening of the drain by approximately 0.9 m to improve the drainage in the area.

In order to summarize the findings of the characterization and initial impact assessment, the following table has been prepared. The creeks have been classified by the reach type, and in particular, its sensitivity to change.

TABLE 4.5.1: WATERCOURSE SENSITIVITY TO CHANGE			
Creek	**# Reaches**	**Reach Showing Significant Erosion**	**Reaches in Adjustment**
Black Creek	74	4; BLC-12, BCC-14, BLC-26, BLC-NT-1	16
Beaver Creek	27	3: BVC-13, BVC-14, BVC-25	16
Six Mile Creek	17	2: SMC-5, SMC-7	2
Frenchman’s Creek	15	5: FRC-4,FRC-5,FRC-6,FRC-9,FRC-14	3
Millers Creek	11	2: MLC-7, MLC-8	3
Baker Creek	3	0	0
Kraft Drain	4	3:KFD-1,KFD-3,KFD-4	4
Bertie Bay Drain	2	0	0

5. WATERSHED MANAGEMENT OPPORTUNITIES

5.1 General

It has been recognized that there tend to be two levels of management opportunities associated with an area's watershed resources: those which apply to the whole of the respective study area and those which relate to a specific location or environmental unit within the respective watershed area.

The foregoing premise has been used to develop watershed management opportunities for the study area as a whole, as well as for the following drainage systems:

- *Black Creek*
- *Beaver Creek*
- *Baker Creek*
- *Miller Creek*
- *Niagara River Shore (Niagara River #16, 19, 20, 21, & 22)*
- *Frenchman's Creek*
- *Fort Erie*
- *Lakeshore*
- *Kraft Drain*
- *Bertie Bay Drains & Lake Erie 1*
- *Six Mile Creek*

[Note: On account of the relatively small size, and similar characteristics, the analysis has combined the Niagara River neighbourhood areas into Niagara River Shores, and has combined Lake Erie 1 with the Bertie Bay Drains.]

Watershed management opportunities identified in this study have been organized according to the following three key systems:

- ➢ *Watercourse Systems*
- ➢ *Natural Heritage Systems*
- ➢ *Stormwater Management*

5.1.1 Definitions of Key Systems

The three key systems to be addressed in terms of management direction within the Watershed Plan are:

(i) Watercourse Systems

Watercourse systems refers to the system of surface water features (creeks and Municipal Drains) and the associated aquatic habitat within, and the riparian zone and valleylands adjacent to the watercourse. The Provincial Policy Statement (2005) defines watercourses, within the definition for surface water features, as "including headwaters, stream channels, rivers, inland lakes, seepage areas, recharge/discharge areas, springs, and associated riparian lands that can be defined by their vegetation or topographic characteristics".

The Conservation Authorities Act (RSO 1990, Chapter C.27, Section 25) defines "watercourse" as *"an identifiable depression in the ground in which a flow of water regularly or continuously occurs"*.

The Ministry of Natural Resources defines the watercourses in terms of the levels of fish habitat (Type 1, Type 2, or Type 3), and provides guidance for the management and restoration of the fish communities.

Depending on the integrated value of the respective surface water features within the study area, there will need to be unique guidance provided in terms of protection, enhancement, or restoration.

Municipal Drains

The Ontario Ministry of Agriculture defines a municipal drain as a drainage system. Most municipal drains are either ditches or closed systems such as pipes or tiles buried in the ground. They can also include structures such as dykes or berms, pumping stations, buffer strips, grassed waterways, storm water detention ponds, culverts and bridges. Even some creeks and small rivers are now considered to be Municipal drains (ref. www.omafra.gov.on.ca).

Fort Erie has a combination of both natural and man-made Municipal drains. Figure 8 depicts the location of the drains, however the Town is currently updating their database and should be contacted for a current listing of Municipal drains.

Municipal drains are created under the authority of the *Drainage Act*. There are 3 key elements of a municipal drain:

Community Project — Landowners who need to solve a drainage problem may submit a prescribed petition under the *Drainage Act* to their local municipality, requesting the establishment of a municipal drain. If certain criteria are met, the municipality appoints an engineer who prepares a report, identifying the proposed solution to the problem and how the costs will be shared. There are various meetings where landowners in the watershed of the municipal drain can voice their desires and concerns. There are also several appeal stages where they can voice their objections. So, the end result of the process is a "communally accepted" project.

Legal Existence — After all appeals have been heard and dealt with, the municipality passes a by-law, adopting the engineer's report. The municipality then has the authority and the responsibility to construct and maintain the project. The cost of the work is assessed to the lands in the watershed in the same ratios as contained within the engineer's report. So for a ditch or a pipe to be a municipal drain, there must be a by-law adopting an engineer's report.

Municipal Infrastructure — Once a municipal drain has been constructed under the authority of a by-law, it becomes part of that municipality's infrastructure. The local municipality, through its drainage superintendent, is responsible for repairing and maintaining the municipal drain. In certain circumstances, the municipality can be held liable for damages for not maintaining these drains. (ref. www.omafra.gov.on.ca)

(ii) Natural Heritage Systems

The Provincial Policy Statement (2005) defines a natural heritage system, and natural heritage features, as “a system made up of natural heritage features (wetlands, coastal wetlands, fish habitat, woodlands, valleylands, endangered and threatened species habitat, wildlife habitat, and areas of natural and scientific interest) and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include lands that have been restored and areas with the potential to be restored to a natural area”.

The management direction builds on: natural heritage objectives and targets; each subwatershed’s natural area status and existing impacts; and opportunities unique to the area.

(iii) Stormwater Management

Stormwater from rainfall and snowmelt either infiltrates into the ground, or runs on the surface. In an urban environment, this runoff is modified as it is conveyed to natural watercourses through lawns, gutters, storm sewers and roadways. Prior to discharging to a swale, creek, wetland, pond, or lake, this stormwater, which often carries pollutants, must be treated in accordance with Provincial doctrine. Stormwater management (SWM) is the application of practices that are designed to protect downstream receiving waters from negative impacts of urban development, such as flooding, erosion, and degraded water quality. Each subwatershed within the Fort Erie Creeks Watershed area should have a system of stormwater management facilities that manage stormwater in accordance with the area’s resource protection objectives.

5.1.2 General Watershed Goals and Objectives

The following list of general watershed-wide goals and objectives has been generated from the combination of input from the Study Team, Technical Steering Committee, and the public (ref. Section 3.2):

1. *Protect, enhance and restore important watercourses/terrestrial natural areas/aquatic habitat*
2. *Manage urban runoff and minimize flooding from existing and future development areas*
3. *Minimize point and non-point source contaminants*
4. *Preserve and enhance the quality and quantity of groundwater.*
5. *Protect the Lake Erie and Niagara River shorelines.*
6. *Integrate rural and agricultural land uses with the ecosystem.*

5.2 Watershed-Wide Constraints and Opportunities

- The Niagara Water Quality Protection Strategy (NWQPS) recognized that there is a general lack of consistency and rigor in land use policies for protecting, improving and restoring water quality and quantity across the Niagara Region. To this end, principles have been established as part of this Watershed Plan, such that the Town of Fort Erie and

Regional Municipality of Niagara can embrace the recommendations for future Official Plan and Zoning updates. Excerpts from the NWQPS are included in Appendix ‘H”.

- The Niagara River Remedial Action Plan (RAP) established 32 different priority activities for implementation, to restore the desired beneficial uses. The Stage II Implementation Annex is on account for “the proposed and anticipated RAP partner and implementation activities”. Excerpts from the RAP are included in Appendix ‘H’.

- In addition to land use policy, other area-wide policies have been proposed, which are less relevant to any one site in particular. These activities would relate to policies for Natural Heritage Systems, stewardship, public education and other overarching mandates related to water quality and quantity management. These policies/strategies were developed in accordance with the applicable Federal, Provincial, Regional and/or Local policies.

- As part of the development of the Fort Erie Creeks Watershed Plan, it is important that all opportunities relate back to the public and stakeholders’ vision and goals. Opportunities will also need to be compatible with the recent provincial planning initiatives (e.g., Places to Grow) to contribute to the Niagara’s sub-area planning and with Regional complementary initiatives.

The following is a list of constraints and opportunities identified at the watershed-wide level. These have been summarized graphically for Stormwater Management and Watercourses on Drawing 1. Natural area significance constraints are presented on Figure NH 8: Protection designation has a High constraint; Conservation has a Medium constraint. The extent of other natural heritage issues is rated by subwatershed in Tables 4.3.3 and 4.3.4.

<u>Constraints/Designations</u>

- Natural Areas
    - Significance
    - High Severity Issues
        - Reduced function because of levelling of slough mosaic
        - Gaps in riparian buffers
        - Spreading imperviousness
        - Agricultural runoff
    - Development, especially along the lakeshore

- Watercourses of Fisheries Significance (ref. Section 2.5.3 and 5.3.1 for definitions)
    - Type 1
    - Type 2
    - Type 3

- Stream Morphology
    - Meander belt width
    - Sensitive points of gradient control

– Flooding and conveyance
  - 100 year regulatory flood plain
  - Municipal Drains
  - Deficient (under-sized) culverts
  - Existing stormwater management facilities
  - Erosion sites

– Water Quality
  - Point Source pollutants
  - Contaminated areas

– Proposed Land Use

<u>Management Opportunities</u>

– Natural Area Enhancement
  - Re-establishment of slough mosaic where feasible in appropriate sites
  - Add riparian buffers to watercourses, and increase buffers on core areas (EPA/ECA/LSA's)
  - Reinstate and strengthen linkages/environmental corridors
  - Fill small gaps to increase core areas
  - Stabilize dunes
  - Re-vegetate recharge areas
  - Restore under-represented natural landscapes and communities
  - Protect emerging coastal corridor and encourage natural area restoration of coastal communities
  - Enhance aquatic habitat

– Watercourses Protection Hierarchy
  - Protect/enhance in-situ
  - Maintain as open; realignment possible
  - Eliminate as necessary; subject to function replication

– Stormwater Management
  - Conceptual location of facilities
  - Watercourse/floodplain improvements
  - Erosion control/stream restoration

5.2.1 Watercourse System Opportunities

Stream Systems

The following is a long-list of watershed-wide opportunities for improvement to the watercourse systems:

- Increase base flow through enhanced infiltration or 'leaky' stormwater facilities.
- Increase base flow due to water imports from Lake Erie and Municipal water supply.
- Reduce temperature of water leaving stormwater management facilities through cooling trenches and shading.

- Maintain existing shading vegetation.
- Restore altered watercourses.
- Restore or enhance the riparian zones along watercourses (also affects water temperature)
- Reduce the amount of sediment washed from fields to reduce contaminants and nutrients that are often most mobile when attached to soil particles.
- Enhance riparian vegetation buffers to reduce contaminant inputs to watercourses.
- Remove existing barriers to fish movement and migration.
- Restore or enhance the straightened watercourse reaches with due consideration of proposed development and changes to flow regime.
- Restore or enhance a portion of low order watercourse as open systems (e.g. swale).
- Maintain or “mimic” upstream sources of sediment where possible.
- Strategically alter the development standard (from urban curb and gutter to roadside swales); protect existing swales where possible through appropriate land use designations.

It is acknowledged that conservation work and the remediation of municipal drains in Fort Erie has been conducted, however, it is encouraged that natural channel processes be implemented in the municipal drains where appropriate. This would be accomplished through additional areas of municipal drain naturalization. This involves designing a cross-section with the appropriate dimensions (low width to depth ratio) matched with a suitable planform and profile to efficiently convey flow and sediment. The channel would still provide all the benefits of the drain, but with reduced deposition. There may be the need for some grading and earthworks to create a nested set of channels and floodplain area, which would reduce the risk of entrenchment and greatly add to the long-term stability of the municipal drain. Through municipal drain naturalization, the cost in remediation work and the impact on the channel systems may be reduced.

Aquatic Biology

Buffers

Some watercourses within the study area have largely retained their natural attributes. When development occurs within designated areas (ref. Official Plan), these should be protected with adequate buffers, reflecting the sensitivity of the resource.

Regeneration

Many watercourses within the study area have been altered (deepened and/or straightened) to drain land for agriculture or to facilitate the construction of transportation routes and other urban infrastructure. It appears that many of the past attempts to create viable agricultural lands in the poorly drained riparian areas surrounding the main creek channels have failed, and throughout the study area these former swamps are regenerating, which has likely resulted in an overall improvement in aquatic habitat over the last fifty years or more. Establishing environmental protection areas with adequate riparian buffers within these regenerating areas, and allowing the regeneration to continue, would ensure that these aquatic habitats will continue to naturalize over time. In some instances where watercourses have been straightened, but the original meandering channels still exist, it may be feasible to re-establish the watercourse within these old channels to provide more aquatic habitat within a natural channel, and to help facilitate regeneration.

Restoration

The remaining watercourses are mostly situated within active agricultural land or urban use land. Many of these may have been dug for drainage purposes or, if natural, have been deepened and/or straightened. Where feasible, buffers should be encouraged, as well as promoting landowner stewardship. When land use changes occur, likely during urban development, watercourses considered viable fish habitat should be reconstructed using natural channel design. Watercourses such as agricultural swales and ditches, that may provide very marginal or no fish habitat, could be either restored and enhanced, where appropriate, or they could be reconstructed in the context of urban development, so that they continue to perform the important role of providing water and appropriate levels of dissolved and suspended materials downstream.

Summary

Watershed management strategies for the study area should include the following:

- Encourage the establishment of appropriately sized vegetative riparian buffers where they currently do not exist or are inadequate.
- Where development results in the relocation of a degraded watercourse that contains fish habitat, appropriate watercourse rehabilitation measures should be undertaken.
- Where development occurs adjacent to a watercourse containing fish habitat, appropriately sized vegetative riparian buffers should be established.
- Stewardship for the watercourses and riparian buffers.

5.2.2 Natural Heritage System Opportunities

Natural heritage systems complement stormwater and watercourse systems. Wetlands and the slough mosaic landscape can retain stormwater to moderate floods. Natural areas can be valuable in maintaining healthy watercourses by filtering contaminants. Natural heritage systems are essential both for habitat and for green infrastructure that can help ease the scale and expense of built infrastructure.

Watershed-wide opportunities for natural heritage systems include:

a) The Regional Municipality of Niagara's Environmental Policies (2005) and the Town of Fort Erie's Official Plan (2006) each have policies that provide an excellent basis for a watershed-level natural heritage plan. Their policies protect the most significant sites (Environmental Protection Areas) and provide flexibility for ecologically responsible planning of sites of more moderate significance (Environmental Conservation Areas).

b) Given the extent of natural area, time alone can encourage succession toward a more climax forest.

c) Restoration of slough mosaic micro-topography, where there are opportunities in appropriate sites, can both boost biodiversity and natural area's flood-moderation and water quality protection roles without having to expand natural area extent. Opportunities might include use (expansion and blockage) of artificial surface drainage patterns in abandoned areas.

d) Restoration of the slough mosaic in the impermeable soils by creation of small closed depressions can help isolate sloughs from drains, both Municipal and farm-specific, to improve natural area functioning while remaining compatible with the drain maintenance essential to the agricultural community. The landscape may also be conducive to the use of simple constructed wetlands to treat non-point source runoff before it discharges to streams.

e) With slough mosaic pattern enhancement where there are opportunities in feasible (e.g., easy access) and appropriate (e.g., levelled poorly drained lacustrine clay; low current significance; downstream flooding) existing natural area, Fort Erie watersheds could add considerable value to its current green infrastructure, an improvement that will help protect the area from the effects of increased storm intensity and soil erosion associated with climate change. These opportunities may help reduce climate change-induced expenditures in engineered flood protection.

f) Restoration of a small hectarage of new natural area could make a large difference in the functioning of corridors and interior forest.

g) The Fort Erie area has the potential to play a role in the *potential adaptation to climate change*. Its strategic location for biota migration to bypass the Great Lakes barriers, combined with its extensive natural cover including the Important Bird Area corridor, makes it a likely northern migration route for terrestrial species. The alternative of the Essex County funnel, at 4% woodland and scrubland (Larsen et al, 1998), is notably lacking in the necessary natural area. For some species, the opportunity will be constrained by the barrier to northward shift of species presented by the built-up area of Buffalo; coordination with American agencies via the Remedial Action Plan linkages could lead to improved cross-boundary corridors.

h) The area has unique opportunities to restore its globally significant coastal communities.
  - Protection and management of the gradually exposed coastal corridor could allow restoration without affecting existing property (assuming provision of water access opportunities). Models for a wide range of climate scenarios all project a decrease in Lake Erie levels for 2050 relative to 1961 to 1990 baseline (Mortsch et al., 2006). Protection could include protection boundaries that remain fixed as lake levels decline; management of road allowance access points to prevent ATV access and encourage native shoreline community restoration while providing low-impact walking access; development of strategies in anticipation of increased demand for lakefront access from people in nearby cities as summer temperatures and gas prices rise.
  - The many large lots along the lake shoreline present opportunities for restoration for property owners excited by the prospect of owning a globally significant community. NPCA could provide: accessible information explaining significance and suggested actions; and technical advice.

i) The unique features present economic opportunities:
  - Large savings from green infrastructure (natural cover providing hydrological and microclimate services) instead of built infrastructure.
  - Current forms of agriculture can be improved through drainage while restoring sloughs and natural area functioning.
  - The hydro power heritage of the region could be expanded to make the area a hub for green energy. Possible options include:

- Alternate agriculture options that work with the landscape capability and avoid off-site drainage and agricultural run-off effects could include low-input ethanol production from willow, switchgrass or Virginia Mallow.
- Wind energy generation that may have potential for farm properties and habitat restoration/management areas near the lake.
- Potential income from sustainable use of natural areas: e.g., timber.
- Tourism and recreation could build on the green theme.
- The flat natural landscape, existing routes and quiet paved roads offer potential for the area to be a cycling mecca for seniors and families.

j) The sense of community could be a foundation for broad-based stewardship efforts and for cost-sharing by downstream beneficiaries. Indeed, given the role the area may play for southern Ontario and the rest of the Carolinian Zone, there may be an opportunity for beneficiaries outside the watershed study area to pay compensation for Fort Erie area stewardship costs. The Alternative Land Use Services (ALUS) model used in Norfolk County could be investigated for applicability.

k) It may be possible to build on the uniqueness of the natural area extent to create a green branding for the area, one that extends to lifestyles, conservation, green roofs etc. – Keen to be Green.

Options for control of invasive exotic species include:

- promoting and using locally sourced native plants
- training to recognize invasive species for early control
- preparing brief information brochures on control of local priority species
- identifying priority sites for management
- staying current with research on control methods and species of concern
- liaising with local media and landscape industry
- placing information signs along popular walking trails.

In summary, the main natural heritage strength of the Fort Erie watersheds is the natural cover's high total area. The main weakness is partial loss of biodiversity and of flood protection because of shoreline development and slough levelling.

