SIXTEEN MILE CREEK, AREAS 2 & 7
SUBWATERSHED UPDATE STUDY (SUS)

TOWN OF MILTON

DRAFT FINAL

MARCH 2013
Revised MAY 2015

AMEC ENVIRONMENT & INFRASTRUCTURE

in consultation with

Blackport and Associates
C. Portt and Associates
Dougan and Associates
Parish Geomorphic

TABLE OF CONTENTS

Section **Page No.**

TABLE OF CONTENTS

Section **Page No.**

TABLE OF CONTENTS

Section **Page No.**

APPENDICES

TECHNICAL APPENDICES
(Under Separate Cover)

TABLE OF CONTENTS

Page No.

LIST OF FIGURES

LIST OF DRAWINGS

TABLE OF CONTENTS

Page No.

LIST OF TABLES

TABLE OF CONTENTS

Page No.

1. INTRODUCTION

1.1 Background and Scope

The Sixteen Mile Creek Subwatershed Planning Study, Areas 2 & 7, January 2000, built upon the direction outlined in the Watershed Plan and Official Plan, to prescribe management approaches for key resources within the various subwatershed study areas.

At the time of preparation, for Milton's Urban Expansion Area (ref. Schedule B, Town of Milton Official Plan), only the Phase 1 area (Bristol Survey) was elevated to a Secondary Plan level of detail. The balance of the Urban Expansion Areas were at that time defined as broad "block-based" land uses, with nominal or no information on internal roadways, land use mix and other related information.

Due to this relative imbalance in planning detail (i.e. between the Phase 1 Secondary Plan Area, and the rest of the Urban Expansion Area for Milton), the Subwatershed Management Strategies from the January 2000 study were necessarily less precise, for areas outside of Phase 1 (Bristol Survey).

The subsequent Secondary Plans for Milton's various planning neighbourhoods namely Sherwood (Phase 2), North of 401 Business Park, Derry Green and Boyne Survey have, and will need to, incorporate and build upon the information (i.e. recommendations) set forth in the original Subwatershed Plan and subsequent updates, as detailed within this Update Study.

All Secondary Plans have also had the requirement for a Functional Stormwater and Environmental Management component study which focuses on local resource issues and management, rather than those at the subwatershed scale, premised on more resolute land use information.

The following objectives were considered for guidance in the original Sixteen Mile Creek Subwatershed Planning Study for Areas 2 & 7, and remain relevant to this Update Study:

i) Any management strategy must embrace the fact that human activities will continue within the Subwatershed and that urbanization within the Official Plan designated areas is imminent.

ii) Subwatershed Management Strategies must meet current Federal Department of Fisheries and Oceans – “No Net Loss” policy objectives for fisheries habitat.

iii) In terms of impact assessment and alternative strategy evaluation, it is necessary to concurrently address the requirements of the economic, social and physical (natural) environment.

iv) Stormwater Management practices should, to the greatest extent possible, preserve the existing hydrologic regime, including surface and groundwater flows.

v) Land use, proposed for the urban area, should complement the recharge/discharge characteristics of the subwatersheds, enhance and protect terrestrial resources (including corridors) and stream systems.

vi) Opportunities for restoration/rehabilitation of degraded resources, including retrofit areas, should be identified.

A comprehensive monitoring program has been initiated by the Town in order to verify the effectiveness of attaining the foregoing objectives in the respective development areas. The monitoring program has been underway for several years for the Bristol Survey lands (Phase 1) and for the Sherwood Survey (Phase 2) lands; this data has been helpful in better understanding the effectiveness of stormwater management and environmental management techniques related to development in each area.

1.2 Approach

There tend to be two levels of management opportunities associated with Subwatershed resources, those which apply to the whole of the subwatershed study area and those which relate to a specific location or environmental unit.

In addition, there are natural or man-made features which can be used to logically delineate or define development areas for the purpose of a more discrete assessment, these include:

Natural	***Man-made***
Watercourses	*Roadways (major)*
Watershed Divides	*Land use (existing and proposed)*
Topography (Escarpment)	*Utility Corridors*
Environmental Features	

The foregoing premise was used in the original Subwatershed Study to divide the developing land base within Areas 2 & 7 into the following neighbourhood areas.

- *Milton Phase 1 (Bristol Survey)*
- *Milton South-West/South (Part of Phase 2 and 3)*
- *Milton North-West (Part of Sherwood Survey – Phase 2)*
- *Milton North (Employment Lands North of 401)*
- *Milton Business Park (Business Park #2 or Derry Green)*
- *Milton South-East (Most of Phase 3 or Boyne Survey)*

The study of each subwatershed's resources defined the specific constraints to land use change. Key information which has directed efforts toward protection, preservation, rehabilitation, restoration and mitigation has included:

- Terrestrial features of significance (woodlots, wetlands, successional areas and plantations)
  - High constraint
  - Medium constraint

(Note: the approach used in the original study has been revised as part of this Update Study to ensure that there is a "systems" approach; this relies on identified functions, and conformity to available policy rather than only on assigned constraint levels; this is discussed later in this report.)

- Watercourses of Fisheries Significance
  - High
  - Medium
  - Low

- Stream Morphologic Constraints
  - Meander belt width
  - Sensitive points of gradient control

- Valley Setbacks
  - Geotechnical setback criteria

- Proposed Land Use
  - Detailed secondary plans
  - Conceptual Official Plan land use

- Flooding and Erosion sites

The foregoing constraints and opportunities formed the basis for establishing management strategies for the developing, developed and non-developing areas. Specifics associated with management opportunities have been prescribed as follows:

- Watercourses Protection Hierarchy
  - Protect/enhance in-situ
  - Maintain as open; realignment possible
  - Alter or remove as necessary; subject to function replication

- Terrestrial Unit Enhancement
  - Linkages/corridors
  - Habitat enhancement/consolidation
  - Development buffers

- Stormwater Management
  - Possible facilities location and type
  - Diversion opportunities
  - Retrofit areas

1.3 Rationale for Subwatershed Update Study

Early in 2007, the Town of Milton planned to initiate the Secondary Planning Studies for Derry Green (Business Park 2) and the Boyne Survey (Phase 3) lands, which are both located within the Sixteen Mile Creek Watershed. The Town elected to initiate the Sixteen Mile Creek

Areas 2 & 7 Subwatershed Update Study in response to Conservation Halton's general policy to update guiding studies and reports every 5 years in order to ensure that the guiding principles are consistent with current Regional, Provincial, and Federal legislation and policies, as well as to provide updated baseline information which would guide the preparation of the Functional Stormwater and Environmental Management Strategies for these areas. While the January 2000 Subwatershed Study served as a basis for the Subwatershed Update Study, the constraint ranking and baseline inventory provided within this Subwatershed Update Study, specifically as pertaining to the Derry Green and Boyne Survey lands, is considered to supercede the information provided within the original Subwatershed Study for these lands.

A portion of the Phase 3 Boyne Survey lands are located within the Indian Creek Subwatershed. The Indian Creek Subwatershed Study was completed in December 2004, which provided constraint rankings for the environmental features through these lands. While additional investigations have been completed for the subject portion of the Phase 3 lands within the Indian Creek Subwatershed, as part of this Subwatershed Update Study, these investigations are intended to complement the baseline inventory and recommendations advanced in the December 2004 Subwatershed Study for the Indian Creek. While the recommendations provided in the December 2004 study are considered current and pertinent to the development of the Phase 2 lands, the recommendations specific to the Phase 3 lands have been updated as required based upon the conclusions and recommendations advanced in this Subwatershed Update Study, as well as more recent legislation, policies, and guidelines.

Recognizing that the basis for conducting this Update Study is primarily to refine the baseline environmental constraints within the future Secondary Planning areas within the specific areas within the Sixteen Mile Creek Watershed and to update the management opportunities and requirements in response to current legislation and Conservation Halton's general policy, a Work Plan has been established consultatively between the Town of Milton and Conservation Halton in order to provide direction regarding the requirements for the field investigations and the analytical processes (ref. Appendix 'A'). Through this process it has been acknowledged that the Indian Creek Subwatershed Study information remains current, however certain gaps have been identified with respect to the characterization of the Boyne Survey lands within the limits of the Indian Creek Subwatershed; consequently, it has been agreed that a scoped assessment would be completed for the Indian Creek Subwatershed in order to address these apparent gaps in the characterization of the Boyne Survey lands; this information is cross referenced between the SUS and Boyne Survey FSEMS.

1.4 Review of New Legislation, Policies and Directions

The Town of Milton, Conservation Halton, and the Subwatershed Team met in 2007 to discuss factors influencing the need to update the Subwatershed Plan for Areas 2 & 7. The following outlines some of the specifics in this regard as related to changes in legislation, policies, guidelines, as well as new directions and issues within the land use and environmental management sector, which have arisen since 1998, the year the original Subwatershed Study was initiated:

Legislation, Policies, Guidelines

- Greenbelt/Places to Grow
- PPS (2005) and MNR Natural Heritage Reference Manual (First Edition,1999 and Second Edition, 2010)
- Generic Regulations/New Policies
- Endangered Species Act
- Regional Policies
  - ROPA 25, Section 115
  - Natural Heritage System through Subwatershed Study – Greenlands
- Sustainable Halton
- Regional and Candidate Provincial Sixteen Mile Creek ANSI / PSW's
- Significant Wildlife Habitat Technical Guidelines (2000)
- Source Protection
- COSEWIC
  - Red Side Dace/Recovery Plan
- Regional OP – 2031
  - Ultimate Development Scenario
- Significant Woodlands Policies
- Nutrient Management Act
- Farm Management Plans
- Pesticide Act
- Migratory Birds Convention Act
- 2005 & 2014 PPS, Section 2.1.2
- Conservation Halton Landscape Planting Guidelines

New Directions/Issues

- Climate Change
- LID (Low Impact Development)
- Headwater Swales/Streams (Drainage Density)
- Regional Flood Control
- Phosphorus/Algae Management
- Road Salt listing as a contaminant
- Meander Belt Width – New Conservation Halton Guidelines
- Protection of function of Topographic depressions
- Ecosystem/Systems Approach
- Runoff Volume controls
- Landscape Scale Analysis (broad feature assessment)
- Fish Habitat
  - Direct/Indirect Fish Habitat definition
  - TRCA/CVC New Guidelines
- DFO Risk Management Framework
- First Nations considerations
- Draw down in Stormwater Management Ponds
- Low Stream Energy

This report provides the background to the various discipline investigations related to 2007 and 2008 field work and related analysis/assessment. In addition, the information provides noteworthy findings related to Public Agency consultation with respect to specific field walks for terrestrial and aquatic features.

The information provided within this report represents the basis from which the environmental management system and Natural Heritage System for the Derry Green and Boyne Survey

Secondary Planning Area have been developed. Recognizing that the information presented within the document will become integrated into the Secondary Plans for the Derry Green and Boyne Survey areas, and in order to better ensure that the information presented in this document would be incorporated into the analyses to be completed as part of future Subwatershed Impact Studies (SIS's), the Functional Stormwater and Environmental Management Strategy and Conceptual Fisheries Compensation Plans for the Secondary Planning Areas have been prepared as separately bound Technical Appendices to this Subwatershed Update Study.

2. UPDATED GOALS, OBJECTIVES AND TARGETS

2.1 Introduction

The purpose of this report section is to provide the background to the process for establishing specific physically-based subwatershed scale goals, objectives and targets for use in this Update Study. Clearly there are numerous background considerations in this regard, including previous documentation at a watershed scale, historical assessments conducted on a subwatershed scale, as well as the governing Acts, Guidelines and Policy. This report section provides an overview of each of these, while laying out a course to develop more specific goals, objectives, and targets through the Subwatershed Update Study process and associated consultation with agencies and stakeholders.

2.2 Sixteen Mile Creek Watershed Plan

The Sixteen Mile Creek Watershed Plan 1996 provided strategies for various development and land use activities within the Sixteen Mile Creek Watershed. The recommended strategies for urbanization (new development) were categorized in the Watershed Plan as follows:

- Natural Heritage System
- Modifications to Urban Form
- Subwatershed Planning
- Flood Plain Management
- Milton Wastewater Treatment Plant
- Stormwater Management Facilities Sizing Criteria

The strategies and associated objectives and targets for each category are discussed in further detail below, including any updates which have been advanced as part of this Update Study.

2.2.1 Natural Heritage System

The Natural Heritage System (NHS) methodology (ref. Section 5) has been applied for evaluation of terrestrial resources with respect to the overall watershed resources and integrity of the natural functions and linkages within the watershed. The updated approach is in accordance with the Provincial Policy Statement (2005 and 2014) which provide direction for the identification of an ecosystem approach for protection or integration of certain resources that have been identified as 'significant' according to provincial standards: wetlands, habitats of endangered or threatened species, fish habitat, woodlands, valleylands, wildlife habitat, and areas of natural and scientific interest. The current Halton Regional Plan (2006) incorporates features as 'Escarpment Natural Area' and 'Greenlands A and B'. ROPA 25 (2007) contained updated natural heritage policies including the Region of Halton Significant Woodlands Policies, and the mandate for a watershed based approach for the development of Natural Heritage Systems. ROPA 38, as approved by Regional Council in December 2009, implements the Sustainable Halton NHS framework developed as part of the growth management strategy; it should be noted that neither ROPA38 nor Sustainable Halton policies specifically apply to the Boyne District Secondary Plan and the Derry Green Business Park. The Town of Milton Official Plan reflects the Halton Region Greenlands categories, and identifies Environmental Linkage Areas which are primarily watercourse-based.

The following updated objectives and targets build upon those previously defined for the Natural Heritage System and terrestrial resources in the Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2004). They have been updated based on the current study approach, available Natural Heritage System policies, and further refined based on comments received from Conservation Halton staff.

i) Identify and classify natural/semi-natural terrestrial features and assess their significance according to their conformity with significance categories established by the Province, Region and Conservation Authority, based on criteria regarding size, biophysical attributes and ecological functions for the purposes of developing a sustainable natural heritage system for the urban and rural portions of the watershed

ii) Given the depleted, degraded and fragmented state of existing terrestrial resources in the subwatershed study area, the key objective of the subwatershed plan is to achieve a 'net gain' in terms of the extent of natural terrestrial habitat and associated functions and linkages. The goal is a well-linked system within the urban setting which promotes the maintenance and enhancement of key subwatershed resources.

iii) All identified 'Significant' terrestrial features should be protected and enhanced within a recommended Natural Heritage System, to be defined as part of the Secondary Plan processes.

iv) The Subwatershed Update Study and Functional Stormwater and Environmental Management Strategy (FSEMS) will define standards for protection and linkage of these resources. These protection and enhancement requirements will be integrated into detailed Subwatershed Impact Studies (SIS).

v) Other terrestrial features not meeting policy-based significance criteria should be integrated into a linked system which optimizes their integrity and functions within the future urban landscape. The system can be further enhanced with habitat restoration, and integration of protected natural areas with land uses that support the functionality of natural features (such as parkland, golf courses, school campuses and other uses that can incorporate naturalized elements.

vi) All identified linkage features in the subwatershed study area represent constraints to future land uses and are to be protected and enhanced. Within the Milton Business Park / Derry Green and Phase 3 / Boyne Survey urban expansion areas, some linkage features may be modified, and their relocation and enhancement should place a high priority on natural heritage system objectives wherever feasible and practical in an urbanizing landscape.

vii) The functioning components of linkages should be protected and enhanced. Terrestrial linkage features can be used to accommodate trail systems.

viii) Stormwater management facilities should be integrated outside the NHS but due to their related hydrologic functionality, contribute complementary landscape connectivity functions and naturalized cover that is routinely used by wildlife.

ix) The SIS for each detailed study area will refine desirable riparian corridors and other linkage features following an integrated multi-disciplinary assessment. This will include

recommended corridor dimensions as well as structural components to be considered at subsequent planning and design stages. The identified terrestrial system should also accommodate existing and new wetland and pond features that can support identified species of concern in the urban setting.

2.2.2 Modifications to Urban Form

The Watershed Plan recommendations associated with “modifications to urban form”, primarily relate to changes to typical urban form which minimize impacts to the hydrologic cycle. Specific recommendations included:

- minimizing imperviousness
- provision of on-site (source) storage
- maintaining water balance - increasing and/or preserving groundwater recharge
- promotion of urban tree planting
- retain natural features
- promote use of cisterns primarily in commercial, industrial and institutional sites
- conduct pilot studies of alternative development forms
- provide flexibility in municipal design criteria to allow consideration of alternative design standards

2.2.3 Subwatershed Planning

The Sixteen Mile Creek Watershed Plan recommended that Subwatershed Plans be completed prior to, or in conjunction with the preparation of Secondary Plans. The Watershed Plan also identified subwatershed issues, goals and management strategies for each subwatershed. The specific issues, goals and strategies for Subwatershed Areas 2 & 7 are outlined in Tables 2.2.1 and 2.2.2. A number of “watershed-wide” issues, goals and strategies were also identified through the Watershed Plan for consideration during the subsequent Subwatershed Planning process including:

i) Control of post-development flow rates to pre-development levels to mitigate downstream flood damage potential.

ii) Reduce imperviousness, enhance infiltration and promote runoff dispersion through multiple or discrete outlets, particularly in "coldwater subwatersheds" and those which discharge to "coldwater" systems.

iii) Treatment of storm runoff prior to discharge to receiving water is required to address water quality impacts. Stormwater Management facilities (i.e. wet ponds, wetlands) are recognized as the most effective “Stormwater Management Practices (SWMP's)" for pollutant removal. Special design considerations such as bottom draw, shading and other measures may also be required to address thermal impacts.

iv) Maintain pre-development flow-duration exceedance characteristics to minimize erosion potential.

v) Maintain existing groundwater recharge rates on an area-basis and protect groundwater quality.

With respect to Natural Heritage Systems, the Provincial Policy Statement (2005) recognizes watersheds as an "*ecologically meaningful scale for planning*". Regional Official Plan Amendment 25 (2004) provided updated policies which include the integration of watershed and subwatershed plans to support Secondary Planning, and criteria to identify Significant Woodlands as defined under the Region's policies.

2.2.4 Flood Plain Management

The existing Provincial Policies relating to Flood Plain Management have been recommended for the Sixteen Mile Creek Watershed Plan. An assessment of the extent of Regulatory Flood Plains will be required for areas where development plans consider alteration to flood limits or where flood lines have not been developed.

2.2.5 Milton Wastewater Treatment Plant

The Sixteen Mile Creek Watershed Plan recognized that the Milton Wastewater Treatment Plant contributes significantly to baseflow in the Sixteen Mile Creek. As such, the Watershed Plan recommended that, should the plant ever be decommissioned, an assessment of potential impacts of closure on stream (base) flows and the associated aquatic habitat and appropriate mitigation options should be considered. The Region of Halton has recently (October 2012) requested proposals to conduct this assessment on its behalf.

2.2.6 Stormwater Management Facilities Sizing Criteria

Performance/Sizing Criteria

Based on the analysis completed through the Sixteen Mile Creek Watershed Plan, a number of stormwater management facility sizing criteria have been identified for the Milton Urban Expansion area. These criteria relate to mitigation of flood, erosion and quality of stormwater impacts.

- **Flood Control**

Stormwater management techniques, or combinations thereof, must provide effective flood impact mitigation in accordance with Provincial regulations and Common Law obligations. The *Sixteen Mile Creek Watershed Plan* also adopts these principles.

- **Erosion Control**

Stormwater management facilities must provide effective erosion control as required according to Watershed Plan Objectives of maintaining existing erosion duration exposure. Generally, fulfilment of this objective requires the maintenance or "over control" of the runoff peak flows rates through extended detention of runoff with gradual release of stored water over a number of hours or days.

➢ Stormwater Quality

Stormwater management techniques, or combination thereof, must provide effective stormwater quality performance in accordance with Provincial guidelines and Subwatershed Goals and Objectives. Level 1 (currently referred to as Enhanced) Habitat Protection facility performance (i.e. 80% removal of suspended sediment) would be required based on the existing fishery resources of the Sixteen Mile Creek and presence of a "special concern" fish species in the East Branch of the Sixteen Mile Creek.

Subwatershed-Based

Based on the unique characteristics of Subwatershed Areas 2 & 7, the Sixteen Mile Creek Watershed Plan 1996 identified the following objectives/targets and management strategies (ref. Tables 2.2.1 and 2.2.2).

Area 2

Table 2.2.1 outlines the subwatershed specific resources, issues, objectives and targets for Subwatershed Area 2 as determined through the Sixteen Mile Creek Watershed Plan.