Other major threats, common to the rest of southern Ontario and the planet, include climate change and lack of public awareness of human effects on the ecosystem. Ironically, adapting to climate change is linked to some of the opportunities: a widening shoreline corridor and the possible restoration of globally significant communities if lake levels drop; the northward expansion of species; and the vital role of enhanced natural areas in mitigating worsening flooding, erosion and associated costs. A number of ecologically sustainable economic opportunities are also possible.

The general opportunities are:

- *Preservation* for subwatersheds with good quality habitat and services, few threats and good current protection
- *Protection* for subwatersheds with good quality habitat and services but subject to some threats and low current protection

- *Enhancement* for subwatersheds where natural area is present but of lower quality and where improved services would be beneficial.
- *Restoration* for subwatersheds where there is inadequate natural area as well as a need for ecological services.

Opportunities will be considered for each subwatershed appropriate to its unique characteristics, in the following Section 5.3.

5.2.3 Stormwater Management (Quality and Quantity) System Opportunities

Reduce Impact of Stormwater Runoff from Developing Areas on Pollutant Loading:

- Provide stormwater quality treatment facilities (wet ponds, wetlands, hybrids) prior to discharge to receiving watercourses.
- Maximize infiltration to reduce wash off and transport of pollutants

Reduce Nutrient Loading and Concentrations in Creeks, Lake Erie and Niagara River:

- Changes in land use and stormwater management could reduce nutrient loading; consideration for Low Impact Development form (LID).
- Increased shading from riparian vegetation could reduce biologic plant growth within the watercourses (e.g. algae), reducing the diurnal oxygen fluctuations created by the biological organisms.
- Expanded riparian buffers could help filter nutrients
- Reductions in water temperatures could increase dissolved oxygen solubility and concentration within the water.
- Simple, constructed wetlands could help treat rural non-point source runoff before discharge to creeks
- Increased efficiency of treatment facilities

Enhance Groundwater:

- Introduction of potable municipal water to greenfield development areas typically increases water balance due to lawn watering.
- Enhanced infiltration in centralized stormwater management facilities.
- Potential source infiltration through appropriate passive lot infiltration facilities.
- Utilization of manmade wetlands for stormwater could enhance infiltrating groundwater quality and quantity.
- Tertiary treatment of septic systems.

Mitigate Flooding impact of Stormwater Runoff from Development on Peak Flow Rates:

- Provide stormwater quantity storage facilities to attenuate stormwater runoff prior to discharge to receiving watercourses.
- Enhance functioning of immature, levelled lowland lacustrine Environmental Conservation Areas by restoring the slough mosaic landscape where feasible, appropriate opportunities.
- Maximize infiltration at source to reduce runoff volumes.

- Improve conveyance (watercourses and culverts).
- Flood proof flood vulnerable areas

Reduce Impact of Stormwater Runoff from Developing Areas on in-stream Erosion Potential:

- Provide stormwater quantity storage to attenuate peak flow to non-erosive flow rates
- Maximize infiltration at source to reduce runoff volumes (through the use of stormwater Best Management Practices and Low Impact Development form).
- Enhance functioning of immature, levelled lowland lacustrine ECA's by restoring swale/slough landscape where feasible, appropriate opportunities.

5.3 Area-Specific Management Opportunities

The development of the Watershed Strategy has been separated into two parts: watershed-wide recommendations, and area-specific recommendations. The first represents a collection of high-level recommendations that are to be applied broadly, and consist largely of policies and non site-specific actions, such as stewardship.

The second set of recommendations suggests specific actions to deal with specific issues or problems, within each of the subwatersheds (i.e. the entire Fort Erie Creeks Watershed Plan study area has been divided in to eleven subwatershed areas. In a few locations, the subwatershed boundaries used for natural heritage mapping are slightly different from those used in the stormwater analysis: the difference has no effect on the recommended actions.) This process of generating a list of recommendations, and a prioritization of the actions on the list, will enable the agencies and associated stakeholders to structure their programs around the key recommendations. The listing of the site-specific recommendations will also help make the actions clear and implementable.

Prior to generating the list of area-specific recommendations for management opportunities, the watercourses have been classified according to their sensitivity to change, and a constraint rating has been developed for each reach. The purpose of this rating is to guide the implementation of future actions, whether or not they include development or restoration works that directly impact the watercourses.

5.3.1 Integrated Rating of Watercourse Systems

Table 5.3.1 summarizes, on a watercourse basis, organized by reach, the integrated constraint rating for the respective reaches, based on discipline-specific input related to each discipline. The proposed actions or each watercourse in the study area must consider the results of the net rating for each reach.

Each of the watercourses in the Fort Erie Creeks study area has been assessed on the basis of the various environmental factors and considerations, as outlined in the following:

Watercourses

The majority of the channels within the study area fall under a *medium* stream morphology constraint rating. This means that channel enhancement would benefit the overall function form and value of the stream system. These reaches are generally widening or aggrading, have poor sediment conveyance and lack any bed morphology. There is only one reach of the reaches investigated that has been defined as a high constraint from a strictly geomorphological perspective: Reach FRC-3. Reach FRC-3 is a stable reach with pronounced pool-riffle sequences, vegetated banks and a well-defined channel corridor. This reach would not require channel enhancement works. There are three reaches identified as low constraints. These reaches were agricultural, straightened channels, with no significant impact to the channel system.

Fisheries

The Fort Erie Creeks watershed plan fisheries classifications ratings are defined as follows:

MNR Type 1:

Areas that limit the overall productive capacity (i.e. if these areas are harmfully altered the productive capacity of the area would be reduced). Sensitive fish species (part or all of their life cycle) and/or habitats are present (including springs, seeps, upwelling areas, seasonally inundated spawning habitats, refugia, nursery areas, over-wintering areas, and ephemeral pools). These areas require a high degree of protection, however may also be enhanced with care, and can achieve a high potential for habitat compensation.

These habitats provide an important ecological function that would potentially be difficult to replicate. They have a low potential to benefit from rehabilitation, as they require none. Generally, these habitats are natural and have a correspondingly diverse fish community. They may contain critical habitat, and may contain a rare fish species or community.

MNR Type 2:

This habitat is important but below its productive capacity and is ideal for enhancement or restoration projects. Sensitive species may or may not be present part or all of the time. Fish community is below potential due to habitat related issues, however, may be increased if the limiting factors are reversed.

These habitats provide an ecological function that can likely be replicated or enhanced if alterations are undertaken appropriately. Generally, these habitats are degraded and thus they have a high potential to benefit from rehabilitation. Their fish communities vary in diversity and complexity. This category also includes marginal habitat that provides an important linkage to upstream habitats.

MNR Type 3:

Areas with low productive capacity, where common species may or may not be present, and no sensitive species and/or specialized habitat are present (incidental exceptions of fish presence may occur in some locations, e.g. the Welland Shipping Canal). Areas can negatively affect downstream, down-drift or connected fish habitats, and should not be considered for compensation opportunities.

These habitats provide a simple ecological function (i.e. downstream contributions) that can likely be replicated or enhanced. They will not benefit much, if any, from rehabilitation, as their potential is severely limited by base conditions (usually lack of water flow). Generally, these habitats are swales and other ephemeral drainage features that are dry most of the time, and do not support fish, although in some situations a few individuals of one or two tolerant species such as brook stickleback or fathead minnow may be temporarily present.

These classifications provide guidance for how watercourses may potentially be treated in future planning, whether in the context of development (urban, agricultural, transportation, etc.), or in identifying candidate habitats that would most benefit from limited habitat restoration funds. Their purpose is to help achieve an overall net gain in fish habitat and productivity within the Fort Erie Creeks watershed. Application of the recommended treatments will result in the higher quality natural habitats being retained or enhanced in-place, and the lower quality degraded habitats being improved through natural channel design and habitat enhancement and creation. The classification inherently acknowledges that there are some drainage features that do not contribute directly to fish productive capacity.

Terrestrial Resources

Terrestrial resource constraints relate to the presence in, or near, the watercourse riparian zone of high or medium constraint/value features, such as woodlots and wetlands.

The first rating is for vegetation adjacent to the creek and riparian zone. High corresponds to a vegetated Environmental Protection Area or Locally Significant Area along greater than 25% of the reach length; Moderate is vegetated Environmental Protection Area or Locally Significant Area along 1% to 25% of the reach OR vegetated Environmental Conservation Area along greater than 25% of the reach; and Low is the remainder.

The second rating is of the wetland rating associated with the creek itself and its immediate bank area: High is Provincially Significant Wetland (PSW) along greater than 25% of reach length; Moderate is PSW along 1% to 25% of the reach; and Low is no PSW.

Stream Morphology

Stream Morphology morphological constraints relate to the drainage density, erosion susceptibility, and/or stability of the channel form (aggradation/degradation).

Flooding/Conveyance

Flooding constraints are considered “high” if the reach is a natural watercourse, and has a floodplain associated with it, has structures identified in the floodplain, and the conveyance capacity cannot be replicated artificially. If there are no identified hazards such as structures or roadway overtopping, then the constraint is considered “medium”.

Flooding constraints are also considered “medium” if the reach is a Municipal Drain, and has a registered floodplain associated with it, however the conveyance capacity can be replicated artificially.

If there is no registered floodplain, the constraint rating has been left blank.

Summary

Table 5.3.1 has been organized by subwatershed. Constraints have been defined as H-High, M-Medium, L-Low, and fish habitat as Type 1, 2, or 3 (MNR). Subwatersheds not listed do not have any defined watercourses in the area (e.g. Fort Erie and Lakeshore which are mostly urbanized areas, and Niagara River #20, #21, and #22, and Lake Erie 1).

A semi-quantitative net rating of watercourse sensitivity has been established by combining the four component ratings, and by calculating a High, Medium, or Low preference rating based on the following formulae:

- High: must have at least 2 components scored “High” or Type 1 fish habitat, and none scored “Low”
- Low: must have at least 2 components scored “Low”, no more than 2 scored “Medium”, none scored “High”, and cannot be Type 1 fish habitat
- Medium: all other combinations of criteria scoring
- High: if the second part of the watercourse terrestrial rating (watercourse greater than 25 % in a PSW) was high, the net rating would automatically be high.
- High: if the fisheries habitat is Type 1, the net rating would automatically be high.

Note that a blank indicates a lack of any identified aquatic, terrestrial, stream morphology or flooding/conveyance constraint. Also, in some of the more isolated headwater reaches, and Municipal Drains in particular, the stream morphologic assessment was not conducted.

TABLE 5.3.1: INTEGRATED WATERCOURSE CONSTRAINT RATING					
Reach ID	**Fisheries/Habitat**	**Terrestrial Resources[1]**	**Stream Morphology**	**Flooding/Conveyance**	**Net Rating**
Black Creek Subwatershed					
BLC-1	Type 1	H/H	M	H	H
BLC-2	Type 1	H/H	M	H	H
BLC-3	Type 1	M/H	M	H	H
BLC-4	Type 1	H/H	M	H	H
BLC-5	Type 1	H/H	M	H	H
BLC-6	Type 1	M/H	M	H	H
BLC-7	Type 1	H/H	M	H	H
BLC-8	Type 1	H/H	M	H	H
BLC-9	Type 1	H/H	M	H	H
BLC-10	Type 1	M/H	M	H	H
BLC-11	Type 1	H/H	M	H	H
BLC-12	Type 1	H/H	M	H	H
BLC-13	Type 1	H/L	M	H	H
BLC-14	Type 1	M/H	M	H	H
BLC-15	Type 1	L/L	M	H	H
BLC-17	Type 1	M/H	M	H	H
BLC-18	Type 2	L/H	M	H	H
BLC-19	Type 2	H/H	M	H	H
BLC-20	Type 2	M/H	M	H	H
BLC-21	Type 2	M/H	M	H	H
BLC-22	Type 2	M/H	M	H	H
BLC-23	Type 2	H/H	M		H
BLC-24	Type 2	L/L	M		M
BLC-25	Type 2	L/L	M		M
BLC-26	Type 2	M/L	M		M
BLC-27	Type 2	L/L	M		M
BLC-28	Type 2	L/L	M		L
BLC-29	Type 2	L/L	M		L
BLC-30	Type 2	L/L	L		L
BLC-31	Type 2	L/L	L		L
BLC-32	Type 1	L/L			H
BLC-NT-1	Type 1	H/H			H
BLC-NT-2	Type 1	H/H			H
BLC-NT-3	Type 1	L/L			H
BLC-NT-4	Type 1	L/L			H
BLC-NT-5	Type 1	L/L			H
MD-1	Type 1	H/H		M	H
MD-2	Type 1	L/H		M	H
MD-3	Type 1	H/H		M	H
MD-4	Type 2	H/H		M	H
MD-5	Type 2	L/H		M	H
MD-6	Type 2	L/L		M	L
MD-7	Type 2	H/H		M	H
MD-8	Type 2	M/L		H	M
MD-9	Type 2	L/L			L
HD-1	Type 2	L/L		M	L
HD-2	Type 2	M/L		M	M
HD-3	Type 2	M/L		M	M
RD-1	Type 2	M/L		M	M
RD-2	Type 2	L/L		M	L
RD-3	Type 2	L/L		H	M
SJMD-1	Type 1	H/H		M	H
SJMD-2	Type 1	H/H		M	H
SJMD-3	Type 1	H/H		M	H
SJMD-4	Type 1	H/H		M	H
SJMD-5	Type 1	H/H		M	H
SJMD-6	Type 1	H/H		M	H
SD-1	Type 2	H/H		M	H
SD-2	Type 2	H/L		M	M
SD-3	Type 2	M/L		M	M
SD-4	Type 2	M/L			M

TABLE 5.3.1: INTEGRATED WATERCOURSE CONSTRAINT RATING					
Reach ID	**Fisheries/Habitat**	**Terrestrial Resources[1]**	**Stream Morphology**	**Flooding/Conveyance**	**Net Rating**
BLC-ST-1	Type 1	H/H	M	H	H
BLC-ST-2	Type 1	H/H	M	M	H
BLC-ST-3	Type 1	H/H	M	M	H
BLC-ST-4	Type 1	H/H	M	M	H
BLC-ST-5	Type 1	L/L	M	M	H
BLC-ST-6	Type 1	M/H	M	M	H
BLC-ST-7	Type 1	H/H	M	M	H
BLC-ST-8	Type 1	H/M	M		H
BLC-ST-9	Type 1	L/L	M		H
BLC-ST-10	Type 1	M/H	M		H
BLC-ST-11	Type 1	L/L	M		H
BLC-ST-12	Type 1	M/L	M		H
BLC-ST-13	Type 1	L/L	M		H
Beaver Creek Subwatershed					
BVC-1	Type 1	H/H	M	M	H
BVC-2	Type 1	H/H	M	H	H
BVC-3	Type 1	M/H	M	M	H
BVC-4	Type 1	H/H	M	M	H
BVC-5	Type 1	H/H	M	H	H
BVC-6	Type 1	H/H	M	M	H
BVC-7	Type 1	H/H	M	M	H
BVC-8	Type 1	H/H	M	M	H
BVC-9	Type 1	H/H	M	M	H
BVC-10	Type 1	H/H	M	M	H
BVC-11	Type 1	H/H	M	M	H
BVC-12	Type 1	H/H	M	M	H
BVC-13	Type 1	H/H	M	M	H
BVC-14	Type 1	H/H	M	M	H
BVC-15	Type 1	H/H	M	M	H
BVC-16	Type 1	H/H	M	M	H
OD-1	Type 1	L/L		M	H
OD-2	Type 1	L/L		M	H
BVC-17	Type 1	H/H	M	M	H
BVC-18	Type 1	L/H	M	M	H
BVC-18A	Type 3	L/H	L	M	H
BVC-19	Type 1	H/H	M	M	H
BVC-20	Type 1	H/H	M	M	H
BVC-21	Type 1	H/H	M	M	H
BVC-22	Type 1	M/H	M	M	H
BVC-23	Type 1	H/H	M	M	H
BVC-24	Type 1	L/H	M	M	H
BVC-25	Type 1	M/H	M	M	H
Baker Creek					
BKC-1	Type 1	H/H	M	H	H
BKC-2	Type 1	H/H	M	H	H
BKC-3	Type 1	H/M	M	H	H
Miller Creek					
MLC-1	Type 1	H/H	M	H	H
MLC-2	Type 1	H/H	M	H	H
MLC-3	Type 1	H/H	M	H	H
MLC-4	Type 1	H/H	M	H	H
MLC-5	Type 1	H/H	M	H	H
MLC-6	Type 1	H/H	M	H	H
MLC-7	Type 1	H/H	M	H	H
MLC-8	Type 1	H/H	M	H	H
HWB-1	Type 1	H/H			H
HWB-2	Type 1	M/H			H
HWB-3	Type 1	L/L			H
Frenchman's Creek					
FRC-1	Type 1	H/H	M	M	H
FRC-2	Type 1	H/H	M	M	H
FRC-3	Type 1	H/H	H	M	H
FRC-4	Type 1	H/H	M	M	H

TABLE 5.3.1: INTEGRATED WATERCOURSE CONSTRAINT RATING					
Reach ID	**Fisheries/Habitat**	**Terrestrial Resources[1]**	**Stream Morphology**	**Flooding/Conveyance**	**Net Rating**
FRC-5	Type 1	M/H	M	M	H
FRC-6	Type 1	M/H	M	M	H
FRC-7	Type 1	H/H	M	H	H
FRC-8	Type 1	M/H	M	M	H
FRC-9	Type 1	H/H	M	M	H
FRC-10	Type 1	H/H	M	M	H
FRC-11	Type 1	L/H	M	M	H
FRC-12	Type 1	M/H	M	M	H
FRC-13	Type 1	H/H	M	H	H
FRC-14	Type 1	H/H	M	M	H
FRC-15	Type 1	M/M	M	M	H
Kraft Drain					
KFD-1	Type 3	H/H	M	H	H
KFD-2	Type 3	H/H	M	H	H
KFD-3	Type 3	H/H	M	H	H
KFD-4	Type 3	H/H	M	H	H
KFD-5	Type 3	H/H	L	H	*H
Bertie Bay Drain					
BBD-1	Type 2	L/L	M		L
BBD-2	Type 2	H/L	M		M
Six Mile Creek					
SMC-1	Type 1	H/H	M	H	H
SMC-2	Type 1	H/H	M	H	H
SMC-3	Type 1	H/H	M	H	H
SMC-4	Type 1	H/H	M	H	H
SMC-5	Type 1	H/H	M	H	H
SMC-6	Type 1	H/H	M	H	*H
SMC-7	Type 1	L/L	M	H	H
SMC-8	Type 1	H/L	M	H	H
SMC-9	Type 1	H/H	M	H	H
SMC-10	Type 1	M/M	M	H	H
SMC-11	Type 1	M/L	M	H	H
MND-1	Type 1	H/L	M	H	H
MND-2	Type 1	H/M	M	H	H
MND-3	Type 1	H/L	M	H	H
MND-4	Type 1	M/M	M	H	H
MND-5	Type 1	H/L	M	H	H
MND-6	Type 1	H/L	M	H	H
Niagara River #19					
DR1,2	Type 3	H/H			H

Note: a blank indicates a lack of any aquatic, terrestrial, stream morphology or flooding/conveyance constraint. Also, in some of the more isolated headwater reaches, and Municipal Drains in particular, the stream morphologic assessment was not conducted.
* These watercourses have been straightened, but the original meandering planform exists on the floodplain, it may be possible to re-establish the watercourse within these old channels to provide aquatic habitat within a natural channel.
1. The first rating is for the adjacent floodplain; the second one is for wetland presence in the creek itself or the immediate bank area.