Table 2.2.1[1.]: Subwatershed Area 2 – West Branch Kelso to Junction with East Branch	
Objectives/Targets	• Maintain resident and migratory coldwater fish habitat extent and extend downstream of Milton if feasible (maintain, reduce water temperature < existing near lethal 24 – 25°C maximums, maintain baseflow, maintain/enhance water quality) • Protect population of Redside Dace (classed as "Special Concern") downstream of Hwy 401 in North Branch (maintain water temperature, maintain/enhance baseflow, maintain/enhance water quality, maintain/enhance appropriate physical habitat) • Maximum infiltration/recharge and contribution to stream baseflow • Maintain existing hydrologic regime/water budget to extent feasible • Facilitate migratory passage of rainbow trout, where appropriate • Protect main stream corridor and enhance if feasible • Ensure no increase in flooding and erosion • Specific peak flow rates and flow exceedance – duration criteria (ref. Sixteen Mile Creek Watershed Plan Appendix D – Tables D.11, D.12, and D.13)
Key Management Strategies/Actions	• Emphasize dispersal and recharge of runoff from all impervious surfaces • Collect additional natural system data prior to development • Enhance riparian cover in new development buffers and through Milton if feasible to ESA • Provide resting cover in concrete channel for migrating trout • Reconfigure Mill Pond as bypass system with no fish access • Assess STP removal implications to ensure no decrease in baseflow or increases in temperature • Minimize valley erosion (geotechnical setbacks and runoff management) • Protect core habitat corridor and streams with appropriate site-specific buffers and other measures • Assess minor tributaries for seasonal baitfish use and other functions which should be maintained or restored with enhancement as part of development proposals • Water temperature controls
[1.] Abstracted from in part from "Sixteen Mile Creek Watershed Plan, Prepared in Support of the Halton Urban Structure Plan", February 1996 Halton Urban Structure Review Consulting Team – Table D.2, page D-3	

Area 7

Table 2.2.2 outlines subwatershed specific resources issues, objectives and targets for Subwatershed Area 7 as determined through the Sixteen Mile Creek Watershed Plan.

Table 2.2.2[1]: Subwatershed Area 7 – East Branch Middle to West Branch Confluence	
Objectives/Targets	• Protect natural heritage systems components, valley ESA • Maintain , enhance water quality • Protect "Special Concern" Silver Shiner population • Protect recharge area • Maintain seasonal fish access to tributaries and rainbow trout migration access, where appropriate • Maintain, enhance riparian cover • Specific peak flow rates and flow exceedance – duration criteria (ref. Sixteen Mile Creek Watershed Plan Appendix D – Tables D.11, D.12, and D.13)
Key Management Strategies/Actions	• Maintain, enhance Middle Branch corridor for ESA through core habitats and upstream to tributary systems (Subwatersheds 3, 4) • Protect core habitat and streams with buffers and other site specific measures as appropriate • Encourage good agricultural practices and control of cattle access to streams, woodlots • Collect and analyze appropriate additional data prior to development • Assess minor tributaries for seasonal baitfish use and other functions, and ensure functions protected or incorporated through restoration/enhancement if appropriate • Ensure corridor studies address fragmentation and cumulative impacts if appropriate • Protect valley from erosion (geotechnical setbacks and runoff management)
[1.] Abstracted in part from "Sixteen Mile Creek Watershed Plan, Prepared in Support of the Halton Urban Structure Plan", February 1996 Halton Urban Structure Review Consulting Team – Table D.7, page D-8	

2.3 Subwatershed Area Strategies

Appendix 'B' provides details with respect to the Urban Area Expansion Management Strategies, specific to the developing areas within Subwatershed Areas 2 & 7 in the Sixteen Mile Creek. These strategies constitute the current base management approaches used to guide development in Milton's expansion lands. They were founded on the field data collected during 1998 and 1999, along with the consultation with the various stakeholders to the process. Direction is provided with respect to General (Area-wide) and Local (Area-specific) scales. Principles are established for Watercourse Management, Natural Heritage System Management, and Stormwater Management. Detailed management strategies specific to the Derry Green and Boyne Survey Secondary Planning areas have been developed based upon these base management approaches, and have been refined, modified, or augmented as required, in response to the existing or anticipated future conditions within each area. These detailed management Strategies are provided in the respective Functional Stormwater and Environmental Management Strategies.

2.4 Natural Heritage System

Natural heritage systems are currently defined under the Provincial Policy Statement (2014) as follows:

> *"a system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The Province has a recommended approach for identifying natural heritage systems, but municipal approaches that achieve or exceed the same objective may also be used.*

Since the completion of the earlier Watershed and Subwatershed studies, there have been advances in the identification of significant woodlands; in 2006 the Region adopted a Significant Woodlands Policy which identifies candidate Significant Woodlands within urban boundaries on the basis of size (0.5 ha threshold) and criteria are included in the Policy for final assignment of Significant Woodland status. The 2005 Provincial Policy Statement (OMMAH, 2005) strengthened requirements for a natural heritage system approach to planning. The 2014 PPS further clarified the definition of NHS, and reflects the current Endangered Species Act (2007) and federal Fisheries Act. Supporting documents to the PPS include the Natural Heritage Reference Manual, 2nd Ed. (2010) and Significant Wildlife Habitat Technical Guide (2000).

Conservation Halton Regulation (2006)

In 2006 the Conservation Authority Regulations were revised, as required under Ontario Regulation 97/04 as part of a conformity exercise mandated by the Province, to strengthen protection of wetlands and watercourses and to define natural hazard limits. The protection and management of watercourses and wetlands, and the defined natural hazard limits, relative to development are subject to the evaluations and setbacks as defined in the Regulations.

Sustainable Halton Plan

The Sustainable Halton Plan is a growth management planning project initiated in May 2006, intended to promote the concept of sustainable development, which is defined in the 2004 Regional Official Plan. Policy 25 of the Regional Official Plan defined sustainability as "*meeting the needs of the present without compromising the ability of future generations to meet their own need*". The policy also states that "*planning decisions in Halton will be made based on a proper balance among the following factors: protecting the natural environment, enhancing its economic competitiveness, and fostering a healthy, equitable society*". The overall goal is to enhance the quality of life for all people of Halton. The Growth Management Strategy that makes up Sustainable Halton Plan was adopted as ROPA 38 by Regional Council in December 2009. The Primary Study Area (PSA) for Sustainable Halton includes the areas outside of

existing urban boundaries and outside the area included in the Province's Greenbelt Plan. It represents the area in which future urban expansion could occur.

The current ROP and HUSP form the framework that applies to Derry Green and Boyne lands; the Sustainable Halton approach and its relevance to the current Subwatershed Update Study is discussed later in this report.

Greenbelt Plan

The Greenbelt Act (2005) designated a Greenbelt Plan area containing Protected Countryside, which contains rural lands and a natural heritage system. Although the Greenbelt does not extend into the areas approved for urbanization in the Town of Milton, designated lands are located to the immediate east and west of these lands, as well as along the Main Branch of Sixteen Mile Creek south of Britannia Road. Where future development abuts portions of the Greenbelt NHS, the approach to the protection of the natural features and functions will need to conform to the natural heritage policies of the Greenbelt Act, and take direction from the technical guidelines that have been prepared by the Ministry of Natural Resources (OMNR, 2013).

2.5 Governing Acts, Guidelines and Policies

As a complement to the overall process of establishing updated subwatershed-scale goals, objectives, and targets, there also needs to be a recognition/understanding of the context of the governing legislation with respect to resource management. Various acts, guidelines, and policies exist at a federal, provincial and municipal (upper and lower tier) level to provide a framework for managing the impacts associated with land use change.

The following table has been prepared summarizing the various forms of legislation, along with their purpose. It should be noted that not all of these tools are necessarily applicable to the Subwatershed Update Study; notwithstanding these have been provided to offer a comprehensive overview.

Table 2.5.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
Federal	Federal Fisheries Act (I)	Act	Purpose is to ensure the conservation and protection of fish and fish habitat.
	Migratory Birds Convention Act (1994)(I)	Act	Purpose is to protect listed migratory species during their nesting period.
	Species at Risk Act	Act	Protection of Wildlife species at risk; recovery plans regarding federally regulated resources.
	Canadian Environmental Protection Act (CEPA)(1999)	Act	The goal of the Canadian Environmental Protection Act (CEPA) is to contribute to sustainable development through pollution prevention and to protect the environment, human life and health from the risks associated with toxic substances.

Table 2.5.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Federal	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
	Department of the Environment Act	Act	Establishes the department of the Environment and sets forth the various powers and responsibilities of the minister.
	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
	Pest Control Products Act	Act	An Act to regulate products used for the control of pests and the organic functions of plants and animals.
	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.
	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.
	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.
	Pesticide Residue Compensation Act	Act	An Act to provide compensation to farmers whose agricultural products are contaminated by pesticide residue.
	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 groundwater’s 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 groundwater’s 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.

Table 2.5.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Federal	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.
	A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (2013, EC/CWS, OMNR, OME) (D)	Guideline	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.
Provincial	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.
	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.
	Provincial Planning Act (D)	Act	The purposes of this Act is to promote sustainable economic development in a healthy natural environment
	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.
	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.
	Fish and Wildlife Conservation Act (1997)	Act	*Fish and Wildlife Conservation Act* enables the Ministry of Natural Resources (MNR) to provide sound management of the province's fish and wildlife.
	Safe Drinking Water Act (MOE) (2002)	Act	Its purpose is the protection of human health through the control and regulation of drinking-water systems and drinking-water testing.
	Municipal Act	Act	The Municipal Act sets forth regulations in regard to the structuring of municipalities in Ontario.
	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.

Table 2.5.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	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.
	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.
	Provincial Water Quality Objectives (MOE) (1994)	Guideline	To provide objectives for the protection of aquatic life.
	Significant Wildlife Habitat Technical Guide (2000, OMNR)	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.
	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.
	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.
	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.
	Subwatershed Planning (MOE) (1993)	Policy	Technical manual on conducting subwatershed planning in Ontario.
	Integrating Water Management Objectives into Municipal Planning Documents (MOE) (1993)	Policy	Policy manual on the integration of watershed management practices into municipal planning documents.
	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.

Table 2.5.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Drainage Act	Act	Provides for the regulation of drainage practices in Ontario.
	Model NMP 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).
	Public Lands Act	Act	The Public Lands Act was implemented to grant the Ministry of Natural Resources charge of the management, sale and disposition of the public lands and forests
	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.
	Endangered Species Act (2007)	Act	Updates species listed and regulated in Ontario
	Clean Water Act	Act	The Clean Water Act was implemented as a legislative measure to protect existing and future sources of drinking water.
	Greenbelt Act	Act	The Greenbelt Act was implemented in support of the Greenbelt Plan to direct land use planning to preserve existing agricultural lands and to provide protection to the land base needed to maintain, restore and improve the ecological and hydrological functions of the Greenbelt Area
	Places to Grow Act	Act	The Places to Grow Act was implemented to promote growth plans which reflect the needs, strengths and opportunities of the communities involved, and promotes growth that balances the needs of the economy with the environment
	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 designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal, and minerals.
	Ontario Regulation 162/06	Regulation	This Regulation allows Conservation Halton to prohibit or regulate development in or adjacent to Shorelines, wetlands, floodplains, watercourses, valleys, dynamic beaches and hazard lands.

Table 2.5.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Amendments to Ontario Regulation 454/96	Regulation	The new regulation represents an update to the Lakes and Rivers Improvement Act. The new regulation provides that approvals under the LRIA are not required for specific activities where Conservation Authorities have Development Regulation under S.28 of the Conservation Authorities Act in effect. The regulation serves to reduce confusion to applicants where previous overlap existed between approvals required from MNR and Conservation Authorities.
Regional	ROPA 38 Sustainable Halton (2009)	Policy	Represents a major update to the Region of Halton Official Plan to bring it into conformity with other legislation and policies. Includes a Sustainable Halton Plan for future sustainable growth and environmental management.
	ROPA 25 (2004)	Policy	Provides direction re: Secondary Planning and Watershed studies; includes the new Significant Woodlands policy and criteria.
	Halton 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.
	EIS Guidelines	Guideline	Guidelines for the conduct of EIS projects in the Region. To standardize and put forward the requirements for EIS completion and review.
	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 Halton 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.
Municipal	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.
Conservation Authority	Policies, Procedures and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy document	Policy	This document outlines the procedures and guiding policies of Conservation Halton in administering Ontario Regulation 162/06, as well as providing legislative background.
	Conservation Halton Landscaping and Tree Preservation Guidelines	Guideline	Guidelines specify the standards for plant material selection and use in landscape restoration and enhancement plantings.
	Conservation Halton EIS Guidelines	Guideline	Guidelines specify the required scope of studies and content for Environmental Impact Studies.

3. UPDATED BASELINE INVENTORY

3.1 Rainfall/Streamflow

3.1.1 Scope/Purpose

The 2007 and 2008 Field Monitoring Program for rainfall and streamflow has been conducted to provide an understanding of the current hydrologic conditions within the subwatershed areas of interest, specifically watercourses and open water features. The rainfall monitoring and flow monitoring have been conducted to determine the dry weather and wet weather conditions within the respective tributaries to the Sixteen Mile Creek. The rainfall data and streamflow data also provides the basis for evaluating existing water quantity conditions within the Sixteen Mile Creek Tributaries for use in the Subwatershed Update Study.

The scope of work for the Rainfall and Water Quantity (Streamflow) Field Sampling Component of the Program was outlined within the Work Plan provided to the Technical Steering Committee in June 2007. The Terms of Reference outlined that one rainfall gauge would be installed within the study area, to be used to characterize rainfall in conjunction with other available information from Conservation Halton and the Town. The flow sampling sites originally outlined within the Terms of Reference are described below in Section 3.1.2.

Streamflow monitoring for Subwatershed Areas 2 & 7 was conducted as part of the background inventory work for the January 2000 Subwatershed Planning Study. As well, the April 2006 Environmental Monitoring Report for the Bristol Survey describes monitoring conducted for the Phase 1 Bristol Survey area. The January 2000 Subwatershed Planning Study indicated that limited data was collected due to the drought conditions which prevailed during the period of study (i.e. 1998 and 1999), and the April 2006 Environmental Monitoring Report indicated that the instream velocities measured at the gauge locations were frequently insufficient to obtain accurate readings. In accordance with the approved Field Monitoring Work Plan, streamflow and rainfall monitoring has been implemented as part of the Subwatershed Update Study, in an effort to supplement the data collected under the previous initiatives, and to implement a more refined monitoring program to better characterize the hydrologic response of the existing land use conditions within the Milton Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) Lands.

3.1.2 Methods

Streamflow monitoring has been completed using Levelogger™ streamflow gauges. Although this represents a revision to the approved Field Monitoring Work Plan, which recommended the use of Flo-Tote™ streamflow gauges, the Levelogger™ system has been successfully applied by Credit Valley Conservation, and reports observed flow depths at the same time intervals at a fraction of the cost of the Flo-Tote system. This methodology change was reviewed with Town staff prior to implementation

As per the approved Field Monitoring Work Plan, the gauges have been installed at the following locations (ref. Drawing 1):

- within Subwatershed Area 2 and Subwatershed Area 7, at the locations previously identified in the January 2000 Subwatershed Planning Study;
- along the Omagh Tributary downstream of the Phase 3 Lands;
- along the Centre Tributary at Sixth Line;
- at two sites downstream of the Milton Business Park Lands, within the Trafalgar Golf and Country Club;
- at the outlet of the Phase 1 Lands to the Centre Tributary.

The gauges were installed between August 13, 2007 and November 26, 2007 at which time frozen winter conditions prevailed within the study area, and were re-installed from April 1, 2008 until August 18, 2008.

Theoretical rating curves (i.e. depth-discharge relationships) have been developed at each of the gauge locations in order to convert the continuous depth data to continuous flow data (i.e. hydrographs) for the monitoring period. Cross-section geometry has been generated based upon field measures at the monitoring sites, as well as available topographic mapping. Roughness coefficients (Mannings) have been established based upon the observed field conditions and calibrated values obtained from monitoring programs under similar field conditions.

Rainfall data has been collected in accordance with the approved Field Monitoring Work Plan. Following consultation with Conservation Halton and Town of Milton, the roof of the Milton Leisure Centre was identified as a preferred location for the installation of the Study Area rainfall gauge; however, this site presented issues with respect to access for both installation and data collection/retrieval. Consequently, a Rainger™ rainfall gauge was installed on the roof of the Milton Sport Complex, located at the southeast corner of Derry Road and Santa Maria Boulevard within the Town of Milton. Rainfall data was collected between September 7, 2007 and November 26, 2007, and from April 1, 2008 until August 18, 2008.

Non-geodetic Total Station Survey has been completed at hydraulic structures (i.e. bridges and culverts) within the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) lands in order to obtain the geometry of the various hydraulic structures, as well as the upstream and downstream inverts relative to the centerline profile of the roadway. The information obtained from the Total Station Survey has been geo-referenced by referencing the road profile information to top of road elevations provided on the high-resolution base mapping within these areas.

3.1.3 Results

Results of the continuous streamflow and rainfall monitoring data are summarized in Appendix ‘C’. A preliminary screening of the monitoring data has indicated the following:

- Limited rainfall occurred within the study area during the period of the 2007 monitoring program (i.e. 108 mm between September and November inclusive).

- Total daily rainfall depths during 2007 were generally 5 mm or less; this is generally considered insufficient to generate a runoff response within the study area (as evidenced by the absence of corresponding flow data during these events).
- Only two events during 2007 generated precipitation depths greater than 10 mm (i.e. 12 mm on October 23, 2007 and 24 mm on November 21, 2007).
- A runoff response was observed at all sites except Q_1 and Q_2 for the October 23, 2007 event.
- A runoff response was observed at all sites for the November 21, 2007 event.
- Significant rainfall occurred during the 2008 monitoring program.
- Observed rainfall events during late July 2008 and early August 2008 were characterized by relatively high volumes (i.e. between 25 mm and 60 mm) within a very short duration (i.e. less than 2 hours).
- Severe storm events during July 2008 and August 2008 were highly localized (i.e. runoff responses were observed at certain streamflow monitoring locations but not necessarily at locations within an adjacent drainage area).

The suite of rainfall and flow data has been screened in order to identify "significant" storm events which occurred during the 2007 and 2008 monitoring season, based upon total rainfall volume, average and maximum intensity, and observed runoff response. The results of this assessment are summarized in Table 3.1.1.

Table 3.1.1: Significant Precipitation Events During 2007/2008 Monitoring Period

Event	Date and Year	Total Daily Precipitation (mm)	Duration (hours)	Average Intensity (mm/hr)	Peak Intensity (mm/hr)	Inter-event Time (days)	Comments
	2007						
1	23-Oct	12	9.75	1.2	6	13+	
2	21-Nov	24	26.25	0.9	6	9+	
	2008						
1	11-Apr	23	10.25	2.2	9	2	
2	3-May	24	6.5	3.7	45	1	
3	28-June	26	1.75	14.9	78	1	
4	19-July	45	0.5 + 10.5	4.1	45	7	Sudden "burst" preceded main storm by less than 7 hours.
5	22-July	30	0.5 + 3	8.6	57	2	Sudden "burst" preceded second cell by less than 6 hours.
6	24-July	29	2	14.5	42	1	
7	5-Aug	59	5	11.8	114	6	
8	9-Aug	28	0.75 + 3	7.5	45	1	Sudden "burst" preceded second cell by less than 2 hours

The results of this assessment indicate that the events during 2007 were characterized by relatively low volumes, long durations, limited intensity, and extended inter-event periods. By contrast, the events during 2008 were characterized by higher storm volumes, short durations, high intensity, and very low inter-event periods. Moreover, as indicated in Table 3.1.1, the more formative events during 2008 were characterized by storms which exhibited a very intense but

short duration “burst” followed a few hours later by a second event which was less intense and longer duration.

The rainfall data collected during 2008 has been further reviewed in order to determine the observed monthly rainfall depths. This information has been compared with the average monthly rainfall depths observed at the Pearson Airport gauge in order to characterize the meteorological conditions as either representative or atypical. The results of this assessment are presented in Table 3.1.2.

Table 3.1.2: Monthly Precipitation Summary

MONTH	Total Monthly Precipitation (mm)		Comments
	AMEC Observed	Pearson*	
Sep 2007	18.75	77.5	Observed rainfall less than 25 % of Pearson historic average
Oct 2007	35.25	NA	
Nov 2007	60.25	NA	
April 2008	42.75	62.4	Observed rainfall relatively comparable to Pearson historic average
May 2008	58.75	72.4	Observed rainfall relatively comparable to Pearson historic average
June 2008	122	74.2	Observed rainfall 1.6 times Pearson historic average
July 2008	146.75	74.4	Observed rainfall 2.0 times Pearson historic average
Aug 2008	112.75	79.6	Observed rainfall 1.4 times Pearson historic average

* Historical 30 Year Average Data Recorded for Pearson Airport Rain Gauge

The results in Table 3.1.2 indicate that the rainfall which occurred during the 2007 monitoring season was substantially lower than the historic average monthly rainfall data. The rainfall which occurred during April and May 2008 was relatively comparable to the average monthly volumes for those months, however the rainfall during June, July, and August 2008 was significantly greater than the average monthly values. Based upon the foregoing, the data collected for 2007 was considered unsuited for model calibration due to the atypically dry conditions which prevailed that year, and has thus been screened from application in the hydrologic model development. The data collected during 2008 was considered suitable for model calibration, due to the abundance of data and conditions under which the events occurred; on this basis, the data collected for 2008 has been advanced for application in the hydrologic model development.

Additional analyses have been completed in order to determine the runoff coefficients at each of the gauge locations for the observed storm events in 2008 in order to determine whether or not the combination of the observed rainfall and runoff response (i.e. volume) is characteristic of the contributing drainage area to the gauge, given the land use conditions within the contributing drainage area. The results of this assessment are summarized in Table 3.1.3.

Table 3.1.3: Summary of Observed Runoff Coefficients at Streamflow Monitoring Locations								
Event Date	Rainfall Volume (mm)	Monitoring Sites						
		Q1	Q2		Q3	Phase 1	Trafalgar Golf Course	
			Local	Local + SWM			North	South
April 11th, 2008	22.75	0.37	0.48	0.32	0.63	*N/A*	0.56	0.93
May 3rd, 2008	24	0.21	0.44	0.30	0.49	0.26	0.33	0.28
June 28th, 2008	26	*N/A*	0.17	0.12	0.36	0.27	0.02	0.18
July 19th, 2008	45	0.32	0.05	0.03	0.10	0.51	0.03	0.11
July 22nd, 2008	30	0.41	0.68	0.45	0.83		0.60	0.52
July 23rd, 2008	28.75	0.58	0.74	0.49	0.59		0.05	0.07
August 5th, 2008	59	0.27	0.45	0.30	0.46	0.35	0.46	0.35
August 9th, 2008	27.25	0.80	1.14	0.76	0.82	0.49	0.46	0.50

An inventory of the hydraulic structures within the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) lands has been developed based upon the results of the Total Station Survey and geo-referencing to spot elevations on the base mapping provided for this study. The summary of the hydraulic structures is provided in Table 3.1.4, and the locations of the hydraulic structures are provided in Drawings 2 and 3 for the Derry Green and Boyne Survey lands respectively.

Table 3.1.4: Hydraulic Structure Inventory (Derry Green and Boyne Survey Areas)					
Crossing Number	Location	Crossing Type	Size of Opening (span x rise) (mm)	Upstream Invert (m)	Downstream Invert (m)
Phase 3 Area (Boyne Survey)					
324	Britannia Rd. , west of Bronte Rd.	C.S.P. Arch	1500 x 900	183.713	183.681
2	Britannia Rd., east of Bronte Rd.	C.S.P	420 diam.	185.183	185.021
3	Britannia Rd., approx, 500 m east of Bronte Rd.	Conc. Open Footing	2480 x 1220	182.849	182.696
4	Britannia Rd., west of R.R. #35	C.S.P	Twin 900 diam.	182.151	182.087
5	Sixteen Mile Creek Main Branch @ Britannia Rd.	Bridge	1971 x 3700	176.342	176.259
6	Britannia Rd., west of Thompson Rd.	C.S.P	500 diam.	188.668	188.338
7	Britannia Rd., east of Thompson Rd.	Conc. Box	3000 x 1200	186.630	186.620
8	Thompson Rd., approx. 300 m north of Britannia Rd.	C.S.P	Triple 900 diam.	189.700	189.620
9	Forth Line, approx. 430 m south of Louis St. Laurent Ave.	Conc. Open Footing	6710 x 1800	191.137	191.147
10	At intersection of Britannia Rd. and Forth Line	Conc. Open Footing	4270 x 1200	189.734	189.808
11	Britannia Road, West of CNR	Conc. Open Footing	2440 x 1070	182.09	181.96
12	James Snow Parkway south of Louis St. Laurent	Conc. Open Footing	20000 X 2800	191.010	190.910
13	CNR	C.S.P.	Twin 900 diam.	189.3 (est)	188.4 (est)
14	R.R. 25 north of Britannia Rd.	Conc. Box	1800 x 900	186.10	186.00
15	Fourth Line north of Britannia Rd.	Conc. Box	5480 x 980	189.658	189.644

Table 3.1.4: Hydraulic Structure Inventory (Derry Green and Boyne Survey Areas)					
Crossing Number	**Location**	**Crossing Type**	**Size of Opening (span x rise) (mm)**	**Upstream Invert (m)**	**Downstream Invert (m)**
Business Park 2 Area (Derry Green)					
1	Fifth Line, first culvert north of Britannia Rd.	Conc. Open Footing	6400 x 1820	188.736	188.738
2	Fifth Line, second culvert north of Britannia Rd.	C.S.P. ARCH	1380 x 1300 (collapsed)	189.172	189.068
3	Fifth Line, south of Derry Rd.	C.S.P	Twin 750 diam.	i) 192.385 ii) 192.411	i) 192.370 ii) 192.346
4	Fifth Line, first culvert north of Derry Rd.	C.S.P	450 diam. 750 diam.	i) 193.013 ii) 193.381	i) 192.954 ii) 193.090
5	Fifth Line, second culvert north of Derry Rd.	C.S.P	500 diam.	193.975	193.925
6	Fifth Line, south of C.P.R. Line	Conc. Open Footing	1520 x 500	193.628	193.534
7	Fifth Line, north of C.P.R. Line	C.S.P	750 diam.	195.226	195.136
8	Sixth Line, north of Derry Road	Conc. Open Footing	2140 x 2140	187.490	187.554
9	Sixth Line, south of C.P.R. Line	Conc. Open Footing	1520 x 1820	190.308	190.324
10	C.P.R Line, west of Fifth Line	Conc. Pipe	300 diam.	197.780	197.680
11	C.P.R., first culvert east of Fifth Line	Conc. Open Footing	1800 x 610 (silted)	194.250	194.215
12	C.P.R., second culvert east of Fifth Line	Conc. Open Footing	1220 x 300 (silted)	192.251	192.215
13	Derry Rd., west of Fifth Line	Conc. Open Footing	740 diam.	193.517	193.172
14	Derry Rd., east of Fifth Line	C.S.P. ARCH	500 diam.	193.458	192.260
15	Derry Road, west of Sixth Line	C.S.P	3000 x 1750	187.090	187.000
16	Fifth Line South of Hwy 401	Conc. Open Footing	2745 x 2000	190.897	190.861
17	Fifth Line South of Main St.	C.S.P.	750 diam	195.324	195.236
18	Fifth Line north of Main St.	C.S.P.	750 diam.	195.226	195.200

3.1.4 Analysis

In accordance with the approved Work Plan for the Subwatershed Study Update, hydrologic analyses have been completed in order to establish frequency flows and Regional Storm flow rates at key locations within the Milton Business Park 2/Derry Green and the Phase 3/Boyne Survey, as well as at key downstream locations within the Sixteen Mile Creek Watershed. These analyses have applied the HSP-F methodology, which was originally applied for the Sixteen Mile Creek Subwatershed Study Areas 2 & 7 (Philips Planning and Engineering Limited, January 2000). Subsequent to the completion of the January 2000 Subwatershed Study, the HSP-F hydrologic model has undergone several revisions and refinements as part of further work within the Sixteen Mile Creek Watershed. Specific revisions/refinements to the model have been completed as follows:

- The drainage area to the Hilton Falls Reservoir and Kelso Reservoir have been revised as part of the Hilton Falls Reservoir Operations Optimization Study (Philips Engineering Ltd., April 2005); specific revisions include increased refinement of the study area

(i.e. increased number of subcatchments) and model calibration to localized streamflow gauges within the study area.

- The drainage areas north of Highway 401 have been refined for the Highway 401 Industrial/Business Park Functional Stormwater and Environmental Management Strategy (Philips Engineering Ltd., July 2000); additional refinements have been completed as well in support of the hydrologic verification for the TAA/Verus Partners stormwater management facility and the associated development of the contributing drainage areas.

- The drainage areas and stormwater management facility rating curves within the Phase 1 Area have been updated as part of various verification exercises for developments within the Phase 1 Area, based upon stormwater management reports submitted in support of the respective development areas.

- The drainage areas for the portions of the Sherwood Survey/Milton Phase 2 Lands located within the Sixteen Mile Creek have been refined as part of the Indian Creek Subwatershed Study (Philips Engineering Ltd., December 2004).

Additional revisions and refinements to the HSP-F hydrologic model have been completed in support of the Subwatershed Study Update, based upon stormwater management studies and subwatershed studies completed in support of various developments within the Milton Phase 1 and Highway 401 Industrial/Business Park areas which were not previously verified using the approved model. As well, in accordance with the approved Work Plan, the model has been refined within the limits of the Business Park 2/Derry Green and Phase 3/Boyne Survey lands; the updated subcatchment boundary plans for these areas are presented in Drawings 4 and 5 respectively, along with the reference nodes for the hydrologic model.

The updated HSP-F hydrologic model has been calibrated using the observed rainfall and streamflow data which has been collected as part of the field monitoring program. The model calibration exercise has consisted of a systematic adjustment to the base parameters within the original model in order to reproduce the observed streamflow response based upon the observed rainfall data. Due to the absence of rainfall during the 2007 monitoring period, only the data collected during the 2008 monitoring period has been used for model calibration. For the purpose of model calibration, generic meteorological data has been incorporated into the simulation time series for the years 2006 and 2007, as well as for the months of January to March 2008 inclusive, in order to provide a “warm-up” period for the model and eliminate any potential bias associated with the initial parameterization for the model. Results of the model calibration are provided in Appendix ‘C’.

The hydrologic analyses which were completed for the January 2000 Subwatershed Study applied hourly precipitation data for the Burlington RBG Station for the years 1962 to 1995. In accordance with the approved Work Plan, the Ontario Climate Centre has been contacted in an effort to obtain precipitation data at 15 minute time steps, as well as to obtain a more extensive period of record beyond that which was used for the original Subwatershed Study. Based upon discussions with OCC staff, the following have been determined regarding the availability of meteorological data:

- Data is available at hourly time steps or greater only (i.e. no data is available at 15 minute time steps).

- Rainfall data only is available at the RBG Station for the years 1996 to 2003, for the months of April to October inclusive (i.e. no data regarding snow accumulation is available).

- No rainfall or precipitation data is available at any station beyond 2003.

In order to extend the simulation time period beyond that which was applied in the original Subwatershed Study, precipitation data for the Pearson Airport station for the years 1996 to 2003 has been appended to the original dataset for the RBG gauge. Although this approach represents a deviation from the methodology specified in the approved Work Plan, the Pearson Gauge is proximate to the Town of Milton, hence the data provided for that gauge is considered reasonably representative of the precipitation within the Town for those years. Similarly, hourly temperature data for the Pearson gauge has been applied for the continuous simulation for the years 1962 to 2003. Consistent with the methodology applied in the original Subwatershed Study, the generic annual datasets developed for the balance of the meteorological input (i.e. dewpoint temperature, solar radiation, potential evapotranspiration, and wind movement) have been applied for the years 1996 to 2003.

The refined and re-calibrated HSP-F hydrologic model has been executed for a 42 year continuous simulation using the updated meteorological time series, and frequency analyses have been completed based upon the simulated annual maximum flow rates using the Consolidated Frequency Analysis software; consistent with the original Subwatershed Study, the Log Pearson Type III Distribution has been applied for the frequency analyses. As well, the HSP-F model has been executed to simulate the Regional Storm event as a discrete storm event in order to generate the peak flow rates at key target locations within the Sixteen Mile Creek Watershed. The simulated frequency flow rates and Regional Storm flow rates are summarized in Table 3.1.5.

Table 3.1.5: Simulated Frequency Flows through Phase 3 and Business Park 2 Areas Existing Land Use (m^3/s)

Node	Location/Description	Frequency (years)								
		1.05	1.25	2	5	10	20	50	100	Regional
Phase 3 Area (Boyne Survey)										
2.402		0.08	0.10	0.16	0.26	0.34	0.44	0.60	0.75	1.87
2.507		0.15	0.24	0.40	0.66	0.87	1.09	1.42	1.70	5.19
2.509		0.39	0.56	0.86	1.38	1.81	2.29	3.03	3.67	9.72
2.510		0.18	0.28	0.45	0.73	0.95	1.19	1.55	1.85	8.10
2.511		0.13	0.19	0.30	0.47	0.61	0.76	0.98	1.17	2.00
2.512		0.33	0.49	0.76	1.21	1.57	1.97	2.56	3.07	10.70
2.514		0.61	0.87	1.32	2.10	2.73	3.44	4.52	5.47	16.00
2.100		12.60	18.40	27.30	41.00	50.90	61.10	75.10	86.30	381.00
2.801		0.18	0.26	0.40	0.66	0.89	1.15	1.57	1.96	4.68
2.802		0.46	0.67	1.05	1.76	2.37	3.09	4.22	5.26	11.70
2.009		0.16	0.23	0.36	0.61	0.82	1.07	1.47	1.84	4.03
7.302		0.86	1.19	1.73	2.65	3.39	4.20	5.42	6.48	20.50
7.304		0.51	0.71	1.03	1.57	1.99	2.44	3.12	3.69	12.80
7.303		0.05	0.07	0.10	0.15	0.18	0.22	0.27	0.32	0.97
7.301		0.23	0.32	0.47	0.71	0.89	1.09	1.38	1.62	5.76
8.530		0.40	0.64	1.03	1.63	2.07	2.51	3.13	3.62	10.70
9.120		0.36	0.59	0.94	1.50	1.90	2.30	2.86	3.29	10.00
7.111		0.52	0.88	1.52	2.68	3.63	4.68	6.26	7.60	31.90
Business Park 2 Area (Derry Green)										
8.230		0.11	0.15	0.22	0.32	0.41	0.50	0.64	0.75	2.34
8.200		0.05	0.07	0.11	0.18	0.23	0.30	0.41	0.50	1.33
8.180		0.09	0.13	0.19	0.30	0.39	0.50	0.67	0.82	2.27
8.171		0.13	0.18	0.26	0.40	0.50	0.62	0.81	0.96	2.85
8.170	Centre Derry Road Crossing	0.23	0.31	0.45	0.69	0.89	1.11	1.45	1.75	5.12
8.150	West Derry Road Crossing	0.10	0.13	0.19	0.30	0.38	0.48	0.62	0.75	2.13
8.110		0.46	0.63	0.90	1.36	1.73	2.14	2.75	3.28	14.50
8.330	West CPR Crossing	0.24	0.32	0.46	0.67	0.82	0.98	1.20	1.37	3.87
8.320		0.37	0.50	0.72	1.07	1.35	1.65	2.10	2.48	7.07
8.290		0.45	0.60	0.86	1.27	1.59	1.93	2.43	2.86	8.36
8.430	East CPR Crossing	0.16	0.22	0.32	0.47	0.59	0.73	0.92	1.09	3.30
8.400		0.23	0.31	0.43	0.63	0.77	0.93	1.16	1.35	4.34
8.390	Centre CPR Crossing	0.24	0.33	0.45	0.66	0.82	0.98	1.22	1.42	4.57
8.380		0.43	0.58	0.81	1.18	1.46	1.77	2.21	2.58	8.16
8.370		0.52	0.69	0.96	1.40	1.73	2.08	2.58	3.01	9.37
8.280	East Derry Road Crossing	1.08	1.43	1.98	2.86	3.53	4.23	5.26	6.12	18.60
8.090		0.54	0.73	1.03	1.54	1.95	2.39	3.06	3.65	16.10
8.010		0.21	0.28	0.40	0.58	0.71	0.85	1.06	1.22	3.99
8.020		0.09	0.11	0.16	0.22	0.26	0.31	0.38	0.43	1.49
8.030		0.21	0.30	0.45	0.72	0.93	1.18	1.54	1.87	6.55
8.050		0.13	0.18	0.26	0.39	0.49	0.60	0.78	0.92	2.92
8.080		0.06	0.08	0.12	0.18	0.23	0.28	0.35	0.42	1.26
8.111		0.42	0.57	0.83	1.26	1.61	1.99	2.57	3.07	13.80
8.220		0.23	0.31	0.45	0.70	0.90	1.13	1.49	1.80	5.20
8.260		1.23	1.62	2.23	3.20	3.93	4.70	5.81	6.74	20.50
8.261	Outlet to Centre Tributary	1.78	2.34	3.24	4.70	5.83	7.04	8.80	10.30	36.00
8.270		1.15	1.52	2.10	3.03	3.73	4.47	5.55	6.44	19.60
8.460		0.14	0.20	0.30	0.46	0.59	0.72	0.92	1.09	7.59
7.090		1.79	2.59	3.61	5.23	6.46	7.76	9.62	11.20	47.6
7.070		7.91	15.9	28.3	48.4	63.2	78.1	98.3	114.0	376.0
7.080		5.23	11.1	21.8	39.9	53.3	66.9	85.1	99.10	292.0
8.680		0.64	0.9	1.28	1.87	2.3	2.74	3.34	3.83	15.0
8.681		2.05	3.96	7.61	14.5	20.3	26.8	36.5	44.80	136.0

Hydraulic models have been developed for the reaches through the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) lands in order to delineate the Regulatory Floodplain through these areas. The HEC-RAS methodology has been applied for this assessment. Cross-section data has been generated based upon the base mapping provided for this study, as well as the hydraulic structure inventory completed for this study. The downstream boundary conditions for the reaches have been set as the Regulatory water surface elevation specified on the 1988 Sixteen Mile Creek Floodline Mapping where available, and as the simulated floodplain elevation from Conservation Halton natural hazard limit hydraulic modelling (HEC-RAS), where specific water surface elevations from the Floodline Mapping did not exist. In accordance with the current practice and requirements of Conservation Halton, the floodline mapping has considered those reaches with drainage areas greater than 50 ha, as well as those reaches of environmental or functional significance (i.e. significant aquatic habitat value, reaches downstream of stormwater management facility outlets, etc.). The Regulatory floodplain has been delineated based upon the results of the hydraulic analyses, and is depicted on Drawings 6, 7, and 8. The results of this assessment indicate that the Regional Storm floodplain for the reaches through the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) lands corresponds closely to that which has been determined previously by Conservation Halton; differences between the two models can be attributed to possible variations in the flows applied in each assessment, as well as different base mapping from which the models and floodplains have been developed.

The constraint ranking for the flood conveyance function of the drainage features has been based upon the conveyance afforded by the feature itself, as well as the adjacent floodplain. Essentially, this assessment has considered the physical condition of the system (i.e. well-defined valley, swale with altered floodplain, etc.), the size of the contributing system drainage area (as an indication of the magnitude of storm flows contributing to the system), the presence or absence of a Regulatory floodplain for the system, as well as any attenuation function which may be afforded by the riparian storage of the system. The foregoing functions of the features have been used in order to determine whether or not functions of specific features and adjacent floodplain system could be replicated by a constructed system. The following summarizes the general classification hierarchy which has been applied for this constraint ranking.

1. High Flood Conveyance Constraint: These features lie within well-defined natural valley corridors, convey runoff from large system areas (i.e. several hundred or thousand hectares), and have a Regulatory floodplain associated with the system. The conveyance function offered by these systems cannot be readily replicated by a constructed corridor, hence these systems are afforded a high constraint and cannot be altered or relocated.

2. Medium Flood Conveyance Constraint: These features convey runoff from relatively moderately sized drainage areas (i.e. typically between 50 and 250 ha), may or may not have a Regulated floodplain, and typically have a less defined corridor (i.e. not within a deep, well-defined and naturalized valley). The conveyance function and riparian storage of these systems can be replicated by a constructed system, but would require the construction of an open watercourse and corridor in order to achieve the same capacity and hydraulic efficiency (i.e. flood depth) within the system.

3. Low Flood Conveyance Constraint: These systems are generally depressional features or swales which convey runoff from a relatively small drainage area (i.e. generally less than 50 hectares), may or may not have a Regulatory floodplain, and do not lie within a well-defined corridor. The conveyance and attenuation functions afforded by these features can be replicated through the implementation of urban infrastructure (i.e. swales, ditches, storm sewers, major overland conveyance system, stormwater management facilities, etc.), hence these features are afforded a low constraint ranking.

3.2 Groundwater

3.2.1 Scope/Purpose

The previous Subwatershed Study was carried out during a time of extended drought conditions. It is the intent that the field component of the current study will provide additional information more specific to groundwater discharge. Where available any background data that was collected subsequent to the previous Subwatershed Study was reviewed to assess potential trends related to the water table or baseflow.

This information has been used to confirm or further characterize the hydrogeologic setting so as to provide a more detailed conceptual model to refine our understanding of potential groundwater flow pathways, groundwater discharge zones and to provide additional input into a semi-quantitative groundwater balance.

3.2.2 Methods

Background Data Review

Additional background data considered for review included:

- Local SIS reports
- Conservation Authority baseflow data
- Bronte Creek Watershed Study
- Halton Aquifer Management Plan (Phase 1, Phase 2 Reports)
- Glacial Till Literature Review
- Tier 1 Water Budget Halton Region Source Protection Area (Draft Report)
- Report on Environmental Monitoring Activities 2006
- Sixteen Mile Creek Areas 2 & 7 Subwatershed Update 2007 Monitoring Summary

Streamflow Measurement and Baseflow Water Quality Sampling

Streamflow measurements were obtained using a combination of the area-velocity method, or direct measurement of flow. Spot baseflow measurements were carried out a sufficient time after any significant precipitation event to limit the stream flow to groundwater discharge.