The integrated net constraint rating used in this study (High, Medium and Low constraint) and the MNR fish habitat classification system (Type 1, Type 2, and Type 3 habitat) are both intended to guide the treatment of watercourses when confronted by development, land use changes, or opportunities for protection or rehabilitation. The principal differences between the two systems are as follows:

1. The integrated net constraint rating used in this report is applied at the subwatershed scale, and is not based on detailed, site-specific information of the sort that is required to identify ‘critical’ habitats, as defined in the MNR system.
2. The system used in this study addresses the potential for watercourses to benefit from alteration, based largely on the assumption that fish communities in degraded channels are likely to benefit from alterations that restore natural features, whereas fish

communities in natural channels with good quality habitat are less likely to benefit, and are more likely to be harmed, by alterations.

It should be noted that while some reaches have a low integrated net constraint rating, they may still contain Type 2 habitat, and as such are considered ideal for enhancement or restoration projects. The net rating is important as a relative ranking tool, to compare all of the reaches.

In the course of any project that has the potential to impact upon a watercourse, an appropriately detailed site-specific study will be required to address the concerns and requirements of DFO, MNR and the NPCA.

5.3.2 Integrated Rating of Terrestrial Natural Heritage Systems

Tables 5.3.4 to 5.3.14 summarize by subwatershed the terrestrial natural heritage status and targets, context, implications for natural heritage function and key issues. The wetland data is current as of June 2005; the natural cover data is current as of 2002; the EPA data uses the June 2005 wetland data. (As MNR updates wetland boundaries, current status percentages for both wetlands and EPA may change.) Minimum guidelines for wetland, treed cover, riparian cover and interior forest are by percentage of the subwatershed and, along with largest forest patch, refer to Environment Canada (2004a) guidelines. Given the large extent of original wetland, the minimum guideline of 10% of the watershed as wetland is used over 6% of each subwatershed. The 18% guideline for protected area (EPA plus ECA) is the threshold for an “excellent” rating set by the Niagara Region Report Card. Guidelines for distribution of natural landscape types and slough mosaic among the 2002 natural areas use the proportions within the pre-settlement natural areas specific to each subwatershed. Targets were assigned as the additions to the 2002/2005 status – both as percentage and hectares - needed to meet the guidelines; urban subwatersheds had some leniency to allow for infill development that helps maintain the natural areas in the nearby rural subwatersheds. The interior forest guideline for forest further than 200 m from the forest edge was omitted because the road grid density makes this guideline unrealistic.

It is strongly emphasized that all the guidelines are minimum generic guidelines for ecosystem function. The very high extent of pre-settlement wetland in the study area suggests that optimum functioning for this landscape will require considerably more than the 10% minimum guideline. Exceedance of the minimum guideline should not be interpreted as surplus wetland. All wetlands play important roles and should be protected. Protection is far easier, cheaper and more supportive of well-functioning systems than restoration once they have been converted.

TABLE 5.3.4:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
BLACK CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Min. 32; Max 79.6	15.5	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	29.3 8.8 20.4	 +9.5%	653 ha forest, largely covered by maturing shrub/meadows
Slough Mosaic	65.7 % (original %)	13.6% (loss of 79.2%)	+54.5% of natural	1097 ha
Largest Forest Patch	200 ha	2805+	OK	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 3.0 0.5	 +7%	 +481 ha
% riparian cover (30 m either side)	75%	42.9	+32.1	186.3 ha i.e., 62.1 km (1-side) or 31 km (2-side)
% Regional EPA	18%	12.0	OK	
% Regional ECA		11.5	OK	
Natural Landscapes	Target (original) distribution 73.6 fine soil lowland 18.3 fine soil mesic 4.8 alluvial 0.7 Shallow mesic 1.3 Shallow upland Tr Coarse mesic 1.2 Organic	 79.9 7.9 8.3 0.1 0.9 Tr 2.8	 More fine soil mesic – though may happen via climate change	

Subwatershed Form	Description
Area	6872.3 ha
Outfall	Niagara River
Shape	Oval
Topography	Flat with slight slopes at river valley. Very gentle east/west slope south of Humberstone Marsh
Alterations since Settlement	Clearance for agriculture. Gradual addition of drains. Small built-up areas at Stevensville and Douglastown. Some natural areas mature, others relatively recent.
Shore	None
Natural Area Distribution	Well-distributed with large area at headwaters.
Function	**Implications of Form on Function**
Habitat	Good extent and better forest as matures. Needs more connections.
Water Protection	Moderate. Some riparian. Good headwaters cover. Loss of much of slough mosaic flow moderation function.
Other	
Key Natural Heritage Issues	Fragmentation reducing habitat value Levelled slough mosaic reduces both diversity and flow moderation capacity Artificial drainage changed hydrology of some areas Lack of riparian buffers reduces corridors and raises susceptibility to pollution reaching streams Farm runoff causes sedimentation and nutrient loading to floodplain areas.
Other Issues	Numerous potential flood areas. A few erosion prone reaches. Increasing imperviousness at Stevensville. Critical fish habitat in lower portion, important in upper.

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.5:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
BEAVER CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 50.2; Min. 20.1	14.5	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	29.7 5.9 23.9	 +6.1	 +212
Slough Mosaic	16.0% (original %)	3.4 (loss of 79.1%)	+12.3% of natural	+ 127
Largest Forest Patch	200 ha	94.4 (without roads, >200 ha)	OK	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 1.9 0.1	 +8.1%	 +282
% riparian cover (30 m either side)	75%	51.3	+23.7%	70.2 ha i.e., 23.4 km (1-side) or 11.7 km (2-side)
% Regional EPA	18%	11.7	OK, with ECA	
% Regional ECA		12.2	OK	
Natural Landscapes	Target (original) Distribution 40.1 fine soil lowland 33.5 fine soil mesic 10.1 alluvial 5.9 Shallow mesic 10.4 Shallow upland 0.1 Coarse soil upland	44.3 18.1 22.9 5.8 9.8 0.0	More mesic – though may happen via climate change	
Subwatershed Form	Description			
Area	3478.9 ha			
Outfall	Into Black Creek			
Shape	Long and narrow, widening in the headwaters			
Topography	Bedrock ridge along east side and rise south of Hwy 3 at the golf course. Flat in south headwaters and downstream of tracks. Very gentle slopes elsewhere.			
Alterations since Settlement	Clearance and slough mosaic levelling. Drains especially at headwaters. More mature forest along middle reaches and in south headwaters. Agriculture is important.			
Shore	NA			
Natural Area Distribution	Good			
Function	Implications of Form on Function			
Habitat	Good creek corridor and linkage of Frenchman's and Black across Beaver's narrow point. Low potential for interior forest extension without farmland intrusion.			
Water Protection	Good riparian buffers for main stem. Some upper drains and tributaries not buffered. Areas shallow over bedrock have scattered coverage.			
Other				
Key Natural Heritage Issues	Fragmentation reducing habitat value Levelled slough mosaic reducing both diversity and flow moderation capacity Farm runoff causing sediment and nutrient loading in floodplain areas			
Other Issues	Flood potential in headwaters Outlet Drain. Erosion in headwaters. Spreading imperviousness in headwaters Critical fish habitat			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland

TABLE 5.3.6:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
BAKER CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10% Max. 80.9; Min. 32.4	39.8	OK	-
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30%	72.7 25.5 47.2	 OK	 -
Slough Mosaic	75.1 % (original %)	8.3 (loss of 88.9%)	+66.8% of natural	+221
Largest Forest Patch	200 ha	98.3 ha. Without roads, >200 ha	OK	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 9.2 0.8	 +0.8%	 +3.6
% riparian cover (30 m either side)	75%	78.8	OK	
% Regional EPA	18%	33.3	OK	
% Regional ECA		21.3	OK	
Natural Landscape	<u>Target (original)</u> <u>Distribution</u> 78.9% fine soil lowland 19.1% fine soil mesic 2.0% alluvial	 82.5% 15.8% 1.8 %	 OK	
Subwatershed Form	Description			
Area	455.0 ha			
Outfall	Niagara River			
Shape	Oval			
Topography	Flat, slight slope in north east			
Alterations since Settlement	Levelled slough mosaic, drains including reversing a stream originally into Miller. Older forest in headwaters, more recent in lower basin and along creek			
Shore	NA			
Natural Area Distribution	Very good			
Function	Implications of Form on Function			
Habitat	High value, though lost some diversity where slough mosaic levelled			
Water Protection	High value			
Other	Potentially significant biota migration corridor for climate change adaptation. IBA			
Key Natural Heritage Issues	Proposed golf course will possibly affect wetlands & interrupt important corridor. OMB will assess			
Other Issues	Flood potential at mouth. Spread of imperviousness in east drain. Critical fish habitat. Natural Areas Inventory found unevaluated wetland.			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.7:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
MILLER CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 60.3; Min. 24.1	22.3	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	46.0 17.1 28.8	 OK with shrub succession	
Slough Mosaic	53.9% (original %)	9.7% (loss of 82.0%)	44.2% of natural	+162 ha
Largest Forest Patch	200 ha	98.0	200 ha	+ 102 ha
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 5.6 0.5	 +4.4%	 + 35 ha
% riparian cover (30 m either side)	75%	62.9	+ 12.1%	+11 ha i.e., 3.5 km (1-side) or 1.7 km (2-side)
% Regional EPA	18%	20.5	OK	
% Regional ECA		20.1	OK	
Natural Landscapes	<u>Target (original) Distribution</u> 57.8 fine soil lowland 18.7 fine soil mesic 2.5 alluvial 14.9 Shallow mesic 3.6 Shallow upland 1.2 Coarse soil mesic 1.2 Coarse soil upland	 64.1 20.8 4.6 5.0 3.6 0.9 1.0	 More shallow mesic – though may happen via climate change	
Subwatershed Form	Description			
Area	795.5 ha			
Outfall	Niagara River			
Shape	Very broad arc			
Topography	Flat at headwaters and lower portions. Very gently sloping across mid section around RR.			
Alterations since Settlement	Cleared and slough mosaic levelled for agriculture. For decades, crossed by QEW, RR and hydro. A tributary was altered to flow to Baker Creek. Little development. Some forests are more mature, others regenerated in last few decades.			
Shore	No lake shore			
Natural Area Distribution	Headwaters have less			
Function	Implications of Form on Function			
Habitat	Good habitat with potential to improve still more			
Water Protection	Good riparian cover. Little cover of recharge areas.			
Other	Areas in lower subwatershed part of potentially important Niagara R. corridor			
Key Natural Heritage Issues	Levelled slough mosaic QEW bisects subwatershed. Auto wrecker and dump			
Other Issues	Several potential flood damage areas. Erosion in mid reaches Increasing imperviousness Critical fish habitat			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.8:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
NIAGARA RIVER SHORE

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 72; Min. 28.8	15.8	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	49.0 21.7 27.4	 OK with shrub succession	
Slough Mosaic	54.1% (original %)	14.5% (loss of 73.3%)	+ 39.6% of natural	+ 68 ha
Largest Forest Patch	200 ha	85.5	OK – hard to expand given elongated shape	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 3.1 0.1	OK – hard to expand given elongated shape	
% riparian cover (30 m either side)	75%	51.6	23.4%	7 ha i.e., 2.2 km (1 side) or 1.1 km (2-side)
% Regional EPA	18%	12.0	OK	
% Regional ECA		37.8	OK	
Natural Landscapes	Target (original) Distribution 71.6 fine soil lowland 28.1 fine soil mesic 0.4 alluvial	 85.1 14.6 0.3	More fine soil mesic areas – though may happen via climate change	
Subwatershed Form	**Description**			
Area	349.4 ha			
Outfall	Niagara River – several very small streams			
Shape	Long, narrow and irregular along River.			
Topography	Flat			
Alterations since Settlement	Cleared for agriculture and slough mosaic levelled. In recent decades, gradual spread of both forest regeneration and riverside residences.			
Shore	No lake shore (though long River shore)			
Natural Area Distribution	Fairly well distributed. Most natural area in Niagara 19 but it's also the biggest.			
Function	**Implications of Form on Function**			
Habitat	Good.			
Water Protection	Moderate. Good "inland" riparian coverage.			
Other	Part of the potentially important Niagara River corridor			
Key Natural Heritage Issues	Levelled slough mosaic Most areas separated from River connection by Parkway and strip of houses.			
Other Issues	Important fish habitat in Niagara 19. Natural Areas Inventory found unevaluated wetlands.			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.9:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
FRENCHMAN'S CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 67.6; Min. 27 (coarse estimates, much missing data)	18.8	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	36.5 13.8 22.6	 +7.3%	126 ha forest largely covered by maturing shrub/meadows
Slough Mosaic	28.2 % (original %)	8.5% (loss of 69.8%)	+20% of natural	126 ha
Largest Forest Patch	200 ha	117.4 ha	200 ha	+82 ha: if let shrub mature & ignore roads, very little new area needed
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 6.2 1.8	 +3.8%	+65 ha, possible as shrub matures
% riparian cover (30 m either side)	75%	58.3	+16.7%	24.0 ha i.e., 8 km (1-side) or 4 km (2-side)
% Regional EPA	18%	16.6	OK	
% Regional ECA		20.0	OK	
Natural Landscapes	Target (original) Distribution 61.6 fine soil lowland 20.1 fine soil mesic 6.0 alluvial 0.8 Shallow lowland 6.9 Shallow mesic 2.2 Shallow upland 2.3 Coarse soil upland	 64.1 19.8 10.1 0.5 2.7 2.4 0.5	 Add to coarse soil upland	
Subwatershed Form	Description			
Area	1723.5 ha			
Outfall	Niagara River			
Shape	Sideways L			
Topography	Flat headwaters. Base of L has some gentle slopes esp. along creek valley			
Alterations since Settlement	Clearing for agriculture. Drain extensions in headwaters. Development and golf courses in corner of the L. Quarry in headwaters pumping water.			
Shore	No lake shore			
Natural Area Distribution	Well-distributed. Less at L corner. More near mouth.			
Function	Implications of Form on Function			
Habitat	Good habitat especially as mature though lost some diversity where slough mosaic levelled.			
Water Protection	Good though lost some flow moderation capacity where slough mosaic levelled.			
Other	Lower watershed part of potentially significant corridor for biota migration in response to climate change. IBA			
Key Natural Heritage Issues	Levelled slough mosaic QEW bisects subwatershed. Urban expansion in corner of L.			
Other Issues	Erosion along reaches below quarry and below tracks. Main stem is critical fish habitat			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

****** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.10: INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS FORT ERIE				
Natural Area Form	**Minimum Guideline**	**2002/2005* Status**	**Target**	**Target area (ha)**
% wetland % original wetland**	10 Inadequate data	0	OK: urban	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	3.2 0.1 2.2 1.0	 OK: urban	
Slough Mosaic	Inadequate data			
Largest Forest Patch	200 ha	7.1	OK: urban	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 0 0	 OK: urban	
% riparian cover (30 m either side)	75%	NA	NA	
% Regional EPA	18%	0	OK: urban	
% Regional ECA		5.5	OK: urban	
Natural Landscapes	Target (original) Distribution 83.5 fine soil lowland 16.5 fine soil mesic	 79.5 20.5	 OK	
Subwatershed Form	Description			
Area	397.5 ha			
Outfall	No clear streams but runoff to Niagara River			
Shape	Oblong			
Topography	Some moderate slopes down to the river but largely gently sloping			
Alterations since Settlement	Complete natural area removal for built-up.			
Shore	No lake shore.			
Natural Area Distribution	Very scattered			
Function	Implications of Form on Function			
Habitat	Very little habitat			
Water Protection	Very little water protection, though not a critical need other than for Niagara River			
Other	Very little microclimate moderation			
Key Natural Heritage Issues	Natural area absence. Intensified built-up in Fort Erie area, however, helps maintain natural area in other subwatersheds.			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.11:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
LAKESHORE

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 96.7; Min. 38.7 (very coarse estimates, much missing data)	10.8	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	30	23.9 4.6 1.8 22.9	OK for urban	
Slough Mosaic	Inadequate data			
Largest Forest Patch	200 ha	39.1	OK for urban	
% Forest Interior - > 100 m from edge - > 200 m from edge	10% 5%	0.7 0	OK for urban	
% riparian cover (30 m either side)	75%	36.3 but very little streams	OK for urban	
% Regional EPA	18%	5.5	OK, with ECA	
% Regional ECA		26.7	OK	
Natural Landscapes	Target (original) Distribution 96.6 fine soil lowland 0.1 alluvial 3.3 Coarse soil upland	98.5 0 1.5	OK	
Subwatershed Form	Description			
Area	364.4			
Outfall	Lake Erie but little stream length			
Shape	Broad arc			
Topography	Flat inland. Short slopes near shore			
Alterations since Settlement	Cleared for fort and agriculture. In last 4 decades both some development and forest regeneration.			
Shore	Approx. 5 km			
Natural Area Distribution	Concentrated.			
Function	Implications of Form on Function			
Habitat	Good for an urban area.			
Water Protection	Minor role			
Other	Microclimate moderation for residents			
Key Natural Heritage Issues	Development – esp. scattered, low density – increases fragmentation and spreads adverse effects. Shoreline development removes rare coastal habitats. Differing wetland estimates			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

****** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.12: INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS KRAFT DRAIN				
Natural Area Form	**Minimum Guideline**	**2002/2005* Status**	**Target**	**Target area (ha)**
% wetland % original wetland**	10 Max. 77.1; Min. 30.8	38.2	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	62.7 19.9 42.8	 OK	
Slough Mosaic	41.4 % (original %)	0.9% (loss of 97.8%)	+ 40.5% of natural	+ 141 ha
Largest Forest Patch	200 ha	103.7	OK for near-urban area	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 11.8 1.9	 OK	
% riparian cover (30 m either side)	75%	91.7	OK	
% Regional EPA	18%	27.4	OK	
% Regional ECA		24.7	OK	
Natural Landscapes	Target (original) Distribution 71.1 fine soil lowland 22.9 fine soil mesic 6.0 alluvial Tr Coarse soil upland	 73.0 19.5 7.5 0	 OK	
Subwatershed Form	Description			
Area	554.7 ha			
Outfall	Lake Erie			
Shape	Rounded square			
Topography	Flat. A very gentle slope around Garrison Road			
Alterations since Settlement	Cleared and slough mosaic levelled for agriculture. Regenerated in last few decades. Scattered development. Drains in last 25 years.			
Shore	A short extent (approx. 0.5 km)			
Natural Area Distribution	Well distributed. A little more sparse in north east toward Fort Erie built-up			
Function	Implications of Form on Function			
Habitat	Very good and will improve as matures			
Water Protection	Very good			
Other	Microclimate moderation for residents			
Key Natural Heritage Issues	Levelled slough mosaic reduces both diversity and flow moderation capacity Artificial drainage changed hydrology of some areas Development – esp. scattered, low density – increases fragmentation and spreads adverse effects. Shoreline development removes rare coastal habitats.			
Other Issues	Both erosion and flood potential Increasing imperviousness. Natural Areas Inventory found unevaluated wetlands.			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.13: INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS BERTIE BAY + LAKE ERIE 1				
Natural Area Form	**Minimum Guideline**	**2002/2005* Status**	**Target**	**Target area (ha)**
% wetland % original wetland**	10 Max. 58.7; Min. 23.5	15.4	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	42.4 1.1 0.1 16.7 24.5	 OK: urban	 As shrub matures, more forest will grow
Slough Mosaic	29.5% (original %)	1.4 (loss of 95.1%)	+28.2% of natural	104 ha
Largest Forest Patch	200 ha	54.5 ha	OK for urban and roads	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 3.4 0.1	 +1.6%	 14 ha
% riparian cover (30 m either side)	75%	83.7	OK	
% Regional EPA	18%	1.9	More along shore	
% Regional ECA		38.8	OK	
Natural Landscapes	Target (original) Distribution 57.5 fine soil lowland 17.2 fine soil mesic 1.2 shallow lowland 7.4 Shallow mesic 16.1 Shallow upland 0.5 Coarse soil upland	 70.5 7.9 1.8 8.0 11.7 0.1	more fine soil mesic, shallow upland and coarse soil upland	
Subwatershed Form	Description			
Area	868.3 ha			
Outfall	Lake Erie			
Shape	Triangular with long shoreline			
Topography	Very gently sloping towards L. Erie. Flat at apex tip and within approx. 1 km of lake except for very steep dunes along shore.			
Alterations since Settlement	Almost all cleared and most natural areas are immature recent growth. No obvious natural stream but several drains including to quarry ponds. Partially built up 70 years ago. Development concentrated in Crescent Park and shore. Very little agriculture remains.			
Shore	Important feature. Will extend as lake levels down.			
Natural Area Distribution	Well-distributed with the exception of Crescent Park and shore			
Function	Implications of Form on Function			
Habitat	Moderate due to good extent. Important shore habitats degraded.			
Water Protection	Moderate. Drains well protected but relatively short. Some recharge areas protected			
Other				
Key Natural Heritage Issues	Levelled slough mosaic reduces both diversity and flow moderation capacity Artificial drainage changed hydrology of some areas Development – esp. scattered, low density – increases fragmentation and spreads adverse effects. Shoreline development removes rare coastal habitats.			
Other Issues	Increasing imperviousness in southwest corner. Natural Areas Inventory found unevaluated wetlands.			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

TABLE 5.3.14:
INTEGRATED RATING OF TERRESTRIAL NATURAL HERITAGE SYSTEMS
SIX MILE CREEK

Natural Area Form	Minimum Guideline	2002/2005* Status	Target	Target area (ha)
% wetland % original wetland**	10 Max. 56.9; Min. 22.8	13.8	OK	
% natural cover - Aquatic - Beach/dunes - Prairie - Shrub/Meadow or Marsh - Treed	 30	39.3 0.7 15.4 23.1	 OK with shrub succession	
Slough Mosaic	20.2 % (original %)	1.1% (loss of 94.7%)	+ 19.1% of natural	+136 ha
Largest Forest Patch	200 ha	85.4	OK for urban	
% Forest Interior - > 100 m from edge - > 200 m from edge	 10% 5%	 2.2 0	 OK for urban	
% riparian cover (30 m either side)	75%	69.4	+5.6%	+ 12 ha i.e., 4 km (1-side) or 2 km (2-side)
% Regional EPA	18%	12.0	OK	
% Regional ECA		19.7	OK	
Natural Landscapes	Target (original) Distribution 43.5 fine soil lowland 21.9 fine soil mesic 8.6 alluvial 4.8 Shallow lowland 9.0 Shallow mesic 12.1 Shallow upland 0.2 Coarse soil upland	 47.4 12.3 14.7 7.1 5.9 12.6 tr	 More fine soil mesic areas – though may happen via climate change	
Subwatershed Form	**Description**			
Area	1813.4 ha			
Outfall	Lake Erie			
Shape	Slightly stretched square			
Topography	Flat through middle. Gentle slopes on either side, esp. to west			
Alterations since Settlement	Cleared for agriculture. Drains extended gradually. Older developments towards headwaters. Thunder Bay and near shore areas developed in more recent decades. Gradual spread of regenerating forest in recent decades.			
Shore	Approx. 2 ½ km			
Natural Area Distribution	Moderately well distributed. Gaps in built-up areas and headwaters.			
Function	**Implications of Form on Function**			
Habitat	Good inland habitat but could improve linkage to north and west			
Water Protection	Good riparian cover			
Other				
Key Natural Heritage Issues	Artificial drainage changed hydrology of some areas Development – esp. scattered, low density – increases fragmentation and spreads adverse effects. Shoreline development removes rare coastal habitats. Levelled slough mosaic reduces both diversity and flow moderation capacity			
Other Issues	Several potential flood damage areas throughout the subwatershed Increasing imperviousness Short eroding reaches Critical fish habitat			

* June 2005 for wetlands; December 2005 for Regional EPA and ECA; 2003 for Natural Cover; 2002 for Forest.

** Maximum is sum of original lowland, alluvial and organic landscapes (where soil data). Minimum is sum of 40% of original lowland + 40% of original alluvial landscape + 100% of original organic landscape to account for slough mosaic that is not all wetland.

5.4 Local Subwatershed Opportunities

Each subwatershed, as depicted on Figures LO (Local Opportunities) 1.1 to 11.1, has been assessed on the basis of local (physical) constraints and opportunities. These opportunities have been organized on the basis of various categories, for both urban and non-urban areas. Table 5.4.1 provides a general summary of various opportunities related to generic watershed systems.

TABLE 5.4.1:
SUMMARY OF LOCAL OPPORTUNITIES

Category	Land Use	
	Urban	**Non-Urban**
Groundwater	▪ Terms of Reference for future studies ▪ Septic standard upgrade to tertiary treatment ▪ Minimum lot size for private services (i.e. 1 acre) ▪ Manmade wetlands for stormwater management ▪ Passive lot infiltration	▪ Passive lot infiltration ▪ Innovative source water management ▪ Septic standard upgrade
Watercourses (erosion, fisheries)	▪ Determine stable parameters ▪ Restoration activities (watercourse form and habitat, vegetative riparian buffers) ▪ Remove of barriers to fish movement ▪ Uses development funding	▪ Maintain Municipal drain in an environmentally sustainable manner ▪ Farm Best Management Practices ▪ Stewardship ▪ Repair degraded creeks, drains ▪ Remove barriers to fish movement ▪ Improve water quality ▪ Restoration opportunities (watercourse form and habitat, vegetative riparian buffers) ▪ Stewardship involvement, including Non-Government organizations
Flooding (infrastructure, floodplain)	▪ Increase capacity of culverts ▪ Increase capacity of bridges ▪ Upgrade trunk sewers ▪ Delineate floodplains; flood-proof damage centres	▪ Delineate floodplains; flood-proof damage centres ▪ Prevent future development in hazard lands
Water Quality	▪ Provide water quality treatment to new development ▪ Retrofit existing development ▪ Locate and treat point source pollutant sources ▪ Educate public regarding nutrient use, such as fertilizers – note elevated levels of phosphorous recorded in Black Creek and Frenchman's Creek ▪ Continue to educate public regarding potential for E. coli pollution	▪ Locate and treat point source pollutant generators ▪ Educate public regarding nutrient use, such as fertilizers – note elevated levels of phosphorous recorded in Black Creek and Frenchman's Creek ▪ Continue to educate public regarding potential for E. coli pollution
Stormwater Management	▪ Determine and set flooding target/criteria ▪ Set erosion control targets ▪ Optimize siting of new and retrofit facilities ▪ Determine implementation and funding mechanisms	▪ Improve agricultural drainage ▪ Maintain Municipal drain in an environmentally sustainable manner
Natural Heritage System	▪ *Protect* – EPAs, LSAs, riparian, function of ECAs. ▪ Encourage infill development in non-natural areas, and, if necessary, natural areas that are not classified as one of the above ▪ *Protect* emerging coastal corridor as lake down ▪ Protection actions specific to Subwatershed needs ▪ *Enhance*: by slough mosaic replacement if feasible opportunity in non-EPA, immature, poorly drained, levelled lacustrine site with potential downstream flooding ▪ *Restore*: riparian and lake shoreline sites as opportunity. Also street plantings, green roofs, roadside swales ▪ Investigate options for owners of natural areas to be compensated for maintaining green infrastructure	▪ *Preserve*: where very high natural area extent and function and low level of concern for issues (e.g., Baker) ▪ *Protect* – discourage urban uses and if development occurs, encourage cluster development and avoid EPAs , ECAs and LSAs ▪ *Protect* emerging coastal corridor if lake draws down due to climate change ▪ Protection actions specific to subwatershed needs ▪ *Enhance*: by slough mosaic replacement if feasible opportunity in immature, non-EPA, poorly drained, levelled lacustrine site with potential downstream flooding. Priority near drains or high % levelled ▪ *Restore* along corridors, riparian areas, steep slopes, dunes, vulnerable recharge areas, irregular gaps – all avoiding best farmland with the exception of compact riparian buffers and site options beyond the watershed plan's resolution. ▪ Investigate growing willow for ethanol, on non-natural areas

The local management opportunities related to each primary category have been developed on the following premises:

Groundwater Management

In order to refine hydrogeological characteristics on a local scale, as compared to the current more regional and intermediate scale assessment, detailed site specific groundwater studies will be required to be carried out for site specific developments by the proponent's consultant. These studies would confirm or refine the existing hydrogeological sensitivity within the context of the regional understanding. More specifically these studies would refine, on a site-specific scale, the groundwater flow system with respect quantity and location of recharge, subsurface flow and linkages of the groundwater to the aquatic (i.e. discharge) and terrestrial systems, and aquifer sensitivity with respect to private and municipal use. These site-specific studies would provide the technical information for specific design of locally-based BMP's to provide appropriate levels of groundwater quality and quantity protection (i.e. maintaining or enhancing baseflow, providing acceptable quality recharge) or provide direction to refine the overall site specific development density and/or design.

Generic Terms of Reference and guidelines for these site-specific hydrogeological studies are offered in Appendix 'SW-E'.

Watercourse Systems

Those watercourses which due to their existing or potential significance are deemed important, have been defined as remaining open. Where realignment opportunities exist, this process has <u>not</u> defined any alternatives due to the lack of any locally-specific land use directives at this time or lack of sufficient topographic detail.

It is expected that subsequent planning processes (i.e. Secondary Plans and Tertiary land use plans) will provide the necessary input to direct where, and to what extent, watercourse realignment (both vertically and horizontally) will be required.

Where watercourse works are proposed, the natural storage-discharge relationship of the watercourse must be replicated (or exceeded) as closely as possible.

A Table has been prepared for each Subwatershed to describe:

a) Stable stream beltwidth
b) Existing watercourse slope
c) An estimate of the existing 2-year and 100-year Regulatory flow to establish an approximate floodplain width for planning purposes (notwithstanding, reaches where the Regulatory floodline mapping has been prepared and would govern).

Fisheries

Many of the watercourses within the study area have largely retained their natural attributes, due mainly to the flat topography and poorly drained soil conditions that result in swampy conditions surrounding them, which has discouraged agricultural and residential encroachment. These same base conditions have almost eliminated the incidence of barriers to fish movement. The drying of watercourses during the summer months is also not an important issue within the study area. Some localized degradation of fish habitat within the study area can reasonably be attributed to the historical alteration of watercourses (deepened and/or straightened) to either drain land for agriculture or to facilitate the construction of transportation routes. In some areas this has also resulted in a lack of appropriate riparian vegetation.

With these existing conditions, the opportunities for fish habitat improvement within each subwatershed area mainly focus upon the rehabilitation of degraded channels and the enhancement or establishment of appropriate vegetative buffers. These are:

- Where watercourses have been straightened but the original meandering channels still persist, an opportunity exists to re-establish the watercourse within these old channels to provide more aquatic habitat within a natural channel.
- Other straightened watercourses can be rehabilitated using natural channel design principles. This will likely happen concurrently with the development of adjacent lands, but may be the result of government, NGO, or private initiatives aimed at habitat restoration.
- Riparian vegetative buffers should be established or enhanced where they are presently inadequate.

Natural Heritage System

The Natural Heritage System is presented on Figure NH8. The figure is intended for general and broad-scale illustration purposes only. More site-specific planning should: refer to any data updates, follow the protection designations and policies of the Regional and Municipal Official Plans, be compatible with provincial policy, Niagara Parks Commission mandate and any applicable provincial plans.

The map shows the main strategy for each natural area and options for natural area restoration:

- Protection areas are areas that have been identified as providing important features and services. Natural areas in Protection class are to be maintained and protected from adverse impacts. They correspond with Environmental Protection Areas and policies of the Regional and municipal Official Plans. A few Protection areas have no natural areas (e.g., valley lands and floodplains) and are options for natural area restoration.
- The Conservation/Enhancement class applies to other areas with regionally or municipally identified natural areas functions. These functions should be maintained where possible. There may also be opportunities to enhance their functioning.
- Other Natural Area/Enhancement class covers the remainder of the existing natural areas. They too can have opportunities for enhancement.
- Restoration Options class applies to areas without natural cover that could potentially provide valuable ecological services if restored to natural cover. Services include filling gaps in corridors and riparian buffers, bulking up core areas, and protecting potentially vulnerable groundwater recharge areas.
- Slough Mosaic Restoration Options class applies to the above three classes where it is estimated the original landscape supported a slough mosaic. If opportunities arise within these areas that prove practical and with net ecological benefits, slough restoration could

add many biological and hydrological services to the areas while complementing drain requirements.

- The Lake Erie Shoreline Band of Restoration Opportunity is a swath within which recommendations for shoreline community restoration could apply where conditions are suitable.

Given the high natural area extent within the settlement area, emphasis should be on protection and enhancement rather than on natural area restoration. Infill and high-density cluster development can allow growth while protecting natural areas. Natural area trails and walkable communities can offer outdoors access. If infill requires incursion into a natural area, EPA's should be avoided in favour of removing areas with relatively low natural area function, following procedures set out in the Official Plan.

Two zones are exceptions to the de-emphasis of natural area restoration in the Settlement Area:

- The Baker – Miller – Niagara River Shore – Lower Frenchman's Creek watersheds corridor as playing a possible important role in biota migration for climate change adaptation. Here, protection and enhancement (e.g., slough mosaic creation where feasible and appropriate opportunities) can be supplemented by restoration to improve the corridor linkage still further; and
- The Lake Erie shoreline for its current and potential highly significant communities and biota. Restoration efforts could boost the extent and diversity of these important communities and the wildlife they support.

The Agricultural Area has both less natural area and less development pressure than the Settlement Area. Restoration can be added to the strategy, especially for riparian buffers, corridor linkage, core enhancement, and protection of potentially vulnerable groundwater recharge areas. Where restoration for green infrastructure beneficial to all of society, some compensation from beneficiaries to providers could be considered. The Natural Heritage plan presented on Map NH8 excludes broad-scale natural area restoration options from Class 1 and 2 agricultural capability soils to minimize conflicts with agriculture. Beyond the map's resolution, however, at the site level, some smaller-scale natural area restoration would be beneficial on these lands. Riparian buffers and small constructed wetlands would reduce non-point source impacts that can be generated by intensively farmed areas. Opportunities for corridor linkages could also be considered.

In many areas throughout the study area, opportunity-based enhancement of lower-significance natural areas by restoration of the natural slough mosaic pattern could boost both biodiversity and flood moderation values of the areas.

The watershed plan is broad-scale. Official Plan requirements for more detailed studies must precede development in or affecting natural areas. Development proposals will require specific studies to:

a) Identify site-specific features including the presence and requirements of species-at-risk using any plans and up-to-date information available from MNR;
b) Identify significant wildlife habitat;

c) Confirm and/or refine wetland boundaries. Any revisions should consult with MNR representatives to develop a consensus on changes;
d) Identify reliance of features on local overland flows and groundwater conditions;
e) Identify stressors specific to the site;
f) Establish protection of the features and functions using buffers, development setbacks and other site specific management approaches in accordance with the principles and suggested approaches in the present study;
g) Identify practical opportunities to enhance natural area function, e.g., sites with relatively easy access for slough mosaic re-establishment, with soils where there was a pre-settlement mosaic pattern, where there would be no disruption of significant natural features and that would benefit from valuable improvement in diversity and flood control;
h) Identify locations for compensation, augmentation, or restoration of natural cover to offset identified impacts or inadequacies, and improve habitat connectivity and ecosystem functions after development; and
i) Identify suitable locations and standards for trails and infrastructure (e.g. utilization of boardwalks and 'soft' engineering approaches to protect woodland and wetland functions).

Stewardship can be encouraged by government, business, organizations and individuals implementing opportunities to:

a) Raise citizen awareness of the role of green infrastructure in the functioning of their local subwatershed, the uniqueness of its natural areas, the issues affecting them and remedial actions,
b) Minimize nuisance wildlife and invasive exotics
c) Maintain drains with best practices to minimize erosion and with a focus of slough mosaic restoration in abutting natural areas
d) Encourage options for rural income based on sustainable use of natural heritage
e) Promote agency-private-NGO partnerships and coordinate information sharing, cost sharing among beneficiaries and actions towards common goals
f) Increase public access to natural areas and shorelines
g) Develop participatory monitoring with highly accessible and meaningful output.

The NPCA currently oversees a stewardship program within the study area.

Stormwater Management

For the purpose of establishing/addressing watershed and subwatershed level targets related to erosion, flooding, baseflow and water quality, a system of distributed stormwater management facilities has been advanced for each subwatershed area with developing areas. While the specific orientation or even number of facilities are subject to refinement through subsequent study, the concept advanced for each subwatershed area has been premised on the following principles:

(a) Where possible, integrate stormwater management facilities into or adjacent to open space areas, or natural systems including proposed linkage corridors and watercourses.
(b) Adopt a philosophy of 'natural' wetland SWMP's for those facilities cites in (a), and wet pond SWMP's for those facilities located in more urban settings.

(c) Generally locate communal stormwater management facilities at or near changes in land use and outlets at watercourses to be maintained.
(d) Minimize the number of stormwater management facilities when possible by maximizing drainage area capture to 40 to 80 ha +/-.
(e) Recognize the inherent economic complexity associated with crossing major utility corridors and roads.
(f) The Municipality has a combination of urban drainage systems (curb/gutter/storm sewers), and rural drainage systems (ditches). In several locations, due to localized topographic constraints, sump pumps connected to the storm sewer, foundation drain collection (FDC) systems, and sump pump discharging to surface, may be considered, as noted in the Town of Fort Erie's "Subdivision Control Guidelines for Development of New Subdivisions & Application Form", 2004. Other Alternative Development Standards (ADS) such as reduced lot grading, are not covered in the Guidelines.