The direct measurement of flow can be carried out by allowing stream flow to be collected within a calibrated bucket for a measured period of time. Another direct measurement of flow incorporated a “flume design” by Blackport & Associates which allows for the collection of

stream flow for a measured period of time within various reach geometries. The collected water was then measured in a calibrated bucket.

Where the area-velocity method is used, a representative section with a regular streambed profile and laminar flow is selected, in order to maximize the accuracy of the measurement. At each location, the total width of the creek is measured and the section divided into representative intervals, where necessary, for which total stream depth and average velocity is measured. Velocity is measured at the surface where stream depths are limited. Measurements are recorded in the field and total streamflow is later calculated using a factor of 0.85 on the surface velocity to obtain a representative velocity.

Baseflow samples were taken at representative sites within Derry Green and analyzed for general chemistry, nitrogen species and metals.

3.2.3 Results

Streamflow Measurement and Water Quality Sampling

Spot baseflow observations/measurements were carried out on 3 occasions in 2007 at 59 sites. 51 sites were located within Subwatersheds 2 & 7; and 8 sites were located within the Indian Creek Subwatershed. Selected sites were again measured in July and September 2008. The summer of 2008 had a significant amount of precipitation and these additional measurements were carried out to better assess this additional recharge. The tabulated results can be found in Appendix 'D'**.** All sites that were measured or observed are recorded in the tables. Locations for these sites can be found on Map 1 in Appendix 'D'**.** The majority of sites were dry during monitoring although a slight increase was noted in the minor tributaries during the November, 2007 monitoring with more significant increases in the 2008 monitoring.

Water quality samples for baseflow were collected at Sites 42 and 45. The water quality data can be found in Appendix 'D'. Sample number M1 refers to spot baseflow Site 42 and M2 refers to spot baseflow Site 45.

Background Data

Halton Region has provided water level data for selected water wells. The Source Protection Program for Hamilton-Halton Region provided groundwater mapping for the shallow groundwater flow system, the deeper groundwater flow system and the hydrograph for a Provincial Groundwater Monitoring Network (PGMN) well within the study area. The PGMN well is screened in the top of the Queenston shale approximately 13 m below ground surface. Groundwater level data was also provided for 3 wells installed for the Environmental Monitoring Program. These wells don't have logs but are assumed to be in the till at depths of 2.5 to 3.0 m and are located in the vicinity of Derry Road and 3rd and 4th line.

The location for the PGMN well can be found on Map 1 (Appendix 'D) and locations for the Halton Region wells can be found on Map 2 in Appendix 'D'**.** All groundwater water level data can be found in Appendix 'D'**.**

3.2.4 Analysis

The spot baseflow values for 2007 tend to indicate similar values to the previous 1998/1999 flows. The values for 2008 show a relative increase in flows at the selected locations. There was less of an increase within the Indian Creek portion of the study area likely indicating less potential for groundwater discharge especially in lower portion.

The groundwater level trends for the Halton Region wells tend to show consistent water levels or a slight increase. The groundwater level trend in the PGMN well shows a minor downward trend from 2001 through 2007 along with seasonal variations of approximately 2.5 m. Data for 2008 shows a general increase of approximately 0.5 m. The wells for the environmental monitoring program were monitored July to November 2006 and showed seasonal trends as well but were more subdued, on the order of 1 m. This was likely due to missing the spring recharge event or buffering of the water table as the wells are located near surface water sources.

The increase in baseflows for 2008 likely correlates with a general rise in water levels due to increased precipitation and recharge. A sustained increase in baseflow at Site 40 may be the result of infrastructure draining of the local water table but has not been determined within the groundwater component of this study. Consistent flow at site 45 may reflect the increased recharge potential within the local surficial sand and gravel (Area A, Map1)

The water quality analysis shows high levels of nitrates in both samples generally indicating a shallow source of groundwater recharge for the groundwater discharge. The lower chloride and sulphate values at Site 45 indicate a source that is more local with less residence time. Both would tend to indicate there is not much groundwater contribution from the deeper shale.

The shallow groundwater mapping (Appendix ‘D’) indicates some minor groundwater divides which to a degree follow the surface water divides. There appears to be a confluence of groundwater flow towards the North and Centre Tributaries. This may give rise to more seasonal resilience of flows in these tributaries. The deeper groundwater flow tends to follow the general pattern of the shallow groundwater flow to the east/southeast (Appendix ‘D’).

3.2.5 Assessment

The key technical findings from the previous studies include the following:

Physiography and Geology

- The study area consists of the physiographic regions identified as the Peel Plain, the South Slope and the Niagara Escarpment.

- The shape of the bedrock surface (including the escarpment) as well as the occurrence of the overburden units which make up the above regions is a result of the repeated glacial advances and retreats which have occurred in Southern Ontario.

- The surficial overburden of the South Slope physiographic unit in the study area is comprised of the silty to clayey Halton Till. The surficial material in the Peel Plain, which covers the majority of the study area consists of glaciolacustrine silts and clays. .

- The topography, below the Milton Outlier, within this area, has a gentle, somewhat undulating form sloping southwest.

- The bedrock underlying the glacial deposits consists of the Queenston shale. The upper 5 m of the shale can be weathered and fractured. The bedrock cap on top of the Milton Outlier consists of the fractured and relatively permeable dolostone of the Guelph-Amabel Formation. The existence of the Queenston shale at or near the surface east of the escarpment has given rise to historical and potential extraction operations.

- The thickness of the overburden below the escarpment ranges from 3 to 25 m. The overburden can contain lenses of more permeable sand and gravel. Channelized deposits of sand gravel occur in the lower portion of the subwatershed. These deposits may range from 1.5 to 6 m thick and may be continuous. Representative cross-sections from the previous Subwatershed Study are included in Appendix 'D'.

Conceptual Groundwater Flow System Characterization

- 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. Relative to the tick clay till there are areas with other hydrostratigraphic characteristics which may provide an increased potential for groundwater recharge. These more hydrogeologically sensitive areas are presented on Map 1 (Appendix 'D') and include; Area A - localized area of surficial sand and gravel (based on the Quaternary Geology), Area B – localized area of thin, fractured till overburden less than 8 m thick (based on overburden thickness map OGS Map 2179), and Area C – localized area of near surface sand and gravel (based on mapping in the Phase 1 Hydrogeology Report, Halton Aquifer Management Plan)

- The underlying bedrock is a low permeability shale which will not provide a significant underdrain and as such will likely not lead to extensive fracturing in the overlying clay tills. Areas where the overburden is thinner may allow for a higher level of infiltration compared to the thicker silt/clay deposits. The cap bedrock of the Milton Outlier is relatively permeable dolostone and can provide for significant recharge where fracturing is prevalent.

- The general direction of horizontal groundwater flow within the shallow overburden/shale system will be northwest to southeast, reflecting the general bedrock and overburden topography. The horizontal component of groundwater flow, particularly within the overburden, will be weak due to low permeability of the silt/clay sediments.

- Discharge likely occurs where the watercourses cut into the upper fractured shale or sand and gravel lenses. The more localized flow that has occurred during the extended period of drought, likely indicates that the recharge source is a more intermediate or regional source.

- Below the toe of the escarpment, groundwater recharge is expected to be relatively low and may be directed to the surface watercourses but the existing hydrostratigraphy indicates that this groundwater movement would be minor. An exception may be the near surface sand and gravel lenses or exposed bedrock,

Groundwater Function and Availability

- Private domestic wells are generally drilled into the Queenston shale (10 to 15 m into the shale), localized discontinuous sand lenses within the silt clay overburden or discontinuous sand and gravel lenses at the overburden/bedrock contact. The quality of water within the Queenston shale is generally poor due to naturally elevated levels of iron, manganese and chloride.

- Groundwater appears to provide for limited baseflow along various reaches at the toe of the escarpment and a number of reaches further down in the system. These include reaches associated with spot baseflow sites 20, 21, 24 ,25, IC9, IC10, IC11,

New Findings

The following discussion was not presented in the previous studies and provides additional technical insight into the groundwater flow system within the Halton Till.

The horizontal component of groundwater flow, particularly within the overburden, will be weak due to the low permeability of the silt/clay sediments. The upper fractured till is expected to transmit relatively higher quantities of water but on a more local scale. A significant amount of research has focused on the hydrogeology of fractured glacial tills and was obtained through a literature review carried out for a subwatershed study in Northwest Brampton. The following are some of the hydrogeologic factors that potentially relate to the till in the study area:

- Frequency and depth of fractures can depend on the clay/silt/sand content, average precipitation and temperature
- Fractures can occur up to 6 m but they are likely more prevalent within the upper 2 to 3 m of fractured till
- The lateral connection within the upper fractured till can be relatively significant but are localized laterally (10's of metres).
- Horizontal flow patterns in the upper fractured till will be controlled by local depressional topography and restricted by underlying more massive and less permeable till
- Vertical groundwater flow below the upper fractured till is generally low unless more permeable, interconnected lenses exist
- Evapotranspiration will significantly reduce water levels in the upper fractured till
- Lateral flow in the upper fractured till reduces more quickly as the water levels drop due to less fracture with depth
- Gradients can be reversed within the underlying massive till (downward to upward) as water levels in the upper fractured till lower thereby reducing recharge to depth

Where the underlying till is massive both vertical and horizontal groundwater flow is restricted. The vertical hydraulic gradients are generally quite higher than the horizontal gradients. Some level of fracturing may occur in the more massive till as well as interconnected more permeable layers

which may transmit more groundwater to depth. In areas where the overburden thickness is on the order of 6 m, it is expected there is an increased potential for groundwater flux to the bedrock but where the overburden thickness is on the order of 2 to 3 m it is expected there is a much more direct connection from ground surface to the upper bedrock.

The potential for draining of the water table due to the presence of certain infrastructure (i.e. storm drains) has been presented. Conceptually the backfill within certain underground infrastructure can be more permeable than the native overburden and therefore acts as a more preferential groundwater pathway. The literature review for Northwest Brampton, previously noted, has presented analytical approaches for the assessment of trench dewatering for geotechnical purposes. The assessment within the Halton Till in Northwest Brampton which is similar to the overburden in Milton indicates that drainage to an open trench would not affect the water table beyond 30 m. This is a conservative number and would be expected to be less in a trench that is actually backfilled.

Specific to the Derry Green area the following hydrogeologic characteristics can be presented:

- The overburden thickness in the northwest portion of Derry Green is less than 8 m. To the south it is 9 to 15 m and thicker to the east (20 to 30 m). The overburden thickness is presented on Map 3 (Appendix 'D').

- Within or immediately adjacent to the Derry Green area there are approximately 12 overburden wells and 14 bedrock wells. The majority of the wells have capacities less than 1.4l/min. Two of the overburden wells and 5 of the bedrock wells have specific capacities of 1.4 to 5.8 l/min. This information was obtained from the Tier 1 Water Budget Halton Region Source Protection Area (Draft Report)

The findings in the current study provide the following:

- Confirmation of the previous hydrogeological characterization
- A refinement of local groundwater flow directions and flow system contribution
- A limited increase in reach specific discharge correlating with increased precipitation and subsequent recharge.
- Potential increase in baseflow from infrastructure draining of a local water table.

3.3 Surface Water Quality

3.3.1 Scope/Purpose

Surface water quality monitoring has been conducted as part of the Subwatershed Study Update in order to characterize existing surface water chemistry, as well as to complement the benthic invertebrate communities sampling (i.e. provide baseline data) in watercourses that may be impacted by development.

3.3.2 Methods

As indicated in the approved Field Monitoring Work Plan, the protocol for the monitoring program consisted of obtaining grab samples at four locations (ref. Drawing 1) during storm events which generated a runoff response, as well as during dry weather periods where stream flows were representative of baseflow/low flow conditions.

The grab samples were delivered to Maxxam Labs for analysis in order to characterize the existing water chemistry within the study area. As per the approved Field Monitoring Work Plan, the grab samples have been analyzed for the following water quality indicators:

- Total Metals
- Escherichia Coli (E.Coli)
- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (BOD_5)
- Chloride (Cl^-)
- Ammonia Nitrogen (NH_3 – N)
- Total Phosphorus
- Total Kjeldahl Nitrogen (TKN)
- Nitrate and Nitrite (NO_3 – N and NO_2 – N)
- Alkalinity and Hardness
- Conductivity

The surface water chemistry sampling component of the monitoring program for 2007 essentially commenced on August 1, 2007, when the project file was established with the analytical laboratory (Maxxam Labs). As indicated previously, the meteorological conditions during 2007 were atypically dry, thus the event of November 21, 2007 was the only storm during the monitoring period which generated sufficient runoff for grab sampling to occur. Although the Work Plan recommended complementary sampling during dry weather events, no baseflow was observed at any of the monitoring locations during the inter-event periods despite numerous attempts (i.e. dry runs); this is again considered a result of the atypical drought conditions which characterized the meteorological conditions during 2007.

Wet weather surface water quality monitoring for the 2008 monitoring program began with the freshet on April 1, 2008, and was concluded on June 3, 2008 at which time three (3) wet weather events had been monitored for the 2008 season. Dry weather sampling commenced with the first event on July 29, 2008 and was concluded on October 24, 2008 when three dry weather samples had been obtained.

In addition, temperature monitoring has been completed. The Levelogger™ flow gauges which were used for the streamflow monitoring component of the study also recorded temperature data; although this differs from the approved Work Plan which consisted of HOBO™ temperature gauges at the water quality monitoring sites, the use of the Levelogger™ system for temperature monitoring has increased the number of temperature monitoring sites from three to six at essentially no cost premium. Temperature records have been obtained consistent with the period for streamflow monitoring (i.e. between August 13, 2007 and November 26, 2007); this includes air temperature readings during the times when the streams were dry.

Temperature records for the 2008 monitoring period have been obtained from April 1, 2008 until August 27, 2008 at which time the 2008 monitoring program was concluded and the gauges were removed from the field. The full record of temperature data is provided in Appendix 'E'.

3.3.3 Results

The full suite of results for the water quality monitoring are provided in Appendix 'E'. The mean and median concentrations of select representative water quality indicators are presented in Tables 3.3.1 through 3.3.8 for the wet weather and dry weather monitoring at each of the monitoring sites.

Table 3.3.1: Summary of Wet Weather Water Quality Monitoring Results for Site Q1 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	4	2	2 - 2	2	2
E.coli (#/100mL)	4	4	30 - 12000	467	363
TKN	4	4	0.8 - 1.8	1.22	1.15
Total P	4	4	0.032 - 0.28	0.116	0.076
TSS	4	4	12 - 32	19.5	17
Copper (µg/L)	4	4	2 - 14	5.75	3.5
Zinc (µg/L)	4	3	12 - 45	24	14
Lead (µg/L)	4	3	1 - 8.5	3.5	1
Nitrate+Nitrite	4	3	0.3 - 0.8	0.6	0.6

Table 3.3.2: Summary of Wet Weather Water Quality Monitoring Results for Site Q2 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	3	2	3 - 5	4	4
E.coli (#/100mL)	3	2	<10 - >20000	862	3200
TKN	3	3	1 - 18	7	2
Total P	3	3	0.11 - 1.4	0.57	0.2
TSS	3	3	10 - 1600	554	51
Copper (µg/L)	3	3	5 - 51	23	12
Zinc (µg/L)	3	3	11 - 190	72	15
Lead (µg/L)	3	3	0.9 - 29	11	3.1
Nitrate+Nitrite	3	3	0.9 - 2.9	1.8	1.7

Table 3.3.3: Summary of Wet Weather Water Quality Monitoring Results for Site Q3 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	4	1	2	2	2
E.coli (#/100mL)	4	4	110 - 1500	314	242
TKN	4	4	0.7 - 2.2	1.4	1.4
Total P	4	4	0.052 - 0.19	0.100	0.078
TSS	4	1	92	92	92
Copper (µg/L)	4	4	2 - 9	3.75	2
Zinc (µg/L)	4	3	6 - 31	17	14
Lead (µg/L)	4	2	0.6 - 3.5	2.05	2.05
Nitrate+Nitrite	4	2	0.3 - 1	0.65	0.65

Table 3.3.4: Summary of Wet Weather Water Quality Monitoring Results for Site IC (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	3	1	3	3	3
E.coli (#/100mL)	3	3	<10 - 3200	68	10
TKN	3	3	1 - 10	5	4
Total P	3	3	0.054 - 0.53	0.27	0.24
TSS	3	3	14 - 760	274	49
Copper (µg/L)	3	3	3 - 30	13	7
Zinc (µg/L)	3	3	12 - 210	81	20
Lead (µg/L)	3	3	0.7 - 17	7.4	4.6
Nitrate+Nitrite	3	3	0.6 - 1.8	1.1	0.9

Table 3.3.5: Summary of Dry Weather Water Quality Monitoring Results for Site Q1 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	2	2	3 – 5	4	4
E.coli (#/100mL)	2	2	10 – 740	86	86
TKN	2	2	1.3 – 1.4	1.35	1.35
Total P	2	2	0.046 – 0.2	0.123	0.123
TSS	2	2	15 – 33	24	24
Copper (µg/L)	2	2	2 – 5	3.5	3.5
Zinc (µg/L)	2	2	10 – 11	10.5	10.5
Lead (µg/L)	2	1	N/A	1.4	1.4
Nitrate+Nitrite	2	0	N/A	4	4

Table 3.3.6: Summary of Dry Weather Water Quality Monitoring Results for Site Q2 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	1	1	N/A	3	3
E.coli (#/100mL)	1	1	N/A	8600	8600
TKN	1	1	N/A	3.4	3.4
Total P	1	1	N/A	0.54	0.54
TSS	1	1	N/A	22	22
Copper (µg/L)	1	1	N/A	10	10
Zinc (µg/L)	1	1	N/A	27	27
Lead (µg/L)	1	1	N/A	4.6	4.6
Nitrate+Nitrite	1	0	N/A	ND	ND

Table 3.3.7: Summary of Dry Weather Water Quality Monitoring Results for Site Q3 (mg/L unless otherwise noted)

Contaminant	Total Number of Samples	Number of Samples Above MDL	Range	Mean	Median
BOD/CBOD	2	1	N/A	3	3
E.coli (#/100mL)	2	2	100 – 160	126	126
TKN	2	2	1.1 – 1.3	1.2	1.2
Total P	2	2	0.13 – 0.28	0.205	0.205
TSS	2	1	N/A	10	10
Copper (µg/L)	2	2	3 – 3	3	3
Zinc (µg/L)	2	1	N/A	8	8
Lead (µg/L)	2	1	N/A	0.6	0.6
Nitrate+Nitrite	2	2	0.2 – 0.3	0.25	0.25

Table 3.3.8: Summary of Dry Weather Water Quality Monitoring Results for Site IC (mg/L unless otherwise noted)					
Contaminant	**Total Number of Samples**	**Number of Samples Above MDL**	**Range**	**Mean**	**Median**
BOD/CBOD	2	2	3 – 8	5.5	5.5
E.coli (#/100mL)	2	2	10 – 90	30	30
TKN	2	2	2.6 – 3	2.8	2.8
Total P	2	2	0.18 – 0.27	0.225	0.225
TSS	2	2	27 – 34	30.5	30.5
Copper (μg/L)	2	2	2 – 3	2.5	2.5
Zinc (μg/L)	2	2	11 – 48	29.5	29.5
Lead (μg/L)	2	2	0.6 – 0.8	0.7	0.7
Nitrate+Nitrite	2	0	N/A	ND	ND

3.3.4 Analysis

The mean and median concentrations observed for each of the monitoring sites have been compared with literature values and results of monitoring programs for similar land use and soils within the contributing drainage areas in order to determine whether or not the results are considered representative and consistent with anticipated conditions. The results of this analysis are presented in Tables 3.3.9 through 3.3.12.

Table 3.3.9: Comparison of Wet Weather Event Mean Concentrations for Site Q1 with Literature Values from Water Quality Models (mg/L unless otherwise noted)					
Contaminant	**2007-2008 Field Monitoring Results**			**Water Quality Models**	
	Range	**Mean**	**Median**	**TWWF**	**RHCWP**
BOD/CBOD	2 - 2	2	2		2
E.coli (#/100mL)	30 - 12000	467	363	100,000	
TKN	0.8 - 1.8	1.22	1.15	1.0	2.8
Total P	0.032 - 0.28	0.116	0.076	0.2	0.5
TSS	12 - 32	19.5	17	100	400
Copper (μg/L)	2 - 14	5.75	3.5	8	5
Zinc (μg/L)	12 - 45	24	14	18	10
Lead (μg/L)	1 - 8.5	3.5	1	4	
Nitrate+Nitrite	0.3 - 0.8	0.6	0.6	2.5	

Table 3.3.10: Comparison of Wet Weather Event Mean Concentrations for Site Q2 with Literature Values from Water Quality Models (mg/L unless otherwise noted)					
Contaminant	**2007-2008 Field Monitoring Results**			**Water Quality Models**	
	Range	**Mean**	**Median**	**TWWF**	**RHCWP**
BOD/CBOD	3 - 5	4	4		2
E.coli (#/100mL)	<10 - >20000	862	3200	100,000	
TKN	1 - 18	7	2	1.0	2.8
Total P	0.11 - 1.4	0.57	0.2	0.2	0.5
TSS	10 - 1600	554	51	100	400
Copper (μg/L)	5 - 51	23	12	8	5
Zinc (μg/L)	11 - 190	72	15	18	10
Lead (μg/L)	0.9 - 29	11	3.1	4	
Nitrate+Nitrite	0.9 - 2.9	1.8	1.7	2.5	

Table 3.3.11: Comparison of Wet Weather Event Mean Concentrations for Site Q3 with Literature Values from Water Quality Models (mg/L unless otherwise noted)					
Contaminant	**2007-2008 Field Monitoring Results**			**Water Quality Models**	
	Range	**Mean**	**Median**	**TWWF**	**RHCWP**
BOD/CBOD	2	2	2		2
E.coli (#/100mL)	110 - 1500	314	242	100,000	
TKN	0.7 - 2.2	1.4	1.4	1.0	2.8
Total P	0.052 - 0.19	0.100	0.078	0.2	0.5
TSS	92	92	92	100	400
Copper (μg/L)	2 - 9	3.75	2	8	5
Zinc (μg/L)	6 - 31	17	14	18	10
Lead (μg/L)	0.6 - 3.5	2.05	2.05	4	
Nitrate+Nitrite	0.3 - 1	0.65	0.65	2.5	

Table 3.3.12: Comparison of Wet Weather Event Mean Concentrations for Site IC with Literature Values from Water Quality Models (mg/L unless otherwise noted)					
Contaminant	**2007-2008 Field Monitoring Results**			**Water Quality Models**	
	Range	**Mean**	**Median**	**TWWF**	**RHCWP**
BOD/CBOD	3	3	3		2
E.coli (#/100mL)	<10 - 3200	68	10	100,000	
TKN	1 - 10	5	4	1.0	2.8
Total P	0.054 - 0.53	0.27	0.24	0.2	0.5
TSS	14 - 760	274	49	100	400
Copper (μg/L)	3 - 30	13	7	8	5
Zinc (μg/L)	12 - 210	81	20	18	10
Lead (μg/L)	0.7 - 17	7.4	4.6	4	
Nitrate+Nitrite	0.6 - 1.8	1.1	0.9	2.5	

3.3.5 Assessment

The results of the water quality assessment indicate relatively little difference in contaminant concentrations between wet weather and dry weather events. The results also indicate that, in general, contaminant concentrations at all monitoring locations were less than values reported elsewhere. The lower concentrations are considered attributable to the season of wet weather sampling in 2007 (late fall/early winter), as well as a dilution effect which occurred during the 2008 monitoring season as a result of the abundance of rainfall.

A further review of the results has indicated no significant seasonal variations in contaminant concentrations. Again, this is considered attributable to the abundance of rain which occurred during the spring and summer of 2008.

3.4 Stream Morphology

3.4.1 Scope/Purpose

The purpose of the geomorphic field component was to upgrade existing data to satisfy the requirements of recent policy directions and fill any gaps in channel morphology data in order to provide an appropriate level of baseline information upon which the Secondary Plan and subsequent post-development targets/monitoring efforts can be based. While the original Subwatershed Study did include a geomorphic component, this work focussed largely on the main branches of Sixteen Mile Creek. Furthermore, the protocols used to assess geomorphic

conditions and constraints have advanced considerably since the initial study; in addition, the drainage network within the Phase 1 and 2 lands had undergone modifications. Consequently, while this report represents an update to the original Subwatershed Study, a large component of the material presented from a geomorphic perspective had not been previously reported. The scope of the geomorphic assessment included the following tasks:

- Site walks of the previously addressed Phase 1 and Phase 2 Sherwood lands to evaluate post-development conditions and channel performance (i.e., evidence of aggradation or erosion);
- Channel reaches within the Business Park 2 and Phase 3 lands would be subjected to 'rapid' field assessments, to identify impacts of land use change, determine channel sensitivity, confirm appropriateness of corridor widths and identify dominant geomorphic processes (e.g., aggradation, widening, planform adjustment);
- Review of any OSAP sites installed by the Watershed Science Centre, Conservation Halton or by Team. Specifically, module 12 (Geomorphology) will be incorporated into the geomorphic assessment; and
- Based on the results of the rapid field assessments, detailed field investigation(s) would be conducted along the most geomorphologically sensitive reach(es) to quantify channel geometry and identify active geomorphic processes.

The geomorphic monitoring component was to focus on updating not only monitoring sites established by the Watershed Science Centre, but also relocating the monitoring sites established by Parish Geomorphic Ltd. through the original Subwatershed Study. As a result, the following tasks were identified:

- Locate and re-measure erosion pins and cross-sections established by the Watershed Science Centre;
- Locate and re-measure control cross-sections and erosion pins established by Parish Geomorphic Ltd. as part of the original January 2000 Subwatershed Study;
- Re-establish monitoring sites in locations where either the existing Watershed Science Centre or Parish Geomorphic monitoring stations could not be located; and
- Where OSAP sites have been installed, the Team will incorporate the monitoring sections into the geomorphic monitoring program. This will help to maximize the transferability of information into a master database.

Given the recent policy direction towards the incorporation of headwater system form and function into the Subwatershed Study process, the following tasks will be undertaken to incorporate this direction into the Subwatershed Study update:

- Locate and re-measure each candidate swale site consisting of a control cross-section, substrate characteristic analysis and photographic record of conditions. Conservation Halton's updated mapping will be referenced for the location of hydrologic connections; and,
- Upgrade existing candidate sites according to the sampling protocol established by Parish Geomorphic Ltd. consistent with the TRCA/CVC method.

3.4.2 Methods

Rapid Assessments

In order to provide insight regarding existing geomorphic conditions on a reach basis, field reconnaissance was conducted throughout the fall of 2007. Rapid assessment techniques (RGA and RSAT) were applied to determine the dominant geomorphic processes affecting each site. A Rapid Geomorphic Assessment (RGA) documents observed indicators of channel instability (MOE, 1999). Observations are quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.41). An RSAT provides a broader view of the system by also considering the ecological functioning of the stream (Galli, 1996). Observations include instream habitat, water quality, riparian conditions, and biological indicators. Additionally, the RSAT approach includes semi-quantitative measures of bankfull channel dimensions, type of substrate, vegetative cover, and channel disturbance. RSAT scores rank the channel as maintaining a low (<20), moderate (20 to 35) or high (>35) degree of stream health.

Detailed Field Investigation

Based on the results of the rapid geomorphic assessments, six detailed geomorphic field sites of the eight originally proposed were established within the study area (Figure 3.4.3). One of the original detailed sites identified in the geomorphic work plan could not be completed due to extensive backwater conditions associated with a large beaver dam. The backwater effects essentially rendered the site inappropriate for gathering data that was reflective of local conditions and could support an erosion assessment. Ultimately, the location of the detailed work was determined, in part, by the need to capture the most geomorphologically sensitive reach(es) within each drainage system, but also by the knowledge that these areas will require servicing by stormwater management facilities. In addition to the six sites completed as part of the Subwatershed Update Study, a detailed site completed in 2007 within Reach 2-II as part of a separate study for the Town of Milton was also included in this report. Results of the investigation can not only be used to characterize pre-development flow conditions, but also to establish targets for stormwater management.

As part of the detailed field assessment, standard protocols and known field indicators were used to quantify bankfull cross-sectional dimensions within the reach (e.g. bankfull depth and width). A modified Wolman pebble count was used to characterize the channel bed substrate materials. In addition to noting bank characteristics, an *in-situ* shear stress test was performed on bank materials. These measurements were completed at five cross-sections per site. A level survey of the detailed site provided a measure of the local energy gradient and bed morphology. For each site, one top of bank control cross-section was permanently installed in order to monitor future change. An attempt was also made to incorporate the OSAP rapid assessment protocol at each site.

Monitoring

The monitoring program undertaken as part of this study was undertaken in two phases, involving monitoring of:

1) Eight monitoring sites re-established on Sixteen Mile Creek from the original Subwatershed Study (SM1 to SM8) and three additional sites identified through work by the Watershed Science Centre (Peru Road, DS Pond 10 and Reach D). Of these sites SM3, SM4 and SM5 are most relevant for future development at the Derry Green (Phase 2) and Boyne Survey (Phase 3) sites.
2) The six detailed field sites established in the Business Park Phase 2 and 3 lands through the update study (BP-I-B, BP-2-A, R7-IV, R7-IX, SWS-1-A-1 and SWS-2-A-1), as described previously.

The location of these monitoring sites is illustrated in Figure 3.4.3. Tables 3.4.1 and 3.4.2 provide details of the monitoring work undertaken during Phases 1 and 2.

Table 3.4.1: Phase 1 Monitoring

Site	Originally Established	Re-established	Monitoring
SM1	1998	Oct 24-2008	Dec 8-2009
SM2	1998	Oct 24-2008	Dec 8-2009
SM3	1998	Oct 24-2008	Dec 8-2009
SM4	1998	Oct 24-2008	Dec 8-2009
SM5	1998	Oct 24-2008	Dec 8-2009
SM6	1998	Oct 24-2008	Dec 8-2009
SM7	1998	Oct 24-2008	Dec 16-2009
SM8	1998	Oct 24-2008	Dec 16-2009
Peru Road		Oct 27-2008	Dec 8-2009
DS Pond 10		Oct 27-2008	Dec 8-2009
Reach D		Oct 27-2008	Dec 8-2009

Table 3.4.2: Phase 2 Monitoring

Site	Established	Monitoring
BP-2-A	Dec 4, 2007	June 18-08, July 21-08, Oct 9-08, (Not monitored Dec of 2009 due to No Trespassing sign)
BP-1-B	Dec 6, 2007	June 18-08, July 21-08, Oct 9-08, Dec 14-09
R7-IV	Nov 19, 20, 2007	June 18-08, July 21-08, Oct 9-08, Dec 16-09
R7-IX	Nov 13, 2007	June 18-08, July 21-08, Oct 9-08, Dec 14-09
SWS-2-AI	Sept 19, 2007	June 18-08, July 21-08, Oct 9-08, Dec 14-09
SWS-1-AI	Sept 20, 2007	June 18-08, July 21-08, Oct 9-08, Dec 14-09

Monitoring of the geomorphic stations took the form of re-measurement of top-of-bank control cross-sections, as well as the length of exposure of erosion pins. An effort was made to secure GPS co-ordinates at all of these sites in order to facilitate long-term monitoring efforts.

Headwater System Form and Function

Headwater drainage features are, in general, poorly defined in nature and have been modified to facilitate drainage of the adjacent lands. While the importance of headwater channels is

generally recognized, a quantitative analysis of their formative requirements, basin contributions and the impacts of channel loss through development and land use change has only recently come to the forefront of research and policy direction within Ontario.

First order streams (streams with no contributing upstream tributaries) are formed when the tractive force exerted by overland flow is sufficient to transport surface sediment (Selby, 1982) (ref. Figure 3.4.1). Several sources offer insight regarding the approximate drainage area required to produce such flows. Brummer (2004) states that, for mountain stream systems, drainage areas of one to several kilometers will support headwater systems. Gomi, et al. (2002), meanwhile, cite a smaller value of 0.01 to one square kilometre for the formation of headwater channels. This latter range of values is mirrored in work by Leopold (1994) and the Sierra Club (2004) who offer similar values of 0.23 and less than one square kilometre for first order streams and headwater streams (defined as first and second order streams), respectively.

While the specific pattern of network development reflects the combined influence of topography, geology and climate, these first order channels eventually merge with other channels and erode the surface until a slope develops. At this point, alluvial streams reach a quasi-equilibrium form in which the surface runoff is sufficient to transport the sediment delivered by the headwater tributaries (Whiting et al., 1999). This sediment is eventually deposited in the lowland tailwater system where the stream reaches its confluence with a receiving water body such as an ocean or lake (Figure 3.4.2).

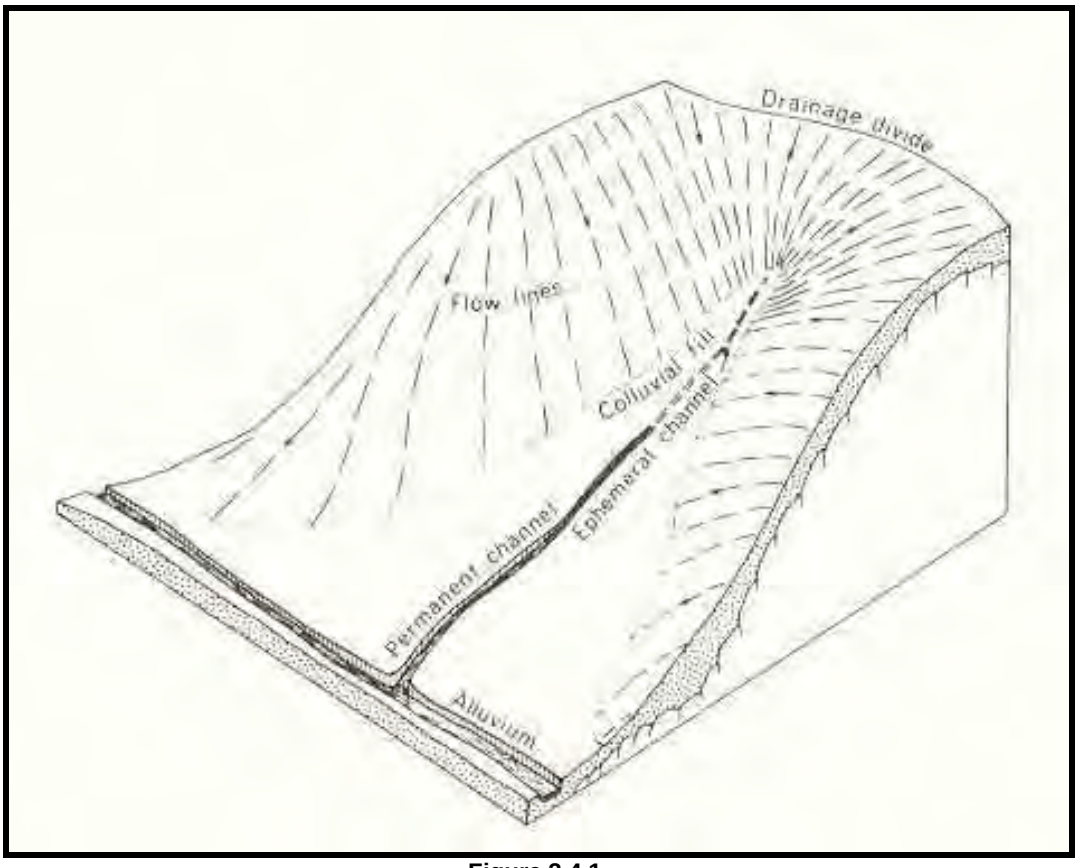

Figure 3.4.1:
Headwater Stream Formation (Selby, 1982)

The primary influence of urbanization on basin morphometry is an alteration of drainage density, as natural conveyance features are ditched, channelized or replaced altogether by pipelines and 'end-of-pipe' stormwater management facilities. While this approach to stormwater management attempts to replicate the water quality and quantity function of headwater swales, it cannot address the form, habitat and sediment delivery aspects of a fluvial network. Stormwater management facilities are designed to mitigate flooding which typically implies a conservative design methodology which results not only in the removal of particulate matter or 'bad' sediment, but also the removal of 'good' sediment from the network. Frequently, this design technique also produces a moderating effect on the flow regime of the system by augmenting low flow conditions and reducing peak flows through attenuation.

Another important element of true headwater areas is the greater proportion of first order streams. A headwater area is found at the subwatershed divide. In this area, there will be more first order streams than further downstream in the watershed. This is one reason why headwater areas are referred to as production areas (ref. Figure 3.4.2). Given these channels, this area produces the energy (from rainfall and corresponding runoff) and sediment to drive the downstream sections.

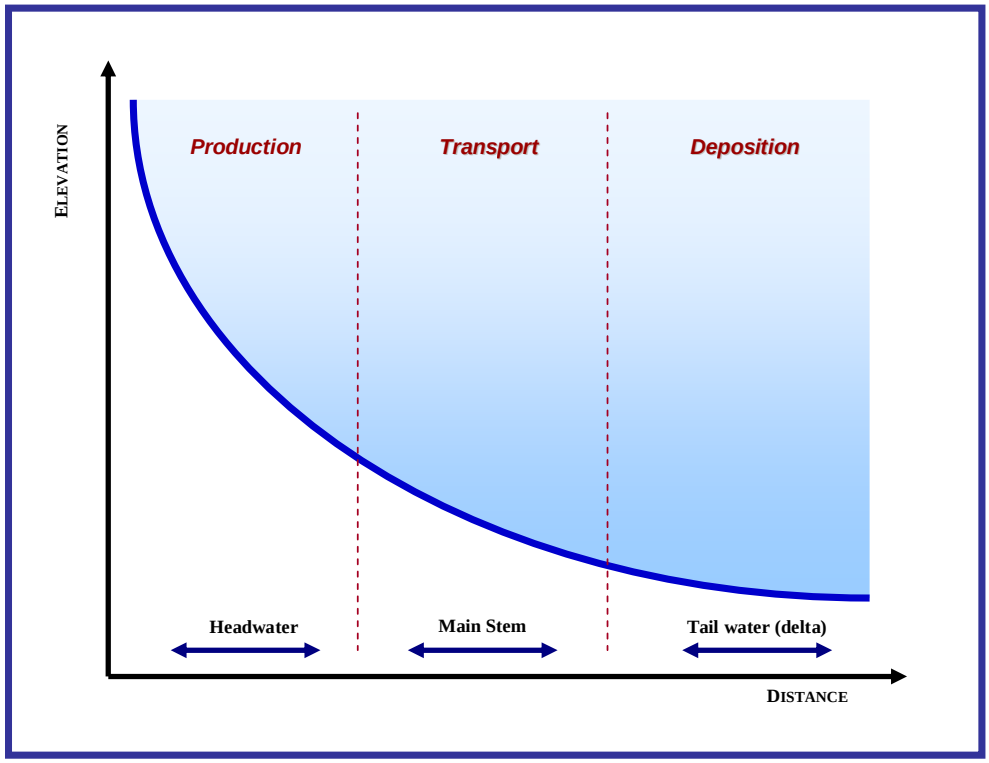

Figure 3.4.2:
Transition Zones along a Fluvial System (modified from Schumm, 1977).

A detailed fluvial geomorphological study was undertaken within the Milton Subwatershed Update Study lands, in order to assess the potential impacts of the proposed development on the streams. The study inventoried and characterized the local channel systems. It also included a specific focus on headwater channels, since the majority of the study area was comprised of a headwater drainage network. The morphology of the headwater portion of a drainage network provides an indication of the hydrological and sedimentological behaviour of the overall system.

Therefore, an understanding of headwater systems should facilitate any subsequent assessment of the lower branches within the subwatershed.

The headwater field sites consisted of two small groups of low-order channels located in Milton Business Park 2 (Figure 3.4.3). Each site consists of two first order swales that feed into a second order channel. Two monitoring transects with two sediment traps per transect were installed on each swale and the channel, and a pressure transducer was installed at the downstream limit of each site. Sediment traps were installed flush with the bed to minimize disturbance to flow and bedload transport, and were emptied after large precipitation events. Sediment traps were also installed on each bank adjacent to in-stream locations to assess the source of sediment in the channel. Longitudinal profiles of all channels were completed to determine local gradients and monitoring adjustments in swale profile. All surveyed information was tied into a local temporary benchmark as a long-term control point.

The pressure transducer setup consisted of mounting pressure transducers inside a 50 mm diameter PVC pipe and wrapped with a non-woven geotextile to prevent excessive sediment accumulation around the sensor head; air vents were drilled into the top and bottom of the pipe to release internal pressure as the flow stage rose and fell. The pipe itself was attached to a 1 m wooden stake that was hammered into the bed and the sensor was positioned 10 cm below the channel invert inside of a plastic container to ensure accurate measurement of the lowest flow stages. Given the uncertainties associated with the flashy nature of the flow regimes for these systems, sensors were programmed to sample at 1 minute intervals to ensure high resolution data of the rise, peak and ebb of flows following a precipitation event. Spot flow measurements were taken to determine discharge under various flow stages for each site. This information can be used to develop stage-discharge relationships.