Flooding

For flooding and infrastructure improvements, the impact assessment has determined that there are twenty-five potential flood damage centres, with the number of structures involved ranging from one to approximately twenty-five.

There are typically four different opportunities to mitigate the flood potential:

(a) Storage – reduce peak flows and floodplain depths downstream
(b) Conveyance improvements – reduce floodplain depths
(c) Local flood-proofing – e.g. berming, raising structures, or dry flood-proofing (no openings below the 100 year level)
(d) Acquisition of land/regulate the floodplain – typically only applied to areas where the first three opportunities are not feasible.

The majority of the potential flood damage centres involve one structure, and the recommendation for those would be local flood-proofing.

Where there is widespread flooding that involves a cluster of structures, storage and conveyance improvements may be more economical than local flood proofing or acquisition.

There are eight potential damage centres with multiple structures on the Black Creek, one on Beaver Creek, one on Frenchman's Creek, one on Kraft Drain, and five on the Six Mile Creek:

- Black Creek at Switch Road, east of the QEW, both sides of the creek
- Black Creek at the Glenney Drain
- Black Creek south of Townline Road
- Black Creek tributary along Netherby Road west the QEW
- Black Creek at the confluence with Beaver Creek, College Street
- Black Creek at Stevensville, Main Street
- Black Creek at Netherby Road
- Black Creek at Point Abino Road
- Beaver Creek u/s of the confluence, Eagle Road
- Frenchman's Creek at Industrial Drive

- Kraft Drain north of Dominion Road
- Six Mile Creek, Bethune Avenue and Shirley Road
- Six Mile Creek (Mann Drain), Dominion Road and Burleigh Road
- Six Mile Creek at Dominion and Centralia
- Six Mile Creek at Bernard Avenue and Nigh Road; and on Bernard Avenue

The Black and Beaver Creeks have larger drainage areas and flows, and the potential for storage and conveyance improvements being a feasible/economical opportunity is not as likely. Local flood-proofing or acquisition may be the recommended opportunity.

Storage is typically proposed in either a retrofit location, or a new centralized system which optimizes the contributing drainage area and control point in combination with topography and available lands.

The Six Mile Creek has five culverts identified that overtop during the 100 year event, and some which would cause a backwater increase of 0.4 m or greater. This suggests that conveyance improvements would at least help mitigate some of the potential for flooding of these structures. Local flood-proofing may be required for the balance.

In addition to the watercourses listed, the NPCA has developed hazard land mapping along the Lake Erie and Niagara River shorelines.

5.4.1 Summary of Local Subwatershed Opportunities

Each of the following tables represents a specific listing of the identified opportunities in each subwatershed, based on the format/structure of the generic opportunities offered in Table 5.4.1. Following each table is a list of the reaches in the subwatershed, together with the stream physical parameters and flow rates. This is primarily for planning and management purposes, should the reach need to be restored or realigned in the future.

Following the tables are two figures for each subwatershed: the watercourse and stormwater management opportunities on the first figure, and the natural heritage strategy on the second figure (Figures LO 1.1, 1.2 through LO 11.1, 11.2).

TABLE 5.4.2: SUMMARY OF LOCAL OPPORTUNITES BLACK CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Riparian buffer zone enlargement (BK-1-5) ▪ Erosion control (BLC11-15) – bank protection ▪ Golf course – riparian buffer zone ▪ Removal of on-line pond (BLC-ST-9) ▪ Bed morphology enhancement ▪ SWM – Erosion control enhancement ▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist (i.e. Reaches BLC-1, BLC-2, BLC-3, BLC-4, BLC-9, BLC-10, BLC-11, and BLC-12)	▪ Riparian buffer zone enlargement ▪ Stabilization of livestock access (BLC-24-30) ▪ Municipal drains - naturalization ▪ Enhance bed morphology ▪ Removal of in stream structures (BLC-26 – weir) ▪ Removal of on-line ponds (BLC-ST-1) ▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist (i.e. Reaches BLC-5, BLC-8, BLC-15, BLC-18, BLC-23, BLC-24, BLC-25, BLC-26, BLC-27, BLC-28, BLC-29, BLC-30, BLC-31, MD-5, and SD-2). ▪ Rehabilitate straightened watercourse sections using natural channel design when the opportunity arises during future development

Flooding (infrastructure, floodplain)	▪ Remediate approximately 11potential flood-prone structures in Stevensville (BLK 205, floodplain Sheet 6), through local flood-proofing	▪ Remediate 7 potential flood damage centres through local flood-proofing:
		  ▪ 2-3 d/s of the QEW at Switch Rd.
		  ▪ 20 trailers in the park west of the QEW south of Netherby
		  ▪ At the Glenney Drain
		  ▪ South of Townline Rd.
		  ▪ College St.
		  ▪ 2 on St. John's drain south of Netherby
		  ▪ 1 on Schil drain west of Point Abino Rd
		▪ upgrade 2 culverts that create significant backwater during the 100 year event (House Road on Main Branch, and Bowen Road on south Tributary)

Stormwater Management	▪ Peak flow and volume control required in Stevensville, subcatchment BLK 205. ▪ Erosion control required on identified susceptible reaches ▪ Retrofit existing development with SWM	
Water Quality		▪ potential point source contaminant loading identified at waster lagoons (QEW), auto wrecker (Neff south of 2'nd C, and Bowen east of Ott), and dump (2'nd C west of Wilhelm). ▪ Educate public regarding nutrient use, given the consistently elevated Total Phosphorous levels ▪ Educate public regarding potential sources of E. coli contamination
Natural Heritage System	▪ Main opportunity: Protection ▪ Protect EPA's; conserve ECA's & LSA's according to OP & to support broad IBA corridor through Douglastown ▪ Extend trees and parkland along the creek ▪ Street trees, roadside swales, green roofs could improve runoff, moderate microclimate. ▪ Where opportunities exist, intensify new development to save areas elsewhere ▪ Where feasible, appropriate opportunity in natural area outside EPA's, enhance by slough mosaic replacement	▪ Main Opportunity: Restoration of corridors, esp. riparian ones (both shown on map & unmapped narrower ones). Include slough mosaic restoration where possible ▪ Protect EPA's , conserve ECA's and LSA's according to OP ▪ Enhance by slough mosaic restoration in existing areas where feasible, appropriate opportunity and need for more biodiversity or flow moderation ▪ Enhance by drain naturalization. E.g., Humberstone Marsh ▪ Consider naturalizing the South Brookfield Road clearing in Humberstone Marsh

TABLE 5.4.3: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE BLACK CREEK									
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**	**REACH NAME**	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
BLC-1	115	0.01	9.62	110.53	BLC-26	58	0.07		
BLC-2	95	0.01			BLC-27	38	0.19		
BLC-3	95	0.04	9.04	106.93	BLC-28	35	0.17		
BLC-4	185	0.01	6.74	66.91	BLC-29	35	0.12		
BLC-5	185	0.01	5.93	60.38	BLC-30	60	0.20		
BLC-6	191	0.01	5.67	57.96	BLC-31	110	0.14		
BLC-7	60	0.03			BLC-ST-1	60	0.06	1.38	11.90
BLC-8	77	0.01			BLC-ST-2	25	0.08		
BLC-9	95	0.01	4.29	46.08	BLC-ST-3	29	0.17		
BLC-10	64	0.02			BLC-ST-4	56	0.08		
BLC-11	143	0.01			BLC-ST-5	47	0.27		
BLC-12	93	0.08	4.18	45.47	BLC-ST-6	43	0.07		
BLC-13	57	0.15			BLC-ST-7	90	0.06		
BLC-14	56	0.44			BLC-ST-8	42	0.37		
BLC-15	80	0.28	1.85	22.03	BLC-ST-9	35	0.17		
BLC-16	115	0.09			BLC-ST-10	48	0.26		
BLC-17	71	0.06			BLC-ST-11	38	0.61		
BLC-18	57	0.06			BLC-ST-12	38	0.26		
BLC-19	46	0.08	1.39	17.96	BLC-ST-13	38	0.26		
BLC-20	46	0.13							
BLC-21	59	0.07			BLC-NT-1	30	0.48		
BLC-22	39	0.08			BLC-NT-2	40	0.48		
BLC-23	39	0.06			BLC-NT-3	37	0.23		
BLC-24	39	0.11	0.79	11.48	BLC-NT-4	38	0.07		
BLC-25	50	0.05			BLC-NT-5	38	0.22		

TABLE 5.4.4: SUMMARY OF LOCAL OPPORTUNITES BEAVER CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Golf course (BVC-1) – riparian buffer zone ▪ Riparian buffer zone enlargement (BVC-22) ▪ Erosion control (BVC-21-25) – bank protection ▪ SWM – Erosion control enhancement ▪ Bed morphology enhancement	▪ Riparian buffer zone enlargement ▪ Erosion control – (BVC 5-16) – bank enhancement ▪ Municipal drains - naturalization ▪ Enhance bed morphology (BVC-10)

Flooding (infrastructure, floodplain)		▪ Remediate 2 potential flood damage centres:
		  ▪ 3 on Eagle Rd near the confluence with Black Creek (floodplain sheet 3)
		  ▪ the golf course clubhouse near the confluence
		  ▪ 1 north of Garrison (floodplain sheet 21)
		▪ upgrade culvert that create significant backwater during the 100 year event (Stevensville Road)

Stormwater Management	▪ Retrofit existing development with SWM	▪ Peak flow and volume control required in Ridgeway, subcatchments BEV 202, 203, 204, 2020. ▪ Erosion control required. ▪ Flood control or mitigation required in existing damage centres.
Water Quality		▪ PS potential contaminant loading identified at decommissioned landfill on Winger north of the creek.
Natural Heritage System	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Street trees, roadside swales, green roofs could improve runoff and moderate microclimate. ▪ Where opportunities exist, intensify new development to save areas elsewhere	▪ Main Opportunity: Restoration to fill out riparian corridors ▪ Add buffers to upper tributaries. Naturalize valleyland EPAs where not yet natural ▪ If opportunities, restore: on shallow over bedrock areas (potentially vulnerable recharge areas) especially in headwaters, & along old RR ▪ Enhancement: when feasible, appropriate opportunity, restore slough mosaic. ▪ Protect EPAs; conserve ECAs & LSAs according to OP.

TABLE 5.4.5:
PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE BEAVER CREEK

REACH NAME	BELT WIDTH (m)	Gradient (%)	Q_2 (m^3/s)	Q_{100} (m^3/s)	REACH NAME	BELT WIDTH (m)	Gradient (%)	Q_2 (m^3/s)	Q_{100} (m^3/s)
BVC-1	82	0.03	2.44	40.66	BVC-15	70	0.21	1.33	15.21
BVC-2	82	0.22			BVC-16	67	0.09		
BVC-3	70	0.03			BVC-17	58	0.14	1.25	13.55
BVC-4	70	0.10			BVC-18	58	0.15		
BVC-5	70	0.04			BVC-19	70	0.04		
BVC-6	70	0.03	1.90	32.31	BVC-20	64	0.12	1.65	22.29
BVC-7	58	0.06			BVC-21	90	0.17		
BVC-8	54	0.03			BVC-22	86	0.17		
BVC-9	65	0.03			BVC-23	70	0.13	1.41	13.90
BVC-10	67	0.15	1.87	26.53	BVC-24	34	0.11	1.34	13.40
BVC-11	56	0.07			BVC-25	49	0.12		
BVC-12	110	0.04	1.55	19.88	BVC-26	46	0.18		
BVC-13	50	0.15			OD-1	55	NA	0.89	7.93
BVC-14	40	0.34			OD-2	54	NA		

TABLE 5.4.6: SUMMARY OF LOCAL OPPORTUNITES BAKER CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)		▪ Erosion control (BKC-2) – bank improvements ▪ Riparian buffer zone (BKC-1 – proposed golf course) ▪ Culvert improvement (BKC-3) – larger structures ▪ Rehabilitate straightened watercourse sections using natural channel design when the opportunity arises during future development.
Flooding (infrastructure, floodplain)		
Stormwater Management		▪ Peak flow and volume control required in subcatchment BAK 200. ▪ Erosion control required.
Water Quality		▪ PS potential contaminant loading identified at lagoon south of Townline Road.
Natural Heritage System		▪ Main Opportunity: Preservation – maintain this very high functioning area. ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Enhancement: when feasible, appropriate opportunity, restore slough mosaic with priority to east drain subwatershed. As ECA shrub and meadow areas mature, forest interior targets will be met. ▪ Restoration: The corridor linkage needs reinforcing – consider expanding corridor along hydro ROW and, if the golf course is developed, that it be designed to avoid the south west corner including the creek and wetlands. For restored areas on lowland lacustrine soils, include slough mosaic restoration.

TABLE 5.4.7: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE BAKER CREEK				
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
BKC-1	66	0.08	0.83	7.07
BKC-2	55	0.05		
BKC-3	59	0.05	0.49	4.60

TABLE 5.4.8: SUMMARY OF LOCAL OPPORTUNITES MILLER CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Erosion Control – bank enhancements	▪ Removal of on-line pond (MLC-7) ▪ Bed morphology enhancement ▪ Erosion control – bank stabilization ▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist. ▪ Reach MLC-6: rehabilitate straightened channel with natural channel design. ▪ Reach MLC-7: rehabilitate straightened channel by re-establishing flow in original natural channel, and any remaining straightened sections with natural channel design.
Flooding (infrastructure, floodplain)		
Stormwater Management		▪ Peak flow and volume control required in subcatchments MIL 100,101. ▪ Erosion control required.
Water Quality		▪ PS potential contaminant loading identified at, auto wrecker, and landfill.
Natural Heritage System	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Extend trees and buffers along creeks as opportunity arises. ▪ Street trees, roadside swales, industrial green roofs could improve runoff and moderate microclimate. ▪ Where opportunities exist, intensify new development to save areas elsewhere	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to OP; protect large block at mouth and improve its linkages ▪ Enhancement: when feasible, appropriate opportunity arises, restore slough mosaic. As ECA shrub and meadow areas mature, forest and forest interior targets can be met. ▪ Restoration: Reinforce links to Baker and Frenchman's watersheds. Extend riparian and, in headwaters, restore some natural area -

TABLE 5.4.9: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE MILLER CREEK									
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**	**REACH NAME**	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
MLC-1	60	0.06	1.69	14.71	MLC-5	51	0.16		
MLC-2	57	0.05			MLC-6	48	0.12		
MLC-3	55	0.17			MLC-7	35	0.25		
MLC-4	51	0.13	1.18	11.80	MLC-8	33	0.30	0.92	8.46

TABLE 5.4.10: SUMMARY OF LOCAL OPPORTUNITES NIAGARA RIVER SHORE		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)		▪ Naturalize river shoreline when opportunities arise.
Flooding (infrastructure, floodplain)		▪ N/A
Stormwater Management		▪ Local treatment where opportunities arise
Water Quality		
Natural Heritage System		▪ Main Opportunity: Protection of EPAs, LSAs and ECAs, especially in Niagara R. 19 ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Enhancement: when feasible, appropriate opportunity exists, restore slough mosaic As ECA shrub and meadow areas mature, forest targets can be met. ▪ Restoration: Connect corridor through Niagara R. 16 to beyond study area. Extend riparian buffers.

TABLE 5.4.11: SUMMARY OF LOCAL OPPORTUNITES FRENCHMAN'S CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Golf course – riparian zone enhancement ▪ Channel straightening near QEW and Thompson Road – natural channel design ▪ Erosion control (MLC4-6) – bank protection, ▪ SWM – Erosion control enhancement ▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist. ▪ Remove barriers to fish migration. Specifically, mitigate fish movement issues at the dam and associated pond at the downstream end of the Bridgewater Golf and CC, upstream of Thompson Rd.	▪ Riparian buffer zone enlargement ▪ Stabilization of livestock access (FRC-14) ▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist. ▪ Reaches FRC-5 and FRC-9: establish natural riparian vegetation buffer along watercourse within the golf courses. ▪ Reaches FRC-7, FRC-8 and FRC-11: rehabilitate using natural channel design and establish natural riparian vegetation buffer along watercourse.
Flooding (infrastructure, floodplain)	▪ Remedial flood damage centre at Industrial Dr.	▪ One potential flood damage centre d/s of Sunset Dr.:
Stormwater Management	▪ Retrofit existing development with SWM	▪ Erosion control required. ▪ Flood control or mitigation required in existing damage centres.
Water Quality		▪ PS potential contaminant loading identified at auto wrecker on Thompson. ▪ Educate public regarding nutrient use, given the consistently elevated Total Phosphorous levels ▪ Educate public regarding potential sources of E. coli contamination
Natural Heritage System	▪ Main Opportunity: Protection ▪ Extend trees and parkland along the creek as opportunity arises. ▪ Street trees, roadside swales, green roofs on industrial buildings could improve runoff and moderate microclimate. ▪ Where opportunities exist, intensify new development to save areas elsewhere ▪ Where opportunity (outside EPAs), restore slough mosaic	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to OP; Protect large block at mouth and improve its links ▪ Enhancement: when feasible, appropriate opportunity arises, restore slough mosaic. As ECA shrub and meadow areas mature, forest interior targets will be met. ▪ Restoration: The corridor linkage needs reinforcing – join to Miller Creek natural areas and extend riparian buffers. Target coarse upland soils & headwaters. ▪ Investigate habitat potential of post-closure quarries to assist forward planning

TABLE 5.4.12: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE FRENCHMAN'S CREEK									
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**	**REACH NAME**	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
FRC-1	109	0.04	N/A	24.65	FRC-9	66	0.22		
FRC-2	85	0.02			FRC-10	54	0.31		
FRC-3	74	0.12			FRC-11	54	0.07	N/A	11.56
FRC-4	73	0.17			FRC-12	58	0.08		
FRC-5	53	0.09			FRC-13	48	0.06		
FRC-6	37	0.18	N/A	19.74	FRC-14	53	0.07		
FRC-7	37	0.18			FRC-15	43	0.40		
FRC-8	39	0.14							

TABLE 5.4.13: SUMMARY OF LOCAL OPPORTUNITES FORT ERIE		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Naturalize river shoreline when opportunities arise.	
Flooding (infrastructure, floodplain)	▪ Relief storm infrastructure ▪ Coastal barriers	
Stormwater Management	▪ Adhere to Town guidelines for new development and infills ▪ Retrofit existing development with SWM	
Water Quality		▪ PS potential contaminant loading in urban centre, treatment plants. ▪ Retrofit CSO's
Natural Heritage System	▪ Main Opportunity: Restoration appropriate to urban setting ▪ Extend trees and parkland along the river as opportunity exists – contribute to migratory corridor. ▪ Encourage owners near river to plant trees ▪ Street trees, roadside swales, green roofs could improve runoff to Niagara River and moderate microclimate. ▪ Where opportunities exist, intensify new development to save areas elsewhere	

TABLE 5.4.14: SUMMARY OF LOCAL OPPORTUNITES LAKESHORE		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Naturalize river shoreline when opportunities arise.	
Flooding (infrastructure, floodplain)	▪ Shoreline Protection	
Stormwater Management	▪ Adhere to Town guidelines for new development and infills ▪ Retrofit existing development with SWM	
Water Quality		▪ PS potential contaminant loading in urban centre, treatment plants ▪ Retrofit CSO's
Natural Heritage System	▪ Main Opportunity: Protection ▪ Protect EPA's; conserve ECA's & LSA's according to OP, checking for wetland ▪ Protect shoreline if lake levels decline and current natural inland linkage from shore ▪ Encourage intensified development ▪ Encourage shoreline owners to restore coastal habitats ▪ Federal government restore on their lands	

TABLE 5.4.15: SUMMARY OF LOCAL OPPORTUNITES KRAFT DRAIN		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Erosion control (KFD1-5) – bank protection, ▪ SWM – Erosion control enhancement threshold values ▪ Natural Channel Design (KFD-5) ▪ Flow that is presently directed through Reach KFD-5 should be re-established into existing original bypassed Reaches KFD-2, KFD-3 and KFD-4. ▪ Existing groundwater inputs should be maintained and enhanced where feasible. ▪ Reach KFD-1: rehabilitate hardened watercourse edge in downstream half of reach	
Flooding (infrastructure, floodplain)	▪ Remediate 1 potential flood damage centre through local flood-proofing: ▪ up to 3 flood-prone structures near the headwaters ▪ Retrofit existing development with SWM ▪ Upgrade 4 culverts that create significant backwater during the 100 year event (Dominion, Kraft)	
Stormwater Management		▪ Peak flow and volume control required in potentially all subcatchments. ▪ Erosion control required.
Water Quality		▪ Potential point source contaminant loading identified at auto wrecker on Kraft and chemical plant on Helena.
Natural Heritage System	▪ Main Opportunity: Enhancement ▪ Enhance existing natural areas through slough mosaic reestablishment if feasible, appropriate opportunity ▪ Intensify development. ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Protect Shoreline if lake levels decline ▪ Encourage shoreline owners to restore coastal habitats ▪ Restore opportunities for corridors to Frenchman's subwatershed (and toward the creek crossing of the QEW) via top end of Bertie Bay subwatershed	

TABLE 5.4.16: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE KRAFT DRAIN				
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
KFD-1			1.25	15.51
KFD-2				
KFD-3				
KFD-4			0.71	9.23

TABLE 5.4.17: SUMMARY OF LOCAL OPPORTUNITES BERTIE BAY DRAINS & LAKE ERIE 1		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Erosion control– bank protection, ▪ SWM – Erosion control enhancement threshold values ▪ Natural Channel Design	▪ Reach BBD-2: rehabilitate straightened channel by re-establishing flow in the existing original natural channel. ▪ Maintain and enhance existing groundwater inputs. ▪ Remove culvert at mouth of watercourse that is presently a barrier to fish migration
Flooding (infrastructure, floodplain)	▪ Shoreline protection	
Stormwater Management	▪ Retrofit existing development with SWM	▪ Peak flow and volume control required in subcatchment BER 102. ▪ Erosion control required.
Water Quality		▪ Crescent Park, Dominion Road CSO
Natural Heritage System	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Where feasible opportunity outside EPA and appropriate landscape (see map NH8) and communities, enhance existing natural areas through slough mosaic reestablishment ▪ Where opportunities exist, intensify new development to save areas elsewhere	▪ Main Opportunity: Protection ▪ Protect shoreline if lake levels decline ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Investigate if the EPAs in the southwest corner should be expanded to accommodate the priority flagged by the Great Lakes Conservation Blueprint (Henson and Brodribb, 2005) ▪ Enhance existing natural areas through slough mosaic reestablishment, if feasible, appropriate opportunity ▪ Encourage shoreline owners to restore coastal habitats ▪ Restore where opportunities for filling corridors or protecting recharge (shallow over bedrock) areas

TABLE 5.4.18: SUMMARY OF LOCAL OPPORTUNITES SIX MILE CREEK		
Element	**Urban**	**Non-Urban**
Watercourses (erosion, fisheries)	▪ Erosion control– bank protection, ▪ SWM – Erosion control enhancement ▪ Enhance bed morphology ▪ Removal of on-line ponds (MND-2, MND-5) ▪ SWM – Erosion control enhancement Enhanced bed morphology	▪ Reach SMC-6: rehabilitate straightened channel by re-establishing flow in the existing original natural channel. ▪ Reach MND-1: establish natural riparian vegetation buffer along watercourse. ▪ Rehabilitate straightened channels (Reaches SMC-7, SMC-8, MND-2, MND-3, MND-4, MND-5, and MND-6) as part of potential future urban or residential development.

Flooding (infrastructure, floodplain)	▪ Remediate 4 potential flood damage centres, through conveyance improvements, and potentially local flood-proofing:
	  ▪ up to 25 flood-prone structures near the intersection of Bethune and Shirley
	  ▪ 3 on Centralia (sheets 2,4)
	  ▪ 1 at Bernard and Nigh
	  ▪ 16 at Dominion and Burleigh, on the Mann drain
	▪ shoreline protection
	▪ upgrade 10 culverts that create significant backwater during the 100 year event	

Stormwater Management	▪ retrofit existing development with SWM ▪ Erosion control required	▪ Peak flow and volume control required in central and upper subcatchments, and MAN102.
Water Quality		▪ PS potential contaminant loading identified at. Auto wrecker on Stonemill south of Garrison Road
Natural Heritage System	▪ Main Opportunity: Protection ▪ Protect EPAs; conserve ECAs & LSAs according to Official Plan ▪ Street trees, roadside swales, green roofs could improve runoff and moderate microclimate. ▪ Where feasible opportunities exist, intensify new development to save areas elsewhere ▪ Where opportunity outside EPA and appropriate landscape (see map NH8) and communities, enhance existing natural areas through slough mosaic reestablishment	▪ Main Opportunity: Protection ▪ Protect Shoreline if lake levels decline ▪ Protect EPAs; conserve ECAs & LSAs according to OP ▪ Enhance existing natural areas through slough mosaic reestablishment, if feasible, appropriate opportunity ▪ Encourage shoreline owners to restore coastal habitats ▪ Extend corridor linkages northward and westward and along creeks

TABLE 5.4.19: PLANNING LEVEL BELT WIDTH CORRIDORS AND GRADIENT FOR THE MAIN REACHES WITHIN THE SIX MILE CREEK									
REACH NAME	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**	**REACH NAME**	**BELT WIDTH (m)**	**Gradient (%)**	**Q_2 (m^3/s)**	**Q_{100} (m^3/s)**
SMC-1	82	0.07	4.82	47.40	SMC-10	43	0.34		
SMC-2	46	0.08			SMC-11	40	0.51		
SMC-3	44	0.07			MND-1	38	NA		
SMC-4	46	0.09			MND-2	38	NA	1.52	15.31
SMC-5	52	0.08	2.50	25.36	MND-3	29	NA	1.06	8.13
SMC-6	30	0.14			MND-4	35	NA		
SMC-7	30	0.19			MND-5	28	NA	0.77	7.50
SMC-8	30	0.16	0.96	7.68	MND-6	28	NA		
SMC-9	42	0.35	0.77	9.40					

6. IMPLEMENTATION

In section 5, a list of site-specific and local opportunities has been generated. These recommendations form part of the Watershed Plan. The list has had a priority assigned to each recommendation (high, or medium) which is provided in Table 6.1.1 to 6.1.11.

The information has been reviewed in detail by the Steering Committee, and comments have been provided by the NPCA, Town, MNR, and Niagara Parks Commission.

6.1 Priority List of Recommendations

The area-specific recommendations, which fall into the general urban areas and non-urban areas categories, have been reviewed with stakeholders and the Steering Committee in order to confirm the important factors for establishing priority. These factors include human health, safety, risk, cost, social impacts, environmental significance, and other related factors. The priority list will become an important administrative and communication tool.

Watercourses

For watercourses, a high priority has been assigned to the removal of barriers to fish migration, removal of on-line ponds, and restoration of severely modified reaches of the watercourses (e.g. anthropogenic modifications).

General restoration, stabilization, erosion protection and reinstatement of historical flows have been assigned a medium priority.

Natural Heritage System

Protection of existing natural areas and their functions is a high priority and well covered by Official Plans. Medium priority recommendations are actions toward improving habitat, hydrologic and microclimate functions and addressing the key issues identified for each sub-watershed area: restoration/enhancement of slough mosaic micro-topography, corridor reinforcement including extension of riparian buffers, and coastal community restoration and stewardship. Consistent with Provincial Policy and directives, it is assumed that urban development will incorporate green infrastructure (e.g., street trees, roadside swales, green roofs) and strive for relatively dense forms to avoid sprawl over natural areas.

Stormwater Management

For stormwater management, a high priority has been assigned to providing management for new development. In the existing urban areas, a medium priority has been assigned to providing retrofit treatment to existing development. A medium priority has also been assigned to identifying and addressing point source pollutants.

Tables 6.1.1 to 6.1.11 list all of the prioritized local actions that have been recommended in the Watershed Plan:

In addition to the priority assigned to each action, there is an entry for land ownership, proponency, cost assumptions, and estimated cost. These elements of the table are discussed in more detail in the following sections.

Land Ownership

The majority of the lands in question are within private ownership, and include the watercourses that pass through private and public lands. Where culvert upgrades are required/recommended, the road may be either private or public (Town, Region). Several of the identified potential sites for Point source pollution are also public.

Proponency

The NPCA are the primary proponent of the Watershed Plan, and would be joined in a large number of recommended actions by the public through stewardship, stakeholders, and the landowners. Stormwater management for new development remains the responsibility of the developer (however, the facilities have been included in the total costing exercise).

Cost Assumptions

Watercourse treatment costing has been based on the broad assumptions that: erosion stabilization (structural and bio-engineering) will be required on both banks and on 50% of the total length of the reach in question. Riparian buffers would consist of primarily vegetation and minor grading would be conducted on 100% of the reach length and on both sides. Livestock controlled areas would be constructed along 50% of the reach length, and on both sides. The proposed unit rates are conservative and based on the Study Team's experience on similar projects over the past 10-20 years.

The flood proofing and culvert replacement costing has been done as part of the flood damage assessment (red. Appendix 'SW-F'). The flood proofing costing is based on berming and landscaping, plus meetings with the private landowners and survey of the potentially affected lands. As noted in the flooding assessment, some of the potentially affected (and hence costed) structures may turn out not to be within the 100 year floodplain.

The Natural Heritage System enhancement will be subject to further study to determine the extent and conditions of site options; hence the estimates of area involved are preliminary. For the slough mosaic restoration, the grading and planting would be selective and not as dense as a reforestation exercise. For the proposed vegetation between adjacent natural areas or along the shorelines, a more-densely vegetated unit rate has been proposed. Restoration includes some compensation for land; near-urban rates are higher. Area estimates factor in subwatershed: natural area target areas, extent of site options available (Figure NH8), flooding, imperviousness, and population requiring ecological services.

TABLE 6.1.1:
SUMMARY OF PRIORITIZED LOCAL ACTIONS
BLACK CREEK

Element	Urban	Non-Urban	Priority	Land Ownership	Proponency	Cost Assumptions	Cost ($1,000's)
Watercourses (erosion, fisheries)	▪ Erosion control (BLC11-15) – bank protection		H	Private	NPCA/Private	1000 m x $200/m	200
	▪ Golf course – riparian buffer zone		M	Private	NPCA/Private	1000 m x $100/m	100
	▪ Removal of on-line pond (BLC-ST-9)		H	Private	NPCA/Private	remove, regrade, restore	50
	▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist (i.e. Reaches BLC-1, BLC-2, BLC-3, BLC-4, BLC-9, BLC-10, BLC-11, and BLC-12)		M	Private		3000 m x $100/m	300
		▪ Stabilization of livestock access (BLC-24-30)	M	Private	NPCA/Private	100 m x $50/m	50
		▪ Removal of in stream structures (BLC-26 – weir)	H	Private	NPCA/Private	remove, regrade, restore	25
		▪ Removal of on-line ponds (BLC-ST-1)	H	Private	NPCA/Private	remove, regrade, restore	50
		▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist (i.e. Reaches BLC-5, BLC-8, BLC-15, BLC-18, BLC-23, BLC-24, BLC-25, BLC-26, BLC-27, BLC-28, BLC-29, BLC-30, BLC-31, MD-5, and SD-2).	M	Private	NPCA	6000 m x $100/m	600
Flooding (infrastructure, floodplain)	▪ Remediate approximately 4 potential flood-prone structures in Stevensville (BLK 205, floodplain Sheet 6), through local flood-proofing		H	Private	NPCA/Town	Flood proofing by berming and vegetating/landscaping	12
		▪ Remediate 6 potential flood damage centres through local flood-proofing: ▪ 2-3 immediately downstream of the QEW ▪ 20 trailers in the park west of the QEW south of Netherby ▪ 1 east of Winger at Main ▪ 2 on St. John's drain south of Netherby ▪ 1 on Schil drain west of Point Abino Rd ▪ 1 west of Winger on the south tributary	H	Private	NPCA/Town	Flood proofing by berming/landscaping	532
		▪ Upgrade 2 culverts that create significant backwater during the 100 year event (House Road on Main Branch, and Bowen Road on south Tributary)	M	Public	Town	$100K per culvert	200
Stormwater Management	▪ Peak flow and volume control required in Stevensville, subcatchment BLK 205. ▪ Erosion control required on identified susceptible reaches ▪ Retrofit existing development with SWM		H	Private	Development	2 extended detention control end-of-pipe facilities (excluding land)	400
Water Quality		▪ Potential point source contaminant loading identified at waste water lagoons (QEW), auto wrecker (Neff south of 2'nd C, and Bowen east of Ott), and dump (2'nd C west of Wilhelm).	M	Public/Private	Region	3 site specific studies	30
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP & to support broad IBA corridor through Douglastown ▪ Extend trees and parkland along the creek		H	Private	NPCA/Town	Public awareness/stewardship 200 trees @ $50	10 10
		• Restore corridors, esp. riparian ones, incl. Slough mosaic where appropriate	M	Private	NPCA	220 ha @ $4.5K/ha	990
		▪ Protect EPA's , conserve ECA's and LSA's according to OP	H	Private	NPCA/Town	Public awareness/stewardship	10
		▪ Enhance by slough mosaic restoration in existing areas where opportunity and need for more biodiversity or flow moderation	M	Private	NPCA	Regrade, plant 50 ha @ $3.5K/ha	175
		▪ Consider naturalizing the South Brookfield Road clearing in Humberstone Marsh	M	Private	NPCA	Plant 10 ha @ $4K/ha	40
		▪ Drain naturalization opportunities, e.g., Humberstone Marsh	M	Public/Private	NPCA		20

Subtotal: High	$1,299,000.
Subtotal: Medium	$2,505,000.
Total	***$3,804,000.***

TABLE 6.1.2:
SUMMARY OF PRIORITIZED LOCAL ACTIONS
BEAVER CREEK

Element	Urban	Non-Urban	Priority	Land Ownership	Proponency	Cost Assumptions	Cost ($1,000's)
Watercourses (erosion, fisheries)	▪ Golf course (BVC-1) – riparian buffer zone		M	Private	NPCA/Private	400 x $100/m	40
	▪ Riparian buffer zone enlargement (BVC-22)		M	Private	NPCA/Private	400 x $100/m	40
	▪ Erosion control (BVC-21-25) – bank protection		H	Private	NPCA/Private	2000 x $200/m	400
		▪ Riparian buffer zone enlargement (BVC 2-4)	M	Private	NPCA/Private	1500 x $100/m	150
		▪ Erosion control – (BVC 5-16) – bank enhancement	H		NPCA/Private	4000 x $200/m	800
		▪ Enhance bed morphology (BVC-10)	M	Private	NPCA/Private	600 x $500/m	300
Flooding (infrastructure, floodplain)		▪ Remediate 2 potential flood damage centres: ▪ 3 on Eagle Rd near the confluence with Black Creek (floodplain sheet 3) ▪ the golf course clubhouse near the confluence	H	Private	NPCA/Town	flood proofing by berming/landscaping	49
		▪ upgrade culvert that create significant backwater during the 100 year event (Stevensville Road)	M	Public	Town	$100K per culvert	100
Stormwater Management	▪ Retrofit existing development with SWM		H	Private	Development	2 extended detention control end-of-pipe facilities (excl. land)	400
		▪ Peak flow and volume control required in Ridgeway, subcatchments BEV 202, 203, 204, 2020.	H	Private	Development	2 extended detention control end-of-pipe facilities (excl. land)	400
Water Quality		▪ PS potential contaminant loading identified at decommissioned landfill on Winger north of the creek.	M	Public	Region	1 site specific study	10
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP		H	Private	NPCA/Town	Public awareness/stewardship	10
		▪ Add buffers to upper tributaries. Naturalize valleyland EPA's where not yet natural, along old R.R., headwaters recharge areas if opportunity	M	Private	NPCA	60 ha @ $4K/ha	240
		▪ Enhancement: when opportunity, restore slough mosaic.	M	Private	NPCA	10 ha @ $3.5K/ha	35
		▪ Protect EPA's; conserve ECA's & LSA's according to OP.	H	Private	NPCA/Town	Public awareness/stewardship	10

Subtotal: High	$2,069,000.
Subtotal: Medium	$ 915,000.
Total:	***$2,984,000.***

TABLE 6.1.3:
SUMMARY OF PRIORITIZED LOCAL ACTIONS
BAKER CREEK

Element	Urban	Non-Urban	Priority	Land Ownership	Proponency	Cost Assumptions	Cost ($1,000's)
Watercourses (erosion, fisheries)		▪ Erosion control (BKC-2) – bank improvements	H	Private	NPCA/Private	800 x $200/m	160
		▪ Riparian buffer zone (BKC-1 – proposed golf course)	H	Private	NPCA/Private	1000 x $100/m	100
		▪ Culvert improvement (BKC-3) – larger structures	M	Private	NPCA/Private	3 x $100K	300
Flooding (infrastructure, floodplain)		▪ No structures, culverts		Private	NPCA/Private		
Stormwater Management		▪ Peak flow and volume control required in subcatchment BAK 200.	H	Private	Development	1 extended detention control end-of-pipe facilities (excl. land)	200
Water Quality		▪ PS potential contaminant loading identified at lagoon south of Townline Road.	M	Public	Region		10
Natural Heritage System		▪ Protect EPA's; conserve ECA's & LSA's according to OP Preserve this high functioning area	H	Private	NPCA/Town	Public awareness/stewardship	10
		▪ Enhancement: when opportunity, restore slough mosaic with priority to east drain sub-watershed. As ECA shrub and meadow areas mature, forest interior targets will be met.	M	Private	NPCA	25 ha @ $3.5K/ha	122.5
		▪ Restoration: The corridor linkage needs reinforcing – consider expanding corridor along hydro ROW and, if the golf course is developed, that it be designed to avoid the south west corner including the creek and wetlands. For restored areas on lowland lacustrine soils, include slough mosaic restoration.	M	Private	NPCA	10 Ha @ $4.5K/ha	45