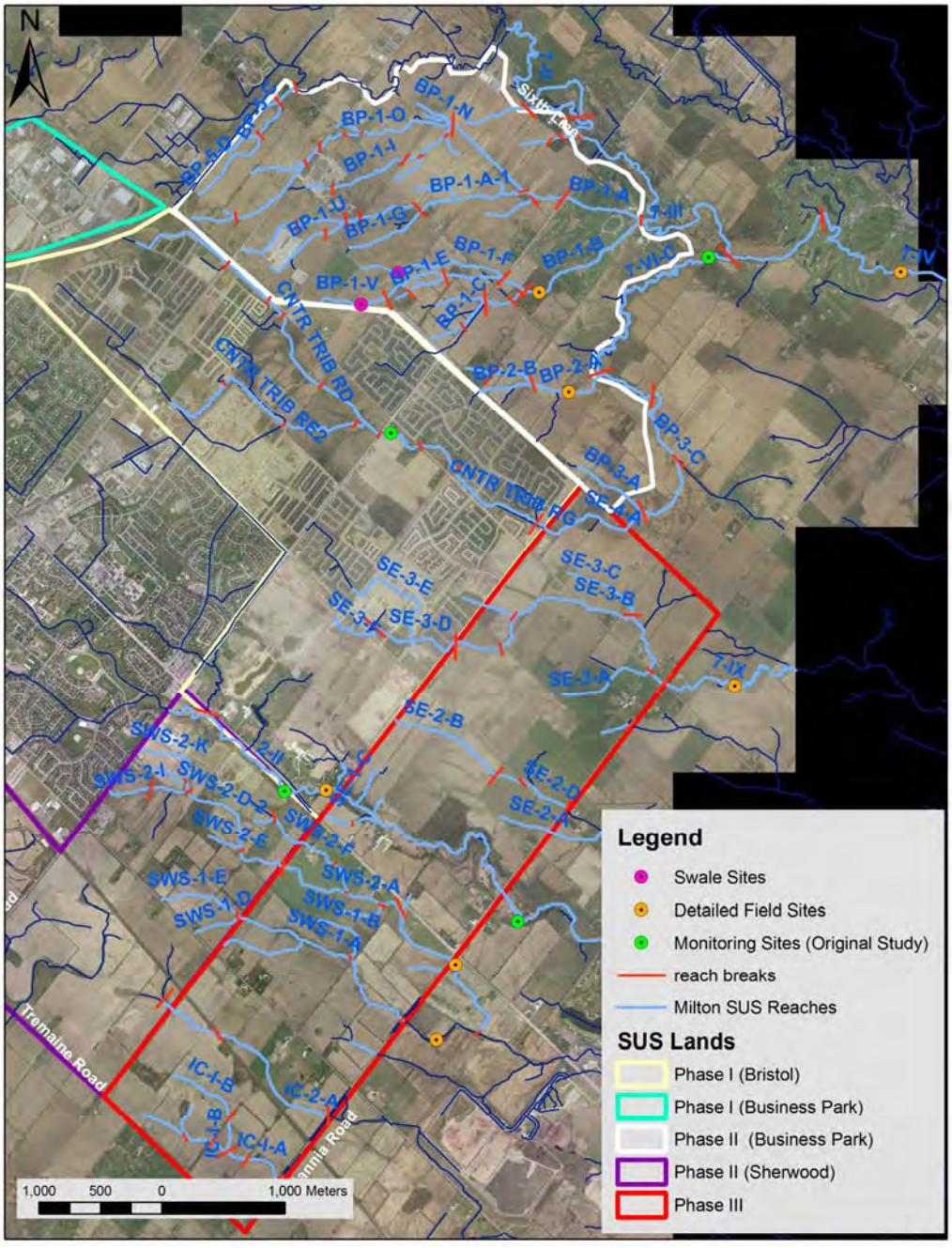

Figure 3.4.3:
Milton SUS Study Area and Field Site Locations.

3.4.3 Results

Rapid Assessments

Due to the extensive scale of the study area, the rapid assessment work concentrated on the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) lands. Upon covering these areas, supplemental work was undertaken to address the remaining Phase 1 and Phase 2 Sherwood lands. Figure 3.4.4 illustrates reaches walked within the study area, as well as their relative RGA condition as an indicator of overall channel stability. The results of the rapid assessment work indicate that the drainage characteristics of the Phase 2 Business Park and Phase 3 lands are typical of headwater systems within Southern Ontario, with the majority of drainage features characterized as swales (i.e., features lacking a defined bed and banks). The exceptions to this generalization were the portions of the west and central branches of Sixteen Mile Creek which flowed within the Business Park 2 and Phase 3 lands, in addition to selected higher order streams accumulating flows from the upstream swale features. In general, the low order streams were found to be stable or 'in regime', while the downstream sections of channel exhibited evidence of stress through active adjustment. Appendix 'F' provides a photographic record of general geomorphic conditions observed within each reach, while Table 3.4.1 provides a summary of the rapid assessment scoring results. The following sections provide a more detailed account of the rapid assessment results for the main branches of Sixteen Mile Creek within the study area.

2-II

Bankfull dimensions along Reach 2-II ranged from 11 to 20 m wide and 0.25 to 0.70 deep. The channel flowed through a well-defined valley system, with scrub forest dominating the riparian corridor, beyond which a mixture of agriculture and urban development represented the dominant forms of land use. Channel widening represented the prevailing geomorphic process, although evidence of degradation and planform adjustment were also observed. Fallen/leaning trees and extensive basal scour, in addition to exposed bridge footings, exposed underlying clay till and the formation of chutes and islands provided confirmation of these processes.

7-III

Bankfull dimensions along Reach 7-III ranged from 11 to 25 m wide and 0.5 to 1.0 m deep. Land use varied from a mixture of scrub meadow/forest and agriculture to manicured lawns associated with a golf course. Several sections of the reach displayed anomalously wide widths which may have been associated with channel disturbances that included road crossings, golf cart crossings and beaver dams. RGA results indicated that the reach was stressed or Transitional. The prevailing geomorphic processes affecting this reach were widening and aggradation, as evident through the formation of bars and a soft, unconsolidated bed, as well as basal scour and exposed tree roots. These results are consistent with the aforementioned channel disturbances.

7-IV

Bankfull dimensions along Reach 7-IV ranged from 11 to 29 m in width and 0.5 to 0.80 m in width. Similar to 7-III, land use varied from a mixture of scrub meadow/forest and agriculture to manicured lawns associated with the adjacent golf course. This reach was subject to extensive beaver activity, adding to the existing anthropogenic disturbances which included road crossings and numerous cart crossings. As a result, numerous sections of the channel had become over-wide. RGA results found the reach to be in a state of active adjustment which was taking the form of widening, aggradation and planform adjustment. Evidence of these processes included basal scour, exposed tree roots, siltation in pools, bar formation, island formation and re-working of bar deposits.

7-IX

Bankfull dimensions along Reach 7-IX were identified in the range of 4 to 6.5 m wide and 0.1 to 0.3 m deep although the channel itself was difficult to discern in sections. Substrate was consistent throughout the length of the reach, comprised of a mixture of clay, silt and sand and reflective of the underlying Halton Till. A dense vegetative buffer of tall herbaceous species and grasses surrounded the channel, with agriculture dominating the adjacent land use. Terrestrial vegetation was also present within the channel itself. RGA results found the stream to be stable or 'in regime' with only minor evidence of planform adjustment, widening and degradation in the form of poorly formed bars, basal scour and an overall lack of depositional features.

Phase 1 and 2 Lands

Rapid assessment work within the Phase 1 and 2 lands focused on tributaries to Sixteen Mile Creek draining the Phase 1 Bristol and Phase 2 Sherwood lands. Lands within the Phase I Bristol boundary have almost entirely undergone development although this development remains in various stages from complete to grading activities. As a result, only the tributaries along the southern extent of the Bristol lands remain unaffected. Reach SE-3-E has been replaced with a stormwater management pond, while Reaches SE-3-D and SE-3-F flow through newly established residential developments. Only portions of SE-3-B and SE-4-A have remained largely intact. Within the Phase 2 Sherwood Lands, none of the reaches appear to have been disturbed extensively to date by development activities. These reaches were largely characterized by undefined swales, with the exception of a portion of the western branch of Sixteen Mile Creek (reaches SWS-2-D-1 and SWS-2-D-2) which displayed a more defined watercourse with evidence of geomorphic processes.

Phase 1: Centre Tributary

Through the Milton SUS study, the Centre Tributary was walked in order to evaluate post-development conditions and channel performance. Results presented in Figure 3.4.4 indicate that all of the reaches constructed as part of the Bristol development were found to be stable or 'in regime'. Reaches A, B, B2, E, F2, F3 and G all exhibited minor evidence of aggradation, however, this is expected given that the site walks were conducted during low flow conditions where fine sediments tend to be stored temporarily within the watercourse. During higher flow events, it is expected that these materials would be transported downstream.

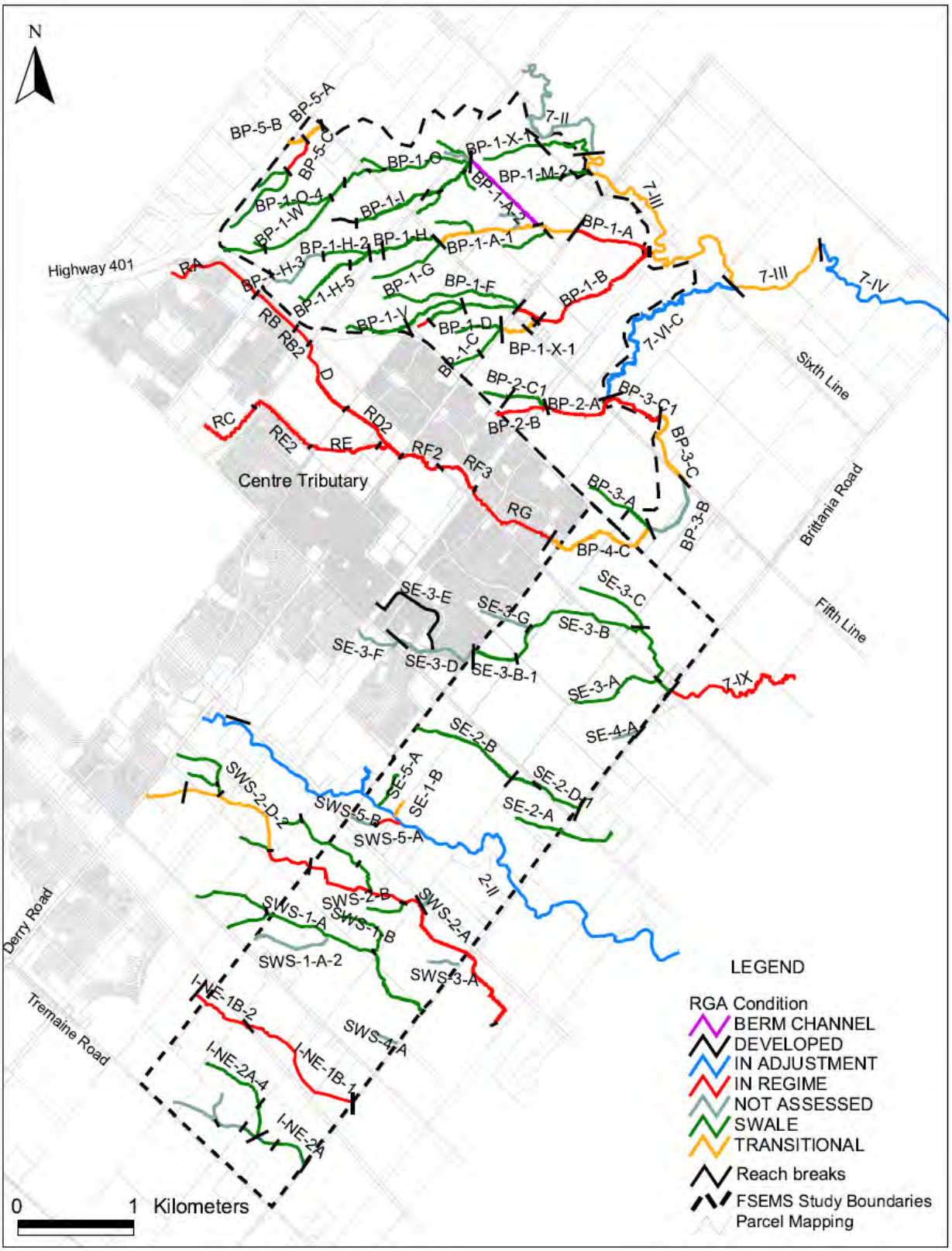

Figure 3.4.4:
Rapid geomorphic assessment results indicating channel stability on a reach basis.
(NB: for more detailed mapping of labelled reaches see Drawings 9 and 10)

Table 3.4.3: Rapid Assessment Results for the Study Area				
REACH	**RSAT SCORE**	**RSAT CONDITION**	**RGA SCORE**	**RGA CONDITION**
Outside-Phase 2 and 3				
7-III	25	MODERATE	0.36	TRANSITIONAL
7-IV	24	MODERATE	0.41	IN ADJUSTMENT
7-IX	17	LOW	0.14	IN REGIME
7-VI-C	20	MODERATE	0.46	IN ADJUSTMENT
CNTR TRIB RA	24.5	MODERATE	0.14	IN REGIME
CTR TRIB RB	21	MODERATE	0.06	IN REGIME
CNTR TRIB RB2	25.5	MODERATE	0.04	IN REGIME
CNTR TRIB RD	24	MODERATE	0	IN REGIME
CNTR TRIB RD2	22	MODERATE	0.04	IN REGIME
CNTR TRIB RC	23.5	MODERATE	0	IN REGIME
CNTR TRIB RE2	22.5	MODERATE	0.04	IN REGIME
CNTR TRIB RE	20.5	MODERATE	0.04	IN REGIME
CNTR TRIB RF	23	MODERATE	0	IN REGIME
CNTR TRIB RF2	23	MODERATE	0.09	IN REGIME
CNTR TRIB RF3	24.5	MODERATE	0.09	IN REGIME
CNTR TRIB RG	26.5	MODERATE	0.07	IN REGIME
BP-3-B	--	NOT ASSESSED	--	NOT ASSESSED
BP-3-C	26.5	MODERATE	0.38	TRANSITIONAL
BP-3-C1	13	LOW	0.13	IN REGIME
Derry Green (Phase 2)				
Tributary BP-1-A				
BP-1-A	11.5	LOW	0.06	IN REGIME
BP-1-A-1	18	LOW	0.22	TRANSITIONAL
BP-1-A-2	--	BERM CHANNEL	--	BERM CHANNEL
BP-1-A-3	--	SWALE	--	SWALE
BP-1-A-4		NOT ASSESSED		NOT ASSESSED
BP-1-A-5	--	SWALE	--	SWALE
BP-1-G	5	SWALE	0.04	SWALE
BP-1-H	10	SWALE	0.17	SWALE
BP-1-H-1	10	SWALE	0.17	SWALE
BP-1-H-2	18	SWALE	0.06	SWALE
BP-1-H-3	--	NOT ASSESSED	--	NOT ASSESSED
BP-1-H-4	16	SWALE	0.06	SWALE
BP-1-H-5	16	SWALE	0.06	SWALE
BP-1-I	9.5	SWALE	0.13	SWALE
BP-1-I-1	--	DEVELOPED	--	DEVELOPED
BP-1-L	13.5	SWALE	0.03	SWALE
BP-1-L-1	13.5	SWALE	0.03	SWALE
BP-1-L-2	13.5	SWALE	0.03	SWALE
BP-1-N	8.5	SWALE	0.04	SWALE
BP-1-O	8.5	SWALE	0.04	SWALE
BP-1-O-1	8.5	SWALE	0.04	SWALE
BP-1-O-2	8.5	SWALE	0.04	SWALE
BP-1-O-3	8.5	SWALE	0.04	SWALE
BP-1-O-4	8.5	SWALE	0.04	SWALE
BP-1-W	--	SWALE	--	SWALE
BP-1-W-1	--	SWALE	--	SWALE
BP-1-W-2	--	SWALE	--	SWALE
BP-1-Y	--	NOT ASSESSED	--	NOT ASSESSED

Table 3.4.3: Rapid Assessment Results for the Study Area				
REACH	**RSAT SCORE**	**RSAT CONDITION**	**RGA SCORE**	**RGA CONDITION**
Tributary BP-1-B				
BP-1-B	17.5	LOW	0.06	IN REGIME
BP-1-B-1	17.5	LOW	0.06	IN REGIME
BP-1-C-1	13.5	LOW	0.28	TRANSITIONAL
BP-1-C-2	16.5	LOW	0.25	TRANSITIONAL
BP-1-C-3	7	SWALE	0.06	SWALE
BP-1-C-4	8.5	SWALE	0.16	SWALE
BP-1-C-5	8.5	SWALE	0.16	SWALE
BP-1-D	18.5	SWALE	0.10	SWALE
BP-1-D-1	6	SWALE	0.04	SWALE
BP-1-F	10.5	SWALE	0.04	SWALE
BP-1-V	18.5	SWALE	0.10	SWALE
BP-1-V-1	18.5	SWALE	0.10	SWALE
Tributary BP-1-M				
BP-1-M	8	SWALE	0.04	SWALE
BP-1-M-1	8	SWALE	0.04	SWALE
BP-1-M-2	8	SWALE	0.04	SWALE
Tributary BP-1-X				
BP-1-X	11	SWALE	0.06	SWALE
BP-1-X-1	8.5	SWALE	0.06	SWALE
Tributary BP-2				
BP-2-A	15	LOW	0.15	IN REGIME
BP-2-B	8.5	SWALE	0.03	SWALE
BP-2-B-1	8.5	SWALE	0.03	SWALE
BP-2-C	18	LOW	0.10	IN REGIME
Tributary BP-3				
BP-3-A	13.5	SWALE	0.03	SWALE
Tributary BP-5				
BP-5-A	23	MODERATE	0.30	TRANSITIONAL
BP-5-B	23.5	MODERATE	0.32	TRANSITIONAL
BP-5-C	21.5	MODERATE	0.067	IN REGIME
BP-5-D	16.5	LOW	0.04	IN REGIME
BP-5-E	16.5	LOW	0.04	IN REGIME
Boyne (Phase 3) lands				
Tributary I-NE-2A				
I-NE-2A	14.5	SWALE	0.04	SWALE
I-NE-2A-1	14.5	SWALE	0.04	SWALE
I-NE-2A-2	14.5	SWALE	0.04	SWALE
I-NE-2A-3	16.5	SWALE	0.07	SWALE
I-NE-2A-4	16.5	SWALE	0.07	SWALE
Tributary I-NE-IB				
I-NE-1B-1	13	LOW	0.04	IN REGIME
I-NE-1B-2	13	LOW	0.04	IN REGIME
Tributary SWS-1				
SWS-1-A	12	LOW	0.26	TRANSITIONAL
SWS-1-A -2	9	SWALE	0.06	SWALE
SWS-1-B	--	SWALE	--	SWALE
Tributary SWS-2				
SWS-2-A	14.5	LOW	0.04	IN REGIME
SWS-2-B		SWALE		SWALE
SWS-2-C	13.5	SWALE	0.04	SWALE

Table 3.4.3: Rapid Assessment Results for the Study Area				
REACH	**RSAT SCORE**	**RSAT CONDITION**	**RGA SCORE**	**RGA CONDITION**
2-II				
2-II	27	MODERATE	0.46	IN ADJUSTMENT
SWS-5-A	10.5	LOW	0.19	IN REGIME
SWS-5-B		NOT ASSESSED		NOT ASSESSED
SE-5-A	--	SWALE	--	SWALE
SE-1-B	12	LOW	0.26	TRANSITIONAL
Tributary SE-2				
SE-2-A	--	SWALE	--	SWALE
SE-2-B	14	SWALE	0.04	SWALE
SE-2-D-1	15	SWALE	0.04	SWALE
SE-2-D-2	15	SWALE	0.04	SWALE
Tributary SE-3				
SE-3-A	11	SWALE	0.04	SWALE
SE-3-B	14.5	SWALE	0.10	SWALE
SE-3-B-1	14.5	SWALE	0.10	SWALE
SE-3-C	--	SWALE	--	SWALE
SE-3-G	--	NOT ASSESSED	--	NOT ASSESSED
Tributary SE-4				
SE-4-A	--	NOT ASSESSED	--	NOT ASSESSED
BP-4-C				
BP-4-C	24	MODERATE	0.25	TRANSITIONAL

Detailed Field Investigation

The results of the field assessment indicate that the landscape of the Milton SUS lands is dominated by two distinct geomorphic zones: the Sixteen Mile Creek valley lands and the headwaters of Sixteen Mile Creek and Indian Creek. The Sixteen Mile Creek main branches are characterized by permanently flowing channels situated within a defined valley setting. The remaining portions of the study area, meanwhile, are typical of headwater systems with numerous undefined drainage features carrying surface runoff downstream to the main branches of Sixteen Mile and Indian Creek. These features display moderate gradients and fine boundary materials characteristic of the underlying Halton Till Plain.

Results of the detailed geomorphic fieldwork meanwhile are summarized in Table 3.4.4, with a detailed account of geomorphic parameters for each site provided in Appendix 'F'. Pebble count and bank material characterization are both indicative of the Halton Till parent materials, generally dominated by clay, silts and very fine sands. Average bankfull dimensions, meanwhile, were typical of a headwater environment, with larger depths and widths restricted to the main branches of Sixteen Mile Creek.