Subtotal: High	$470,000.
Subtotal: Medium	$477,500.
Total	***$947,500.***

TABLE 6.1.4: SUMMARY OF PRIORITIZED LOCAL ACTIONS MILLER CREEK							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ Erosion Control – bank enhancements MLC 8		H	Private	NPCA/Private	500 @ $200	100
		▪ Removal of on-line pond (MLC-7)	H	Private	NPCA/Private		50
		▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist. MLC 1-5	M	Private	NPCA/Private	2000 @ $100	200
		▪ Reach MLC-6: rehabilitate straightened channel with natural channel design.	M	Private	NPCA/Private	800 @ $500	400
		▪ Reach MLC-7: rehabilitate straightened channel by re-establishing flow in original natural channel, and any remaining straightened sections with natural channel design.	M	Private	NPCA/Private	600 m x $500/m	300
Flooding (infrastructure, floodplain)		▪ No structures, culverts					
Stormwater Management		▪ Peak flow and volume control required in subcatchments MIL 100,101.	H	Private	Development		400
Water Quality		▪ PS potential contaminant loading identified at, auto wrecker, and landfill.	M	Public/Private	Region	2 site specific studies	20
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP		H	Private	NPCA/Town		10
	▪ Extend trees and buffers along creeks, as opportunity		M	Private	NPCA	400 trees @ $50	20
		▪ Protect EPA's; conserve ECA's & LSA's according to OP; protect large block at mouth and improve its linkages	H	Private	NPCA/Town		10
		▪ Enhancement: when opportunity arises, restore slough mosaic. As ECA shrub and meadow areas mature, forest and forest interior targets can be met.	M	Private	NPCA	10 ha @ $3.5K/ha	35
		▪ Restoration: Reinforce links to Baker and Frenchman's watersheds. Extend riparian and, in headwaters, restore some natural area -	M	Private	NPCA	90 ha @ $4.5K/ha	405

Subtotal: High	$ 570,000.
Subtotal: Medium	$1,380,000.
Total	***$1,950,000.***

TABLE 6.1.5: SUMMARY OF PRIORITIZED LOCAL ACTIONS NIAGARA RIVER SHORE							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)		▪ Naturalize river shoreline when opportunities arise.	M	Private	NPCA/Private	10,000 x $50/m	500
Flooding (infrastructure, floodplain)		▪ No structures, culverts		Private			
Stormwater Management		▪ Local treatment where opportunities arise	M	Private	NPCA/Private		50
Water Quality				Private			
Natural Heritage System		▪ Protect EPA's; conserve ECA's & LSA's according to OP	H	Private	NPCA		10
		▪ Enhancement: when opportunity exists, restore slough mosaic As ECA shrub and meadow areas mature, forest targets can be met.	M	Private	NPCA	10 ha @ $3.5K/ha	35
		▪ Restoration: Connect corridor through Niagara R. 16 to beyond study area. Extend riparian buffers.	M	Private	NPCA	20 ha @ $4.5K/ha	90

Subtotal: High	$ 10,000.
Subtotal: Medium	$675,000.
Total:	***$685,000.***

TABLE 6.1.6: SUMMARY OF PRIORITIZED LOCAL ACTIONS FRENCHMAN'S CREEK							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ Golf course – riparian zone enhancement		M	Private	NPCA/Private	1000 @ $100	100
	▪ Channel straightening near QEW and Thompson Road – natural channel design (FRC-10)		M	Private	NPCA/Private	400 @ $500	200
	▪ Erosion control (FRC4-6) – bank protection,		H	Private	NPCA/Private	1500 @ 200	300
	▪ Remove barriers to fish migration. Specifically, mitigate fish movement issues at the dam and associated pond at the downstream end of the Bridgewater Golf and CC, upstream of Thompson Rd.		H	Private	NPCA/Private	2 x $50K	100
		▪ Stabilization of livestock access (FRC-14)	M	Private	NPCA/Private	800 @ $50	40
		▪ Establish appropriate natural vegetation riparian buffers where they are inadequate or do not exist. (FRC 12-13, 1-3	M	Private	NPCA/Private	1600 @ $100	160
		▪ Reaches FRC-5 and FRC-9: establish natural riparian vegetation buffer along watercourse within the golf courses.	M	Private	NPCA/Private	1000 @ $100	100
		▪ Reaches FRC-7, FRC-8 and FRC-11: rehabilitate using natural channel design and establish natural riparian vegetation buffer along watercourse.	M	Private	NPCA/Private	1500 @ 500	750
Flooding (infrastructure, floodplain)	▪ Thompson Road ▪ Industrial Drive (6 structures) ▪ Sunset Drive		H	Private	NPCA/Town		180
Stormwater Management	▪ Retrofit existing development with SWM		H	Private	Development	1 study	200
Water Quality		▪ PS potential contaminant loading identified at auto wrecker on Thompson.	M	Private	Region	1 Site-specific Study	20
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP; Protect large block at mouth and improve its links		H	Private	NPCA/Town		10
		▪ Protect EPA's; conserve ECA's & LSA's according to OP; Protect large block at mouth and improve its links	H	Private	NPCA/Town		10
		▪ Enhancement: when opportunity arises, restore slough mosaic. As ECA shrub and meadow areas mature, forest interior targets will be met.	M	Private	NPCA	10 ha @ $3.5K/ha	35
		▪ Restoration: The corridor linkage needs reinforcing – join to Miller Creek natural areas and extend riparian buffers. Target coarse upland soils & headwaters.	M	Private	NPCA	50 ha @ $4K/ha	200

Subtotal: High $ 800,000.
Subtotal: Medium $1,605,000.
Total: ***$2,405,000.***

TABLE 6.1.7: SUMMARY OF PRIORITIZED LOCAL ACTIONS FORT ERIE							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ NA						
Flooding (infrastructure, floodplain)	▪ Public Awareness re: flooding. hazard		M	Private	NPCA/Private	Public awareness/stewardship	10
Stormwater Management	▪ Adhere to Town guidelines for new development and infills		H	Private	Development	1 study	20
	▪ Retrofit existing development with SWM		H	Private	Development	1 study	200
Water Quality		▪ PS potential contaminant loading in urban centre, treatment plants.	M		Region		10
		▪ Retrofit CSO's	M		Town	1 study	20
Natural Heritage System	▪ Extend trees and parkland along the river as opportunity exists – contribute to migratory corridor.		M		NPCA	4000 @ $50	200

Subtotal: High $220,000.
Subtotal: Medium $240,000.
Total: ***$460,000.***

TABLE 6.1.8: SUMMARY OF PRIORITIZED LOCAL ACTIONS LAKESHORE DRAIN							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ N/A						
Flooding (infrastructure, floodplain)	▪ N/A						
Stormwater Management	▪ Adhere to Town guidelines for new development and infills		H	Private	Development	1 facility	200
	▪ Retrofit existing development with SWM		M	Private/Public	Town	1 study	20
Water Quality		▪ PS potential contaminant loading in urban centre, treatment plants	M	Public	Region		10
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP, checking for wetland		H	Private	NPCA/Town		10
	▪ Protect shoreline and natural linkage to inland		M	Private	NPCA	4000 @ 50	200
	▪ Encourage shoreline owners' incl. Fed. Government, to restore coastal marshes, meadows etc.		M	Private/Public	NPCA	30 ha @ $3.5K/ha	105

Subtotal: High	$210,000.
Subtotal: Medium	$335,000.
Total:	***$545,000.***

TABLE 6.1.9: SUMMARY OF PRIORITIZED LOCAL ACTIONS KRAFT DRAIN							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ Erosion control (KFD1-5) – bank protection,		H	Private	NPCA/Private	1000 @ 100	100
	▪ Reach KFD-1: rehabilitate hardened watercourse edge in downstream half of reach		H	Private	NPCA/Private	400 @ 500	200
Flooding (infrastructure, floodplain)	▪ Remediate 1 potential flood damage centres through local flood-proofing: ▪ up to 3 flood-prone structures near the headwater		H	Private	NPCA	Flood proofing by berming/landscaping	87
Stormwater Management	Peak flow and volume control required in potentially all subcatchments		H	Private	Development	5 @ $100	500
Water Quality		▪ Potential point source contaminant loading identified at auto wrecker on Kraft and chemical plant on Helena.	M	Public/Private	Region	50 ha @ 4K/ha	20
Natural Heritage System	▪ Enhance existing natural areas through slough mosaic reestablishment		M	Private	NPCA	10 @ $20	200
	▪ Protect EPA's; conserve ECA's & LSA's according to OP		H	Private	NPCA/Town		10
	▪ Encourage shoreline owners to restore coastal habitats, e.g., meadows, marshes		M	Private	NPCA	5 ha @ $3.5K/ha	17.5
	▪ Restore opportunities for corridors to Frenchman's sub-watershed (and toward the creek crossing of the QEW) via top end of Bertie Bay sub-watershed		M	Private	NPCA	5 ha @ $10K/ha	50

Subtotal: High	$ 897,000.
Subtotal: Medium	$ 287,500.
Total:	***$1,184,500.***

TABLE 6.1.10: SUMMARY OF PRIORITIZED LOCAL ACTIONS BERTIE BAY DRAINS & LAKE ERIE 1							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)		▪ Reach BBD-2: rehabilitate straightened channel by re-establishing flow in the existing original natural channel.	H	Private	NPCA/Private	400 @ 500	200
		▪ Remove culvert at mouth of watercourse that is presently a barrier to fish migration	H	Private	NPCA/Private		50
Flooding (infrastructure, floodplain)	▪ N/A						
Stormwater Management	▪ Retrofit existing development with SWM		H	Private	Town	1 Study	20
	▪ Peak flow and volume control required in subcatchment BER 102.		H	Private	Development	2 Facilities	400
Water Quality		▪ Crescent Park, Dominion Pumping station overflow	M	Public	Region	1 site specific study	10
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to OP		H	Private	NPCA	Public awareness/stewardship	10
	▪ Where opportunity outside EPA and appropriate landscape (see map NH8) and communities, enhance existing natural areas through slough mosaic reestablishment		M	Private	NPCA	10 @ $20 Regrade and replant 10 ha @ $20K/ha	200
		▪ Protect EPA's; conserve ECA's & LSA's according to OP	H	Private	NPCA/Town	Public awareness/stewardship	10
		▪ Investigate if the EPA's in the southwest corner should be expanded to accommodate the priority flagged by the Great Lakes Conservation Blueprint (Henson and Brodribb, 2005)	M	Private	NPCA	Site specific study	10
		▪ Enhance existing natural areas through slough mosaic reestablishment	M	Private	NPCA	10 ha @ $3.5K/ha	35
	▪ Encourage shoreline owners to restore coastal habitats	▪ Encourage shoreline owners to restore coastal habitats	M	Private	NPCA	60 ha@ $3.5K/ha	210
		▪ Fill in corridor gaps or restore to protect recharge area, when opportunity	M	Private	NPCA	5 ha @ $10/ha	50

Subtotal: High $ 690,000.
Subtotal: Medium $ 515,000.
Total: ***$1,205,000.***

TABLE 6.1.11: SUMMARY OF PRIORITIZED LOCAL ACTIONS SIX MILE CREEK							
Element	**Urban**	**Non-Urban**	**Priority**	**Land Ownership**	**Proponency**	**Cost Assumptions**	**Cost ($1,000's)**
Watercourses (erosion, fisheries)	▪ Erosion control– bank protection, SMC-S		H	Private	NPCA/Private	500m m $200/m	100
	▪ Removal of on-line ponds (MND-2, MND-5)		H	Private	NPCA/Private	2 x $50/m	100
		▪ Rehabilitate straightened channels (Reaches SMC	M	Private	NPCA/Private	600 x $500/m	300
Flooding (infrastructure, floodplain)	▪ Remediate 5 potential flood damage centres, through conveyance improvements, and potentially local flood-proofing: ▪ up to 25 flood-prone structures near the mouth, Bethune and Shirley ▪ 3 on Centralia (sheets 2,4) ▪ 1 at Bernard and Nigh ▪ 16 at Dominion and Burleigh, on the Mann drain		H	Private	NPCA/Town		753
	▪ upgrade 4 culverts that create significant backwater during the 100 year event		H	Public	Town	2 culverts @ $200K 2 culverts @ $150K	700
Stormwater Management		▪ Peak flow and volume control required in central and upper subcatchments, and MAN102	H	Private	Development	4 facilities	800
Water Quality	▪	▪ PS potential contaminant loading identified at. Auto wrecker on Stonemill south of Garrison Road	M	Private	Region	1 site specific study	10
Natural Heritage System	▪ Protect EPA's; conserve ECA's & LSA's according to Official Plan		H	Private	NPCA	Public awareness/stewardship	10
	▪ Enhance existing non-EPA natural areas through slough mosaic reestablishment, if appropriate opportunity		M	Private	NPCA	20 ha @ $3.5K/ha	70
		▪ Protect EPA's; conserve ECA's & LSA's according to OP	H	Private	NPCA/Town		10
		▪ Enhance existing non-EPA natural areas through slough mosaic reestablishment, if appropriate opportunity	M	Private	NPCA	30 ha @ $3.5K/ha	105
	▪ Encourage shoreline owners to restore coastal habitats	▪ Encourage shoreline owners to restore coastal habitats	M	Private	NPCA	70 ha @ $3.5K/ha	245
		▪ Extend corridor linkages northward and westward and along creeks	M	Private	NPCA	30 ha @ $10K/ha	300

Subtotal: High	$2,473,000.
Subtotal: Medium	$1,030,000.
Total:	***$3,503,000.***

Cost Summary

Each of the subwatershed tables has sub-totals for recommended actions, split into High and Medium priorities. A total of ***$19,673,000*** is the preliminary cost estimate for the recommended actions.

This can be broken down into the sub-totals for the High priority list:		$9,708,000.
	Medium priority list:	$9,965,000.

6.2 Discussion on Monitoring and Adaptive Management Plan

Watercourses

The installation of geomorphic control sites established across the study area through the detailed geomorphic field effort will provide an invaluable tool for future studies to both qualitatively and quantitatively assess future change within the study area. Monitoring sites have been placed strategically at key locations within each subwatershed to provide results that are both spatially representative and indicative of the geomorphic variability within the watershed.

Results of future erosion monitoring can be fed back into the watershed plan, and locations that are exhibiting above-normal or unexpected rates of erosion can be addressed before all of the proposed future development proceeds.

Natural Heritage System

The natural heritage monitoring plan should strive for an optimum balance of necessary data and pragmatism. The latter is essential to ensure the on-going implementation basic to successful monitoring. Existing monitoring should be used where possible and appropriate. Involvement of local volunteers can help build ownership to their watershed and a sense of place. Indicators should link to watershed goals, objectives and targets and include each of Stressor, Ecological Effect and Human Response aspects to help capture the linkages, resulting progress and understanding of any necessary adaptations in the management response. Regular progress reports should be simple and clear for maximum outreach to the residents.

Table 6.1 proposes a set of possible indicators toward meeting the above criteria. Valid monitoring depends on replication. Each indicator will need clear presentation of what exactly the measure is, the protocol, endpoint, features (scale, time periods, variability), interpretation, limitations, illustration, implementation. Indicators with volunteer participation should use standard methodologies designed for non-experts and for valid comparisons with monitoring elsewhere. The suggestions are preliminary: monitoring system development will depend on local capacity and on integration with monitoring of watercourses and stormwater management.

Monitoring results can be used to adjust the watershed plan actions and to ease stressors, where appropriate and feasible.

TABLE 6.1: SOME POSSIBLE INDICATORS FOR MONITORING OF TERRESTRIAL NATURAL HERITAGE				
Aspect	**Indicator**	**Approach**	**Frequency**	**Agency**
Stressor	Area ECAs and LSAs developed	Log as occur	annual	Town
	Perimeter of EPAs abutting new development	Log as occur	annual	Town
	Building permits within 200 m of lake shore	Log as occur	annual	Town
	Population Density	Census years Air photo measured area	5 years	NPCA
Effect	% forest, % interior, % riparian	Air photos	5 years	NPCA
	Amphibians species and numbers	FrogWatch or Marsh Monitoring Program	annual	NPCA with volunteers
	Fowler's Toad numbers	Check with Recovery Plan	annual	NPCA with volunteers
	Date first flowering white trillium, white water lily, wild strawberry	PlantWatch	annual	NPCA with volunteers
	Corridor completeness	% of corridor system with natural cover: air photo	5 years	NPCA
Response	Area of slough mosaic landscape restored	Log as occur	annual	NPCA
	Area restored within 200 m of lakeshore	Log as occur	annual	NPCA
	# Fort Erie students at outdoor education at least 1 day/year	Log as occur	annual	Boards of Education

Stormwater Management

Stormwater management monitoring is proposed to be conducted by the development proponent for the new facilities, to determine whether they are functioning as designed, in terms of pollutant removal, temperature and other water quality and quantity indicators, prior to assumption by the Municipality.

6.3 Future Studies

Subsequent to the publication of the Fort Erie Creeks Watershed Plan, there will be a need for other secondary level studies to "bridge the gap" between this watershed-scale study and actual implementation of the recommended works at a local level. These studies may originate with development, e.g. plans of subdivision or site plans, or the studies may be a part of restoration initiatives that are brought forward by the NPCA or other Public or Private stakeholders. Regardless of the proponency, the studies would be subject to various agency approval requirements.

Normally these studies would consist of:

- Subwatershed Plans
- Master Drainage Plans
- Locally-specific Restoration Initiatives
- Class Environmental Assessments
- Function Stormwater Management Reports
- Environmental Impact Studies, and
- other Private-sector Development Initiatives.

One example of an identified study would be the further detailed assessment of potential flood damage locations (ref. Watercourse Technical Appendix 'WC-G'). The NPCA has identified several locations that will require further detailed study (e.g. ground survey) to determine the extent of potential damage and a more detailed design of mitigation measures.

In terms of water quality, the NPCA has developed a Draft Restoration Program and Water Quality Improvement Project (NPCA 2007) which is intended to provide guidance and information on funding for future studies and projects.

6.4 Implementation Committee

Further specifics with respect to stewardship programs, and other restoration requirements will be developed after the Watershed Plan is finalized. The next step proposed by the NPCA is the formation of Implementation Committees, consisting of representatives from:

- NPCA
- Town of Fort Erie
- Regional Municipality of Niagara
- Niagara Parks Commission
- Parks Canada

One of the roles of the Implementation Committee is to oversee the implementation of monitoring; either general monitoring of the watershed, or specific monitoring that is developed through the future studies. The Implementation Committee will monitor the progress and success of the Fort Erie Creeks Watershed Plan, measuring the effectiveness of the implemented projects in achieving the Watershed Plan Objectives. Typically, Watershed Plan would be reviewed by the NPCA and the Implementation Committee on an annual basis. The Watershed Plan may be amended from time to time to address changes that occur to the study area, landowners, agencies, stakeholders, and the NPCA.

It is recommended that the Implementation Committee assess the ongoing monitoring program conducted by the NPCA. Additional monitoring by other stakeholders (both historic and proposed) could potentially be reviewed for opportunities to obtain more data.

As a follow-up to the Watershed Plan, the participating landowners and stakeholders should be surveyed as part of the future Watershed Plan review.

The Municipalities in the study area (Fort Erie, Port Colborne, and Niagara Falls) would potentially be represented on the Implementation Committee, and any updates to their Official Plans would need to be reviewed in the context of the Watershed Plan.

7. CONCLUSIONS

The Fort Erie Creeks Watershed Plan is a proactive document, created co-operatively by government agencies and the community to manage the water, land/water interactions, aquatic life, and aquatic resources, to protect the health of the ecosystem as land uses change (Niagara Peninsula Conservation Authority, Terms of Reference, 2005).

The Fort Erie Creeks study area is comprised of a mixture of rural and urban areas, with a large percentage of agricultural land use. There are numerous watercourses and each reach has been characterized and assigned an integrated net constraint rating, base on fisheries, wildlife, wetlands, woodlots, stream morphology, erosion and flooding characteristics, and objectives.

A list of actions in the Watershed Plan has been developed with the agencies and the public. The NPCA will oversee the implementation of the Watershed Plan, together with the other public, Municipal, and agency representatives on the Implementation Committee. The progress made on the Watershed Plan initiatives will be reported by the Implementation Committee. The Watershed Plan will allow for the preservation, restoration, and enhancement of the natural ecosystem within the watershed study area. With the level of public involvement observed during the preparation of the Watershed Plan, it is hoped that environmental stewardship will play an important role in the implementation of the recommended list of actions.

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GLOSSARY OF TERMS

Alluvial Soil
Sediments deposited by recent flood processes. They are variable textures and drainage but are usually imperfectly or poorly drained.

Aquatic
Growing in, living in, or dependent upon water.

Aquifer
A water bearing geological formation. An aquifer can consist of sand, gravel, or rock formations and is capable of storing and conveying water.

Basin
See "Watershed".

Benthic
Any organism or collection of organisms (animals or plants) that live on the bottom of a lake, river or other waterbody.

Best Management Practice (BMP)
Any management practice, either structural or non-structural, used to address impacts from land use changes (increased runoff from urban surfaces, agricultural practices, etc.).

Biodiversity
The genetic, taxonomic and ecosystem variety of a given area

Catchment Area
See Drainage Basin.

Conduit
Conduit is any open or close channel used to convey water.

Contaminant
Any chemical and biological substance in air, water or soil that makes it unsuitable for its intended use or consumption is considered as contaminant. Contaminants could result from natural or unnatural activities.

Contours
A line on a map joining points of same elevation. See also "Topography".

Corridor
Elongate, naturally vegetated area that links larger natural areas. Corridors provide for movement and interchange of plant and animal species necessary for their long-term maintenance.

Creek
A small stream draining a small drainage basin.

Culvert
Any closed channel or large size pipe use to convey water below ground over a short distance usually across roadways or railways.

Detention Pond
System to detain stormwater for a specific time and ultimately discharges completely to a downstream receiver. The purpose of this facility may be to attenuate high peak flows and slowly release them to downstream waterways.

Discharge Zone
Areas where groundwater meets the surface (Typically in stream) and adds flow in the form of base flow to the stream from groundwater.

Dissolved oxygen (DO)
Oxygen that is present in water and available for aquatic organism respiration.

Downstream
Is the direction of the flow of a stream or river; (i.e. down river).

Drainage
Removal of excess surface or subsurface ground water from land segments. Removal could be by naturally or open ditch, stream or subsurface system. Soil characteristics will determine natural drainage of any land.

Drainage Basin
Drainage basin or catchment area is an area that drains by a stream, creek or any other water body. The boundary or limits of a drainage basin separate it from neighbouring drainage systems by heights of land between them. The amount of precipitation, size and physical characteristics of drainage basin, determine peak flows and amount of water which can reach the end of a drainage basin.

Dredging
Removal of sediment from the bottom of a waterbody.

Dry Pond
A detention basin (see "Detention Pond") which does not hold water during non-storm periods (i.e. it is dry with no permanent pool).

Ecological Services
Benefits that humans derive from ecological functions such as photosynthesis, oxygen production and water purification.

Ecosystem
A biological community and its interaction with its environment.

E. coli
Abbreviation for *Escherichia coli*, a disease caused by fecal coliform bacteria.

Enhancement
Strategies and actions to improve the function and health of the ecosystem.

Erosion
Erosion is a physical process by which land is lost by air, water, ice, or gravity processes.

Erosion Hazards
Loss of land due to human or natural processes which may pose a threat to life and property.

Evaluated Wetland
A wetland (see Wetland) that has been visited, mapped and rated using the standard Southern Ontario Wetland Evaluation System.

Evapotranspiration
It is a combination of two terms Evaporation and Transpiration. Evapotranspiration is a combined loss of water through evaporation and plant transpiration process. It is commonly used in agriculture for estimating plant water requirements through its natural growth cycle.

Fecal Coliform Bacteria
A small disease causing, micro-organism present in human and animal feces and is used as an indicator of other disease causing bacteria. *E. coli* is one of these micro-organisms.

Fill Line
Fill lines are usually shown as straight lines delineated outside floodplains, following existing features such as fences, roads, etc. It identifies the area where future development and/or filling is restricted.

Filter strips (also know as buffer strips)
Some time also called “riparian zones” or “filter strips”. A strip of land along a water body typically planted with natural vegetation from grasses to small forest. Vegetation filters stormwater and is a quality control method suitable for low flows, typically recommended for agricultural and low-density development.

Flood line
Lines marked on map identifying limits of regulatory flooding along a designated river or creeks. See also “Floodplain”.

Floodplain
Area adjacent to streams or rivers that would be inundated by flooding during a Regulatory storm (such as Hurricane Hazel Storm (1954) or 100-year event). It has been generally applied to watercourses that drain areas greater than 125 ha.

Forebay
Forebay is a stormwater Best Management Practice (BMP) that serves as a storage and trap to incoming coarse particles. Generally it is followed by a secondary treatment system (i.e. wetland or wet pond) before discharging to receiving waters (i.e. creek, lakes).

Forest Patch
The polygon formed by the mapped outline of the forest.

Fragmentation
The process where natural area clearance for agriculture and urbanization results in decreasing natural area size, increasing intrusions within and separation among natural areas. It is considered a serious threat to habitat value and to biodiversity.

Functions (Ecological)
The processes – chemical, physical and biological - within an ecosystem that maintain its communities and interact with its adjacent ecosystems.

Geographic Information System (GIS)
A system of computer software that is capable to process spatial data. It links tabular information (charts, databases etc.) with spatial data (maps, aerial photography).

Grassed Swales
Grassed swales are a recognized BMP, usually in the form of ditches with mild slopes often planted with marshy plants and grasses. Mild slopes encourage ponding of stormwater and allows for the quality control of stormwater.

Green Infrastructure
Ecological features and processes, both natural and engineered, that directly improve the functioning of human communities. It includes natural areas, aquatic systems, urban trees, green roofs etc. that contribute to such roles as flood abatement, water quality protection and microclimate moderation.

Groundwater
Subsurface water below groundwater table within a saturated water zone. Contrast to "Surface Water".

Habitat
Place where a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for its life.

Herbicide
Chemicals used in agricultural activities to kill unwanted vegetation and weeds.

Hydrology
Science that deals with the water of earth and its cycle. The cycle includes precipitation, evapotranspiration, surface flows, infiltration, ground water recharge and waterbodies.

Hydrologic cycle
The hydrological cycle renew our fresh water resources. The cycle includes precipitation, evapotranspiration, surface flows, infiltration, ground water recharge and waterbodies.

Hydrogeology
Science of groundwater, including groundwater movement and its chemistry.

Hydraulics
Science pertaining to flowing or moving water in open channels or close conduits.

Hydrocarbon
A class of substances which consist of carbon and hydrogen. Generally petroleum products are called hydrocarbons.

Infiltration
Infiltration is the process through which water flows from the soil surface to the subsurface soil. Also includes the flow of subsurface water to subsurface conduits: like tiles or sewers through cracks or broken joints.

Inlet
An inlet is an entrance to a storm sewer or other waterbody including a stormwater management facility.

Interior Forest
The central portion of a forest patch (see above) that is far enough away from the forest edge to be relatively free of influences of adjoining land uses, better reflecting pre-settlement habitat conditions.

Lacustrine Soil
Soil developed on sediments deposited in post-glacial lakes.

Landfill
Area of land, pit, or excavation used for the permanent disposal of waste, typically engineered complete with a leachate management system (see also Old Fill Site).

Leaching
Leaching is the process by which soluble constituents dissolve in water or other solvent and are carried down through the soil.

Load or Lading
The amount of a material entering a system over a given time interval.

Lowland
An area where poorly drained soils are dominant.

Major System
Term used in hydrology when heavy rain storms cause an overflow of the "minor system" (i.e. storm sewer) and flow through the "major system", which could consist of roads and major drainage channels. Also see "minor system".

Marsh
Marsh is a wetland overgrown with coarse grasses, sedges, and rushes. It is subject to periodic flooding and in fact may depend on some natural variation in water level.

Master Drainage Plan
A comprehensive report/process which defines the method of managing runoff quantity and quality for existing and future land uses.

Mesic
An intermediate degree of wetness between well drained and poorly drained where imperfectly drained soils dominate.

Micron
A unit of measurement used for one millionth of a metre.

Micro-organism
Entities that cannot be seen without the aid of a microscope, including bacteria, viruses etc.

Mineral Soil
Soil consisting mainly of clay, silt or sand.

Minor System
The minor system consists of drainage pipes, roadway gutters, enclosed conduits, and roof leader connections designed to convey runoff from frequent, less intense storms, to eliminate or minimize inconvenience in the area served.

Municipal Drains
Municipal drains are constructed ditches and close conduits constructed primarily in rural areas, under the authority of Drainage Act. Their main purpose is to improve drainage of agricultural lands, it also convey excessive water collected by roadside ditches, residential areas, industrial area, etc.

National Topographic System (NTS)
Standard topographic maps at the scale of 1:50,000 which cover all of Canada.

Natural Heritage
Terrestrial natural areas including their habitats, species and ecological services.

Nitrification
Is a biochemical process through which ammonium nitrogen is transformed to nitrate nitrogen.

Non-Point Source pollutant (NPS)
Pollutants that discharge to waterbodies from sources other than a specific location or outlet. Agricultural activities are major source of NPS pollutants, where a large number of chemicals are used and a portion reach to the water bodies through various physical processes over time.

Nutrient Management Plan
A plan prepared for a farm to manage and document the plant nutrients (nitrogen, phosphorus and potassium) from all sources, organic (biosolids, manure, sludge etc), chemical fertilizer, legume nitrogen fixation and crop residues.

Off-line
Stormwater infrastructure that is located 'off-line' from a waterbody such as a creek..

Oil and Grease Traps
Devices used to collect oil and grease from water.

On-line
Stormwater infrastructure that is located 'on-line' within a waterbody such as a creek.

Organic Soil
Soil made up of the remains of dead plant material, in accumulations over 40 cm deep.

Outlet
Outlet is a point at which water is discharged from a drainage basin to a stream, river, or channel.

Outfall
Outfall is a point or structure where stream, river, conduit etc discharges to a receiving waterbody.

Particles
Term generally used for solids (colloids) suspended in water or wastewater, these vary widely in size, shape, and density.

Peak Oil
Point, some experts predict as soon, when oil production will start to decline rapidly and prices start to soar, once easily accessible fields are depleted.

Pesticide
Chemical used in agriculture and residential lawn care to kill organisms that are harmful to cultivated plants and animals.

Point source
Any discernible confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, container, landfill, vessel or other floating craft, or industry from which pollutants are or may be discharged from. Contrast to "Non-point source".

Poorly Drained Soil
Soil that is saturated most or all of the year.

ppm
Parts per million, a unit of concentration. Also replaceable with mg/l.

Precipitation
Precipitation includes any form of rain or snow.

Preservation
Strategies and actions to ensure healthy well-protected natural areas continue that status.

Protection
Where there are some threats, strategies and actions to ensure continued healthy functioning of natural areas by lowering the risk of those threats to the natural areas.

Quality Control Facility
A depression into which stormwater is temporarily detained during a storm. This facility is typically permanently wet (e.g. wet pond, wetland etc.) with water tolerant vegetation such as bulrushes. The treatment process involves filtration through vegetation, sedimentation through detention and displacement.

Raw Water
Surface or ground water not receiving any kind of treatment.

Reach
Reach is a comparatively short length of a stream or channel with similar characteristics.

Recharge Zones
Areas where water moves downward from the surface and infiltrates into the water table.

Regeneration
The growth of forest on abandoned farmland.

Relative humidity
Relative humidity is an amount of water vapor in the air and is expressed as a percentage of the maximum amount that the air could hold at the given temperature.

Restoration
Strategies and actions to replace a natural area that has been removed.

Retrofit
A retrofit can be a Best Management Practice (BMP) to address impacts from existing development either through a modification of existing stormwater management system or new facility, typically to treat existing stormwater for quality or quantity impacts.

Riparian
Anything connected with or immediately adjacent to the banks of a stream or other body of water.

Runoff
Water that flows over the land surface into a waterbody.

Saturated Soil
Soil with all its interstices filled with water.

Sediments
Soil, sand, silt, clay or minerals washed off during rain from land to waterbodies. Sediments accumulate in rivers, reservoirs or other waterbodies.

Settlement Area
In the Fort Erie Creek watersheds, the area of the Town of Fort Erie including and surrounding the built-up portions. It extends several kilometers inland from Lake Erie and the Niagara River and also includes Stevensville.

Slough
A small shallow depression characteristic of the unaltered micro-topography of much of the Fort Erie watersheds' lacustrine clay plains. These sloughs are very numerous, collect water in the spring and after heavy storms and, with the network of slightly higher ground, provide a range of habitats.

Slough Mosaic
A complex pattern of very shallow ridges and closed depressions characteristic of the natural form of the poorly drained lacustrine clay plains of Niagara Region.

Stormwater
Drainage from storm events whether it is overland or within a storm sewer system.

Stormwater Wetland
A constructed facility with shallow water depth and marsh plants. Wetlands provide maximum pollutant removal through plant uptake, retention, settling, and microbial activity. The design includes microtopography, pondscaping, and multiple species of wetland trees, shrubs, and plants, though it will not contain all the ecological functions of a natural wetland.

Surface Water
All water open to the atmosphere (e.g., rivers, streams, creeks, lakes, reservoirs, seas, etc.). Contrast to "Groundwater".

Swamp
A treed wetland.

Tile Drain
Subsurface slotted pipe system laid to drain excess water from the soil and transport to nearby drainage system. Commonly used in agricultural lands where soils are poor in natural drainage to dry the soil to assist in planting and growth.

Topography
Topography shows relative elevation and physical features of surface areas including natural and manmade features.

Total Suspended Solids (TSS)
Total amount of particulates in a water sample. TSS is used to determine the quality of water.

Turbidity
Turbidity in water or wastewater is caused by the presence of suspended matter, resulting in the cloudiness of water. Turbidity can be removed through filtration.

Upland
An area where well or rapidly drained soils dominate.

Virus
Virus is the smallest life form and capable of producing infectious diseases in humans or other large animals.

Waterbodies
Refers to all forms of surface water from creeks and streams to lakes and reservoirs.

Watercourses
Refers to moving surface water in natural or man-made channels (e.g. creeks, streams, rivers, canals, etc.)

Watershed
A region draining to a waterbody such as river, creeks or lakes through a single outlet (ref. "Drainage Basin").

Water Table
Subsurface layer below which the ground is completely saturated with water.

Wetland
An area that is saturated with water or has a water table at or near the surface. A wetland has plant and animal species that are adapted to a wet environment.

Wet Pond
A stormwater best management practice (BMP) employed for treatment of water quantity and quality. It has a deeper permanent pool of water than a wetland, generally greater than 1.0 m and less than 3.0 m.

Winter De-icing
The application of various materials (e.g. salts, sand, etc) that reduce the risk of slipping on icy surfaces.

Acronyms

ADS	Alternative Development Standards
ANSI	Area of Natural and Scientific Interest
BAK	Baker Creek
BER	Bertie Bay Drain
BEV	Beaver Creek
BKC	Baker Creek
BLC	Black Creek
BVC	Beaver Creek
CN	Curve Number
DEM	Digital Elevation Model
DFO	Department of Fisheries and Oceans

ECA	Environmental Conservation Area
EIS	Environmental Impact Study
EMC	Event Mean Concentration
END	Endangered
EPA	Environmental Protection Agency
FEC	Fort Erie Creeks
FRC	Frenchman's Creek
HEC-RAS	Hydrologic Engineering Centre – River Analysis System
KRD	Kraft Drain
LaMP	Lakewide Management Plan
LID	Low Impact Development
LMA'S	Local Management Areas
LSA	Locally Significant Area
LSA	Landscape Scale Analysis
MAD	Mann Drain
MAN	Mann Drain
masl	Metres above sea level
MIL	Miller Creek
MLC	Miller Creek
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
NAI	Natural Area's Inventory
NAI	Natural Areas Inventory
NGO	Non-Government Organization
NH	Natural Heritage
NHIC	Natural Heritage Information Centre
NPCA	Niagara Peninsula Conservation Authority
NRVIS	Natural Resources Values Information System
NWQPS	Niagara Water Quality Protection Strategy
OBBA	Ontario Breeding Bird Atlas
OBM	Ontario Base Mapping
OMMAH	Ontario Ministry of Municipal Affairs and Housing
OMNR	Ontario Ministry of Natural Resources
OP	Official Plan
OPG	Ontario Power Generation
PPS	Provincial Policy Statement
PSW	Provincially Significant Wetland
RAP	Remedial Action Plan
RGA	Rapid Geomorphic Assessment
RSAT	Rapid Stream Assessment Technique
RTD	Roth Drain
SARA	Species at Risk Act
SC	Special Concern
SCH	Schihl Drain
SIX	Six Mile Creek
SMC	Six Mile Creek
SMP	Shoreline Management Plan
SOLRIS	Southern Ontario Land Resource Information System

STJ	St. John's Drain
SWH	Significant Wildlife Habitat
SWM	Stormwater Management
SWMHYMO	Hydrologic software – StormWater Management HYdrologic MOdel
THR	Threatened
WSPA	Watershed Planning Area
WSEL	Water Surface Elevation
YOY	Young-of-the-year