Table 3.4.4: Channel Characteristics for the Detailed Geomorphic Field Sites							
Parameter	**BP-I-B**	**BP-2-A**	**R2-II**	**R7-IV**	**R7-IX**	**SWS-I-AI**	**SWS-2-AI**
Bankfull Width (m)	4.62	3.87	14.2	16.7	5.14	0.97	1.73
Bankfull Depth (m)	0.24	0.17	0.42	0.70	0.18	0.15	0.19
Average Bankfull Gradient (%)	0.75	0.47	0.23	0.09	0.13	1.25	0.34
Bed Material D_{50} (cm)	0.015	0.001	0.85	0.55	0.0002	0.035	0.0007
Bed Material D_{84} (cm)	0.56	0.09	5.96	5.7	0.0029	2.51	0.014
Bank Materials	Cl/Silt	N/A	Si/cl/fs	Cl/vcs/si	Cl/si/vfs	Si/fs	Si/vfs

Monitoring

Monitoring of the six detailed field sites established as part of this study was conducted between fall 2007 and fall 2008. These sites have been re-visited a minimum of two times, including re-measurement of control cross-sections as well as erosion pins. In the case of site BP-2-A, bank heights were insufficient to allow installation of erosion pins. At this site, only cross-sectional measurements have been provided. Results of the monitoring are presented in Appendix 'F', which indicates that the average absolute percent change in cross-sectional area over the monitoring period ranged from 0.01 to 4.14%, with site SWS-1-A-1 displaying the least amount of change, while site SWS-2-A-1 showed the greatest degree of adjustment. All of the data presented, however, are well within the range of natural rates of geomorphic adjustment and error associated with repeated measurements. In some cases (SWS-2-A-1, BP-2-B, R7-IX) this adjustment was in the form of aggradation, while others (SWS-1-A-1, BP-1-B) the trend was towards erosion through a combination of incision and widening.

Erosion pin results confirm the findings of the cross-section monitoring, indicating an overall range in absolute erosion rates of 1.30 to 3.49 cm/yr within the study area. These translate to 100 year erosion rates of 13.0 to 34.9 mm which are also well within natural rates of channel adjustment. Reach R7-IX showed the greatest rate of change; although it took the form of aggradation. Reaches R7-IV and BP-1-B indicated minor rates of erosion.

Watershed Science Centre EMP - Geomorphic Component

An Environmental Monitoring Plan (EMP) was developed by the Watershed Science Centre (WSC), Trent University, in order to fulfill the Terms of Reference (TOR) for the Phase 1 Development Area of the Town of Milton Urban Expansion Project. Through this EMP, monitoring activities were conducted during the 2003, 2004 and 2005 field seasons. The following section summarizes the findings of the geomorphic monitoring component presented in the EMP report submitted by the WSC for the Milton Urban Expansion study area.

Installation of Erosion Pins

Erosion pins were installed at five locations throughout the Phase 1 (Bristol Survey) Area in the summer of 2004 where future erosion was thought to be possible. These pins were inserted upstream, downstream and at the area of concern. However, due to an error in the GPS coordinates provided to the 2005 field crew, none of the erosion pins could be located. The error has since been located and corrected, and attempts were to be made to locate and re-measure these pins in the future. To date, however, no erosion pin monitoring information has been put forward.

Monitoring Channel Cross-Sections at Previously Established Sites

Although an initial attempt was made by the WSC to re-locate long-term monitoring stations established by Parish Geomorphic Ltd. as part of the original Subwatershed Study, these stations were not found. Consequently the initial installation of control cross-sections occurred in 2004. Subsequent to their installation, it was determined that the cross-sections had not

been properly identified. As such, subsequent data collection was not conducted in the same locations. Instead, stream cross-sections were surveyed at 4 new sites in 2005 that were estimated to be in the immediate proximity of sites surveyed, and two additional sites were surveyed as well. These sites are deemed to be representative of the reach, including riffles and pools if possible, or areas of special interest, such as undercuts and places of evident erosion. Five cross-sections were surveyed at each site, perpendicular to the stream's thalweg.

Channel gradients were generally greater for the 16 Mile Creek and East 16 Mile Creek sites than reaches along the Centre Tributary in the Phase One Area. The stream channel for both Reach D below the railway crossing and Reach F upstream of Clark Street had been reconstructed; however, while the Reach D gradient was the same as the planned gradient for the reconstructed channel, the measured Reach F gradient immediately upstream of Clark Street was roughly twice as great as the planned average gradient of 0.002. Channel width at the sites on 16 Mile Creek and East 16 Mile Creek contrasted markedly with the narrow stream widths for the Centre Tributary. The exception was Reach D on the Centre Tributary, where widths were much wider than those measured for Reach F. This may have reflected potential backwater effects on this reach of the Centre Tributary noted above. There may have been impoundment of water between this reach and that of Reach F at Derry Road, which resulted in larger stream widths in Reach D. Channel cross-sections at the extensively-restored Reach D also showed a regular form not exhibited at the restored Reach F section upstream of Clark street or at the unrestored Reach F section at Derry Road. Monitoring results for the WSC geomorphic cross-sections was not provided in the EMP report.

Re-establishment of Monitoring Channel Cross-Sections

In October 2008, Parish Geomorphic Ltd. re-established the long-term monitoring stations established both through the original Subwatershed Study, and through subsequent efforts by the Watershed Science Centre. The location of these sites was determined through a combination of available mapping, GPS coordinates and insight from PARISH staff responsible for the original field effort. In some cases, the location of the monitoring site was modified slightly because the original location had been modified by development or channel design work. Appendix 'F' provides a detailed account of each monitoring location, including cross-sections, GPS coordinates and a photographic inventory. Eight monitoring sites were re-established on Sixteen Mile Creek from the original Subwatershed Study and three additional sites identified through the Watershed Science Centre work were also re-established.

Headwater Form and Function

BP-I-F

Results of the headwater field investigation of Site BP-I-F have been provided in Appendix 'F'. Site BP-I-F is located directly west of Fifth Line, north of Derry Road (Figure 3.4.5). The site itself consisted of two first order features draining into a second order swale, with two control cross-sections and sediment traps associated with each feature. Average top of bank widths ranged from 1.15 to 1.23 m, while depths averaged 0.11 to 0.12 m. While the site was originally established in April of 2008, with monitoring occurring in May, agricultural tilling of the land resulted in the need to completely re-establish all cross-sections and sediment traps in June of

2008. Subsequent to this re-installation, monitoring was conducted through to October of 2008 (six site visits). Preliminary monitoring results indicate that the overall trend within the first and second order swales is sediment production. This observation is consistent with the function of headwater systems. Percent change in cross-sectional area ranged from -2.3 to 1.62%. Only Transect 4 (1st Order) and Transect 6 (1st Order) were reported as exhibiting an overall trend of erosion (sediment production). While this trend, initially, appears counter-intuitive, the baseline cross-sectional dimensions were established during particularly wet conditions in June, which could have skewed the results. Moreover, these sites are extremely sensitive to seasonal fluctuations which may or may not be reflected by the overall percent change in cross-sectional area. Further complicating matters, the surrounding lands were being actively farmed throughout the sampling season making it difficult to separate the influence of overland sources of sediment.

BP-I-V

Results of the headwater field investigation of Site BP-I-V have been provided in Appendix 'F'. Site BP-I-V is located directly north of Derry Road, near James Snow Parkway (Figure 3.4.5). The site itself consisted of two first order features draining into a second order swale, with two control cross-sections and sediment traps associated with each feature. Average top of bank widths ranged from 1.18 to 1.49 m, while depths averaged 0.05 to 0.09 m. While the site was originally established in April of 2008, with monitoring occurring in May, agricultural tilling of the land resulted in the need to completely re-establish all cross-sections and sediment traps in June of 2008. Subsequent to this re-installation, monitoring has been conducted through to October of 2008 (six site visits). Monitoring results indicated that overall percent change in cross-sectional area ranged from 0.48 to 15.8%, indicating a consistent trend towards erosion (sediment production). Within this overall trend, seasonal variations in cross-sectional area indicated a general pattern towards erosion during late spring, deposition during the summer months, and subsequent erosion during the fall as flow event volumes and frequency increased.

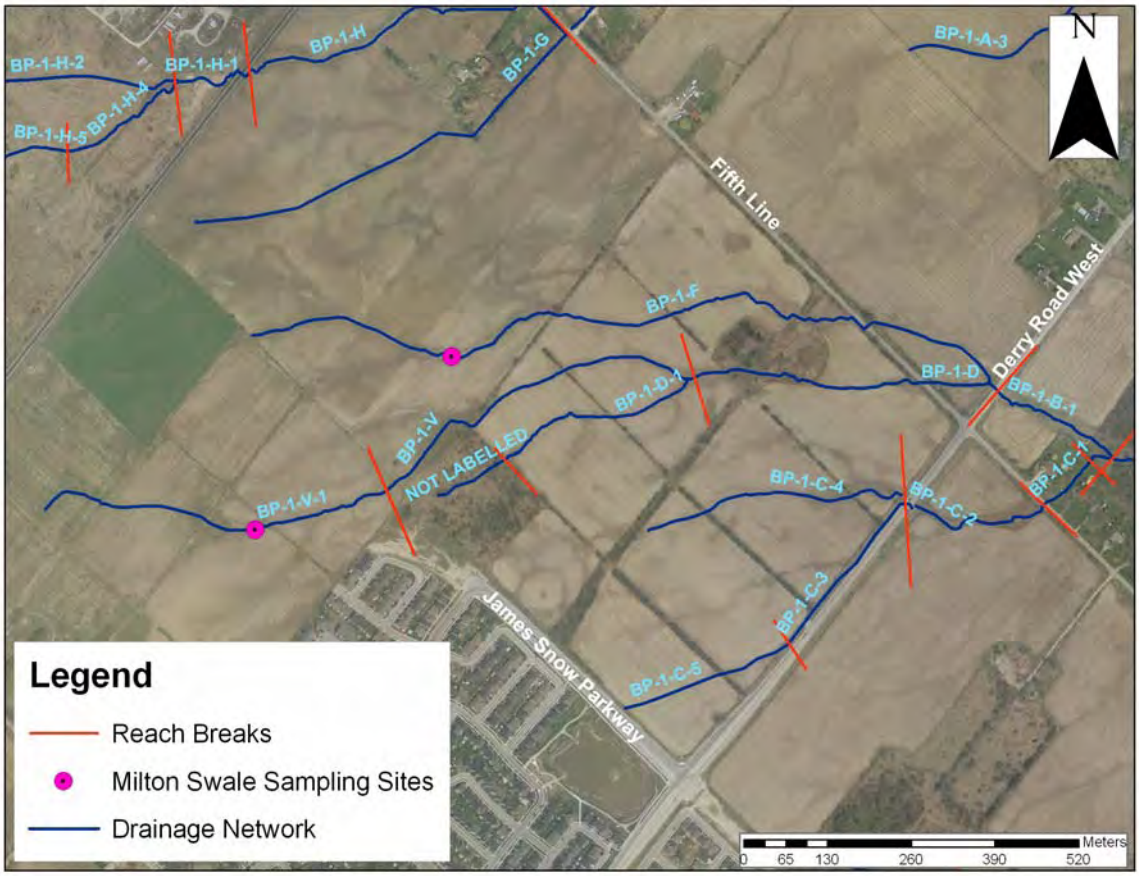

Figure 3.4.5: Location of Milton Swale Sampling Sites.

3.4.4 Analysis

Historic Assessment

In order to document changes in land use and planform adjustment over time, a historical assessment was undertaken, with the aid of aerial photographs from 1954 and 1983, in addition to digital imagery from 2008. This assessment also quantified migration rates, where possible, for the different reaches, to account for channel migration over the likely planning timeframe. Typically, these rates would be quantified using aerial photographs dating back to 1954. However, due the lack of available physical aerial photographs from that period, photographs dating back to 1983 were used instead. Tributaries were grouped together for the sake of simplicity.

The results of the historical assessment show that land use in Phase 1 (Bristol Survey) was dominated by agricultural land, with patches of forest visible in several locations, in 1954. By 1983, much of the land had been converted for urban and residential purposes. This trend continued on to 2008, with only a few sections remaining undeveloped. At least one of the reaches shows a stormwater pond nearby as well. Land use in Phase 1 (Business Park) was also dominated by agriculture in 1954. In 1983, some urban development was observed, with Highway 401 visible, and some other commercial development, but the area was still largely

agricultural. Some rivers flowing through here had been re-routed to allow for this development. The urbanizing trend continued on to 2008.

Land use in Phase 2 (Business Park) was dominated by agricultural land, in 1954. There were several locations where rivers flowed through forests, and many other forested areas were visible on the landscape. In 1983, the landscape was still dominated by agriculture, but many of the forests had been clear-cut. Residential buildings sprouted up in a few locations, and a golf course is conspicuously present in the area. Also, a power generation facility had begun operations near the northern limit of the area. In 2008, the land was still dominated by fields, but a yard, thought to be used for storage of hydro poles, is visible near the power generation facility, along with some increase in the size of the residential area. Land use in Phase 2 (Sherwood) was similarly dominated by agricultural land in 1954, with the north-eastern edge bordering the Town of Milton. The land use remained largely the same, in 1983, the main changes occurring in Milton, nearby. This was the case in 2008 as well, with the Town starting to expand into the area.

Land use in Phase 3 was dominated by agriculture as well, in 1954. A portion of Sixteen Mile Creek flows through this area, with the creek bounded by forests in several sections. In 1983 and 2008, the landscape was still dominated by agriculture, but some residential buildings were observed near the channel in a few locations, in 1983, and more in 2008. Some of the forests had been clear cut to allow this development to take place.

Table 3.4.5 highlights the findings of the historical assessment which quantified lateral migration rates for the identified study reaches. Migration rates ranged from 0.02 to 0.18 m/yr for the reaches in the study area. The streams with lower migration rates can be said to be more stable, and of lower geomorphic risk, while the opposite would be true for those reaches with higher migration rates.

Table 3.4.5: Average Migration Rates for Creeks in the Study Area

Reaches	Absolute Mean Lateral Migration Rate (m/yr)
BP-4-C (and tributaries)	0.10
BP-3-A – BP-2-B-1	0.12
BP-1-B – BP-1-C-1	0.05
BP-1-A – BP-1-5	0.18
7-VI-C	0.14
BP-1-N-1 – BP-1-L	0.02
7-II	0.03
SWS-1-A – SWS-1-A-2	0.17
SWS-2-A – SWS-2-D1	0.11
2-II	0.18
SE-2-A – SE-2-B	0.04
SE-3-A – SE-3-C	0.03

Meander Belt Width

For the purposes of this study, meander belt widths were developed from a geomorphological perspective on a broad scale and, as such, should be subject to refinement during the FSEMS and SIS stage. This would also determine whether the meander belt width represents the constraining parameter for watercourse extent relative to the Regulatory floodline or ecological considerations. It should be noted that stream corridors were only designated for those reaches displaying defined bed and banks. 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., 2001). Within a subwatershed context, studies require the general identification of meander belt widths to facilitate the planning process.

Figure 3.4.6a and 3.4.6b illustrate meander belt widths delineated on a reach basis using digital mapping for the undeveloped portion of the study area.

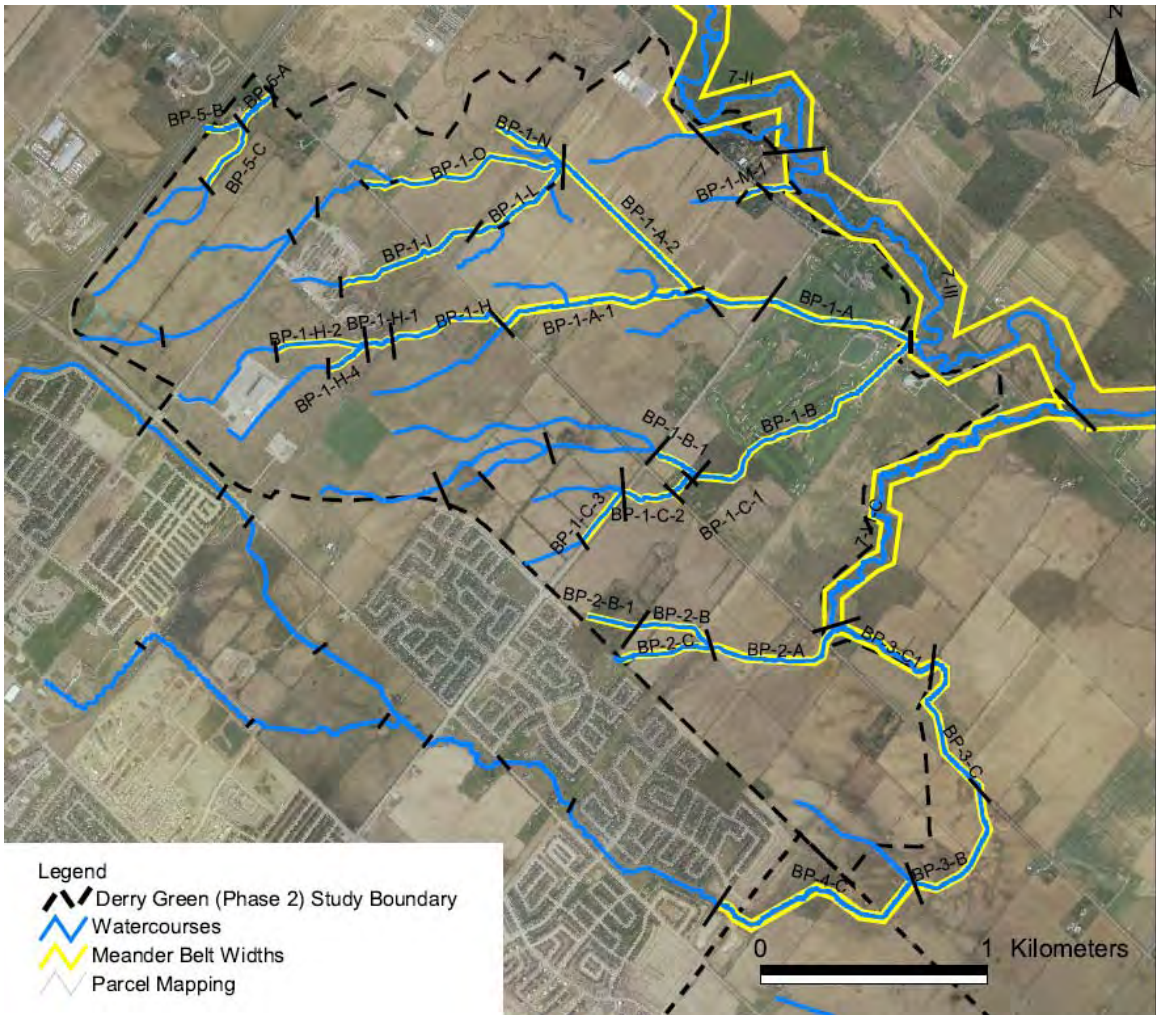

Figure 3.4.6a: Meander Belt Width delineation for the Derry Green (Phase 2) lands (only defined for reaches of Medium Geomorphological Constraint and above – ref. Section 3.4.5)

Figure 3.4.6b: Meander Belt Width delineation for the Boyne Survey (Phase 3) lands (only defined for reaches of Medium Geomorphological Constraint and above – see Section 3.4.5)

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. For confined channels, the meander belt width is generally defined by parallel lines drawn parallel to the central valley trend of the reach. The meander belt width does not refer to the bottom of valley width. A channel was considered confined if it displayed a well-defined valley with valley wall heights greater than or equal to 2 m. Because the belt width has distinct, linear boundaries, instances can occur where the belt width captures the majority of the river valley but may extend into the valley in isolated areas as the valley undulates back and forth while maintaining a consistent center line trend. In the majority of cases, the meander belt width for a channel is smaller than the flood plain for unconfined systems. When alterations to the flood plain occur (e.g. filling), the flood plain becomes smaller and the meander belt width can become the constraining parameter for watercourse extent.

Table 3.4.6 indicates the meander belt width for each reach within the study area, as well as an additional erosion setback component (ref. Figure 3.4.7). Due to the broad-scale nature of this Subwatershed Update Study, in lieu of calculating the 100 year migration rate for each reach, a factor of safety was generally calculated as 20% of the meander belt width (10% on either side of the meander belt width). Additional valley configurations are presented in Appendix 'F'.

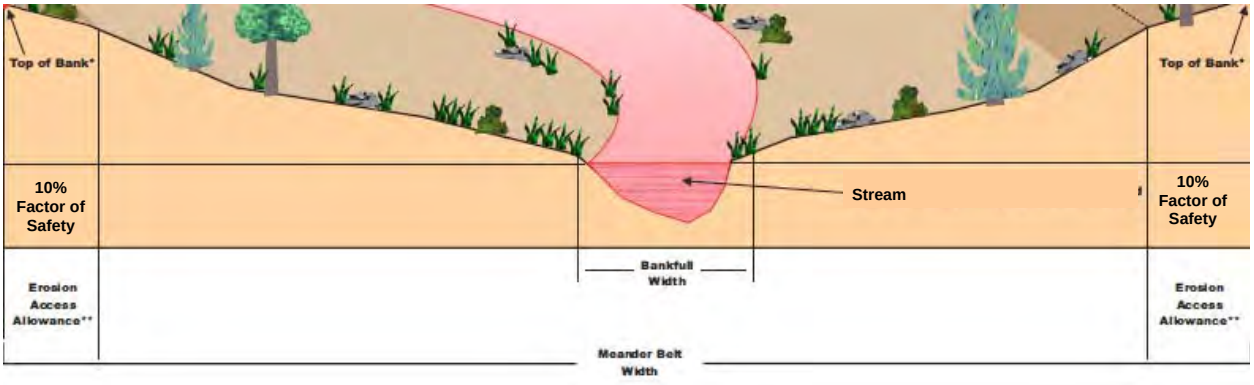

Figure 3.4.7: Schematic showing meander belt width and erosion setback allowance (10% factor of safety)

Table 3.4.6: Meander Belt Widths on a Reach Basis for Creeks in the Study Area			
Reach	**Belt Width (m)**	**10% Factor of Safety Either Side of Channel**	**Final Belt Width (m)**
Outside Phase 2 and 3			
7-II	120.0	12.0	144.0
7-III	150.0	15.0	180.0
7-IV	140.0	14.0	168.0
7-VI-C	65.0	6.5	78.0
Derry Green (Phase 2)			
BP-1-A	20.0	2.0	24.0
BP-1-A-1	25.0	2.5	30.0
BP-1-A-2	20.0	2.0	24.0
BP-1-B	16.0	1.6	19.2
BP-1-B-1	16.0	1.6	19.2
BP-1-C-1	16.0	1.6	19.2
BP-1-C-2	16.0	1.6	19.2
BP-1-C-3	16.0	1.6	19.2
BP-1-H	16.0	1.6	19.2
BP-1-H-1	16.0	1.6	19.2
BP-1-H-2	15.0	1.5	18.0
BP-1-H-4	15.0	1.5	18.0
BP-1-I	15.0	1.5	18.0
BP-1-L	15.0	1.5	18.0
BP-1-M	15.0	1.5	18.0
BP-1-M-1	15.0	1.5	18.0
BP-1-N	15.0	1.5	18.0
BP-1-O	15.0	1.5	18.0
BP-2-A	20.0	2.0	24.0
BP-2-B	15.0	1.5	18.0
BP-2-B-1	15.0	1.5	18.0
BP-2-C	16.0	1.6	19.2
BP-3-B	20.0	2.0	24.0
BP-3-C	20.0	2.0	24.0
BP-3-C1	35.0	3.5	42.0
BP-5-A	15.0	1.5	18.0
BP-5-B	15.0	1.5	18.0
BP-5-C	15.0	1.5	18.0
Boyne (Phase 3)			
2-II	100.0	10.0	120.0
SWS-2-A	25.0	2.5	30.0
BP-4-C	28.0	2.8	33.6

N.B. It should be noted that Conservation Halton requires an additional 15 m setback from greatest hazard for major valley systems or 7.5 m for minor valley systems, respectively. This setback includes a 6 m erosion access allowance. Sixteen Mile Creek and Bronte Creek, along with all of their associated tributaries, are considered major valley systems within Conservation Halton's regulatory policy documentation. Setbacks are to be in public control, in accordance with Conservation Halton recommendations and Town of Milton practices.

Erosion Thresholds

While it is acknowledged that water quality and water quantity are integral components of any proposed stormwater management strategy, so too is erosion control. Stormwater flows need to be controlled and released in such a manner that existing channel erosion or aggradation is not exacerbated by the land use change. This is accomplished through the incorporation of erosion thresholds within the stormwater management approach. For the purposes of this project, erosion thresholds were determined based on the following steps:

1. The most sensitive (or less stable) reach within representative portions of the study area were identified through the Rapid Field Assessment work.
2. Detailed field work was then completed along each of these reaches to a suitable level of resolution to be representative of field conditions and permit a range of hydraulic analyses to be completed.
3. The erosion thresholds were then selected through the application of a suite of analytical techniques including, but not limited to, substrate and bank shear stress and permissible velocity. The actual threshold value was selected based, in part, on technical experience as well as being representative of the field conditions.

Table 3.4.7 presents the erosion thresholds quantified for the study area (Figure 3.4.8). In all cases, a comparison between the critical and bankfull discharge indicates that the bed is likely fully mobilized around bankfull flows. This implies that sediment can be entrained below bankfull flows and that any increase in discharge within these systems may lead to increased sediment transport and would likely exacerbate natural rates of channel erosion.

Table 3.4.7: Flow Characteristics Estimated for the Detailed Geomorphic Field Sites

Parameter	BP-I-B	BP-2-A	R2-II	R7-IV	R7-IX	SWS-I-A-I	SWS-2-A-I
Average Bankfull Width (m)	4.62	3.87	14.2	16.7	5.14	0.97	1.73
Average Bankfull Depth (m)	0.24	0.17	0.42	0.70	0.18	0.15	0.19
Manning's 'n'*	0.028	0.028	0.035	0.035	0.036	0.033	0.033
Bankfull Discharge (m^3/s)	1.46	0.37	4.60	12.29	0.42	0.19	0.52
Average Bankfull Velocity (m/s)	0.87	0.56	0.68	0.59	0.31	0.83	0.56
Maximum Bankfull Velocity (m/s)	1.59	0.89	0.91	1.06	0.51	1.43	0.94
Average Shear Velocity (m/s)	0.13	0.08	8.83	0.09	0.05	0.12	0.08
Stream Power (W/m)	107.65	17.02	103.84	108.51	5.32	22.88	17.49
Maximum Shear Stress (N/m^2)	37.99	13.18	11.52	11.20	4.55	31.82	13.48
Critical Discharge (m^3/s)	0.47	0.16	1.73	1.84	0.03	0.06	0.10
Critical Velocity (m/s)	1.35	0.80	0.62	0.70	0.31	0.98	0.66

* Based on visual estimate

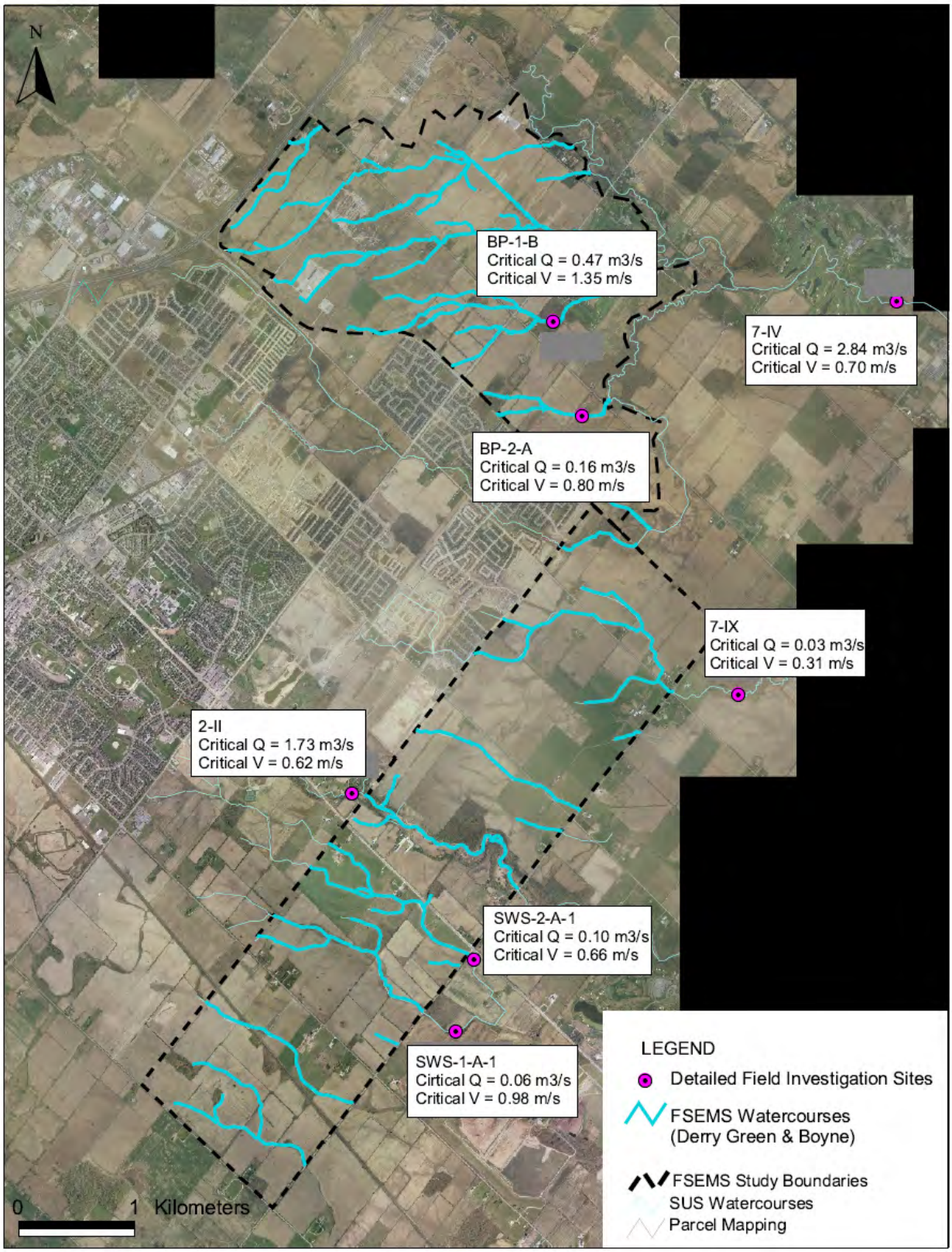

Figure 3.4.8: Erosion Thresholds Quantified for the Milton SUS Lands.

Geomorphic Interpretation of Results

In general the geomorphic findings of this study are consistent with the original work completed for Sixteen Mile Creek Subwatersheds Areas 2 & 7. In essence, there is a dichotomy of form and process between the small, low order tributaries of Sixteen Mile and Indian Creeks and the main branches of Sixteen Mile Creek. Within the small, low order tributaries (as well as the constructed reaches of the Centre Tributary), the overall trend is towards stable systems which exhibit minor evidence of aggradation due to the fine nature of the overburden sediments in this area. The main branches of Sixteen Mile Creek, meanwhile, tend to represent sediment production (erosion) zones. These reaches have incised down to the elevation of the underlying shale geology and currently exhibit evidence of widening as these systems continue to adjust. This overall trend is complicated by extensive disturbances in the form of beaver activity and stream crossings.

3.4.5 Assessment

Geomorphic Constraint Ranking

The role of the stream corridors is multipurpose from a geomorphic standpoint. It not only provides flow and sediment storage during high flow events, it also acts as a filter to prevent sediment and particulate inputs from surface runoff from embedding coarse substrates within the streams. The maintenance of riparian vegetation within the stream corridor acts to stabilize banks and also provides inputs of organic materials and debris which aid in creating a diverse morphology. The meander belt width incorporated into the corridor allows the channel to migrate naturally within its floodplain without the loss of property or structural integrity. For the purposes of this study, a constraint ranking system was developed based on the findings of the desktop and field assessments. The constraint system identifies three categories of high, medium and low constraint which essentially establish the preferred management approach of the stream on a reach basis from a geomorphic perspective. Figure 3.4.9 summarizes the geomorphic constraint rankings on a reach bases for the study area. The basis for each category of geomorphic constraint has been provided below:

1. High Geomorphic Classification: These corridors contain a defined channel with a well-developed channel morphology (i.e., riffle-pool) and/or a well-defined valley. These corridors offer both form and function and have been identified as ‘no touch’ reaches that must be maintained undisturbed in their present condition. They have been deemed high-quality systems that could not be re-located and replicated in a post-development scenario.

2. Medium Geomorphic Classification: These reaches may or may not have a well-defined morphology (form) but do maintain geomorphic function and have potential for rehabilitation. In many cases, these reaches are presently exhibiting evidence of geomorphic instability or environmental degradation due to historic modifications and land use practices. Management options for these reaches include the following:

a. Do nothing: leave the corridors in their present condition and develop outside of their boundaries.
b. Enhance existing conditions: maintain the present location of the corridor but enhance the existing conditions (e.g. bank stabilization, re-establish a meandering planform, connect channel to functioning floodplain).
c. Re-locate and enhance existing conditions: many of the reaches within the study area have undergone extensive straightening and modification for agricultural drainage purposes. As such, they are not as sensitive to re-location and would benefit from enhancements such as the re-establishment of a meandering planform with functioning floodplain and development of a riffle-pool morphology. In the event that these reaches are re-located, the corridor width associated with each reach must, at a minimum, be maintained.

3. Low Geomorphic Classification: these reaches consist of ephemeral headwater systems that lack defined bed and banks (form) but do perform a geomorphic function through the conveyance of flow and sediment. Management options for these reaches include the following:
   a. Do nothing: leave the drainage feature intact and develop the surrounding lands, with a minimal buffer (i.e., a corridor width is not prescribed for these systems).
   b. Combination of stormwater management and open conveyance techniques: the function of headwater streams can be mimicked through the combined implementation of stormwater management techniques with sufficient maintenance of open conveyance systems such as backyard swales to meet drainage density targets. A corridor width is not prescribed for these systems.
   c. Open conveyance techniques: the function of the ephemeral swales is replicated entirely through a system of open conveyance techniques (e.g. backyard swales). A corridor width is not prescribed for these systems.

The study process entails the integration of data between the various study disciplines in support of the development of a Management Strategy for the Milton SUS lands. The following tasks have been identified from a geomorphic perspective:

- Establish constraint rankings for the Milton SUS lands on a reach basis;
- Refine corridor width mapping to reflect overall constraint rankings;
- Establish drainage density targets on a sub-catchment basis for the Milton SUS lands; and
- Develop a Management Strategy for the Natural Heritage System.

Further details are offered in Section 4 and 7, as well as the governing FSEMS documents for Boyne Survey and Derry Green.

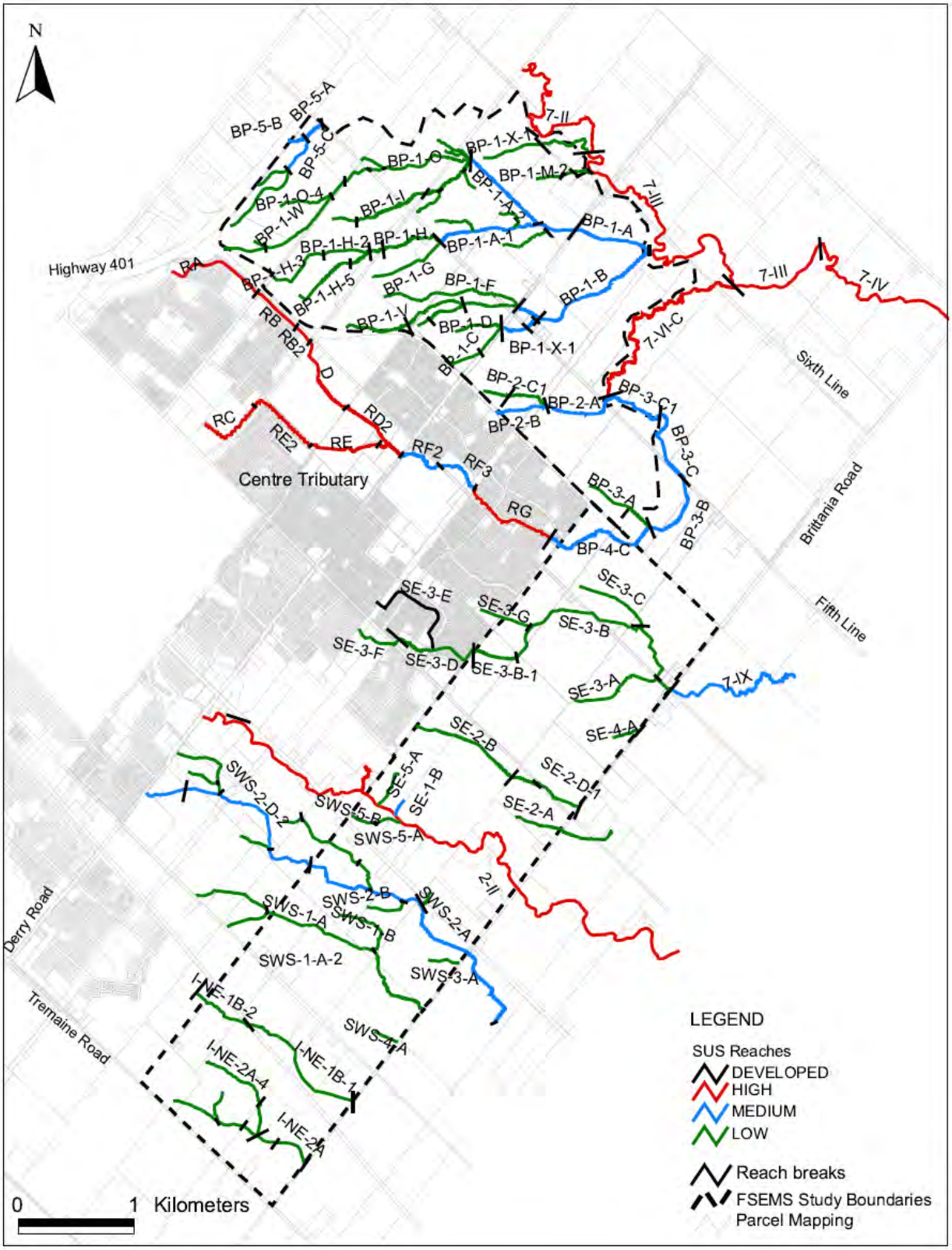

Figure 3.4.9: Geomorphic Constraint Rankings for the Milton SUS Lands.

3.5 Fisheries/Benthics

3.5.1 Scope/Purpose

The watercourses within the Business Park 2 (Derry Green) and Phase 3 (Boyne Survey) were examined to update their condition since the field work undertaken in 1998 and 1999 as part of the original Subwatershed Study, and to reclassify them using interim guidelines for the evaluation, classification and management of headwater drainage features, released by CVC and Toronto and Region Conservation in March, 2007, and updated in March, 2009 (ref. CVC and TRCA, March 2009, Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines). The document describes four main classes of aquatic habitat and provides protection, conservation and mitigation targets for each.

3.5.2 Methods

The classes of headwater drainage features (CVC and TRCA, March 2009) are as follows:

1. Permanent - Provides direct habitat onsite (e.g. feeding, breeding, and/or migration) as a result of year round groundwater discharge and/or permanent standing surface water within a storage feature (i.e. ponds, wetlands, refuge pools, etc.). Habitat may be either existing or potential (i.e. isolated by a barrier). Permanent habitat also may include critical fish habitat (i.e. habitat that is limited in supply, essential to the fish life cycle, and generally habitat that is not easily duplicated or created). Hydrogeological studies and/or water balance calculations may be required to confirm groundwater contributions, as appropriate, with regard to the scale of the development application(s).

2. Seasonal - Provides limited direct habitat onsite (e.g. feeding, breeding, migration and/or refuge habitat), as a result of seasonally high groundwater discharge or seasonally extended contributions from wetlands or other surface storage areas that support intermittent flow conditions, or rarely ephemeral flow conditions. Occasionally, limited permanent refuge habitat may be identified within seasonal habitat reaches.

3. Contributing - Provides indirect (contributing) habitat to downstream reaches – functions generally increase with flow and/or as flows move downstream with increasing length of channel or channel density (e.g. extent of contributing area). There are two types of contributing habitat:

i) Complex contributing habitat – generally as a result of intermittent (or less commonly ephemeral) surface flows, can have marginal sorting of substrates – generally well vegetated features that influence flow conveyance, attenuation, storage, infiltration, water quality, sediment, food (invertebrates) and organic matter/nutrients (i.e. there are two types of nutrients, e.g. dissolved nutrients, and course/fine matter). Generally, two structural types: a) defined features with natural bank vegetation consisting of forest, scrubland/thicket or meadow (as defined in OSAP or ELC); or b) poorly defined features (swales) typically distinguished by hydrophilic vegetation.

ii) Simple contributing habitat – generally as a result of ephemeral (or less commonly intermittent) surface flows – generally not well-vegetated features that influence flow conveyance, attenuation, storage, infiltration, water quality and sediment transport.

Generally two types: a) defined features characterized by crop cultivation, mowing or no vegetation; or b) poorly defined features (swales) may contain terrestrial vegetation.

4. *Not Fish Habitat* - The pre-screened drainage feature has been field verified to confirm that no features and/or functions associated with headwater drainage features is present – generally characterized by no definition or flow, no groundwater seepage or wetland functions, and evidence of cultivation, furrowing, presence of a seasonal crop, lack of natural vegetation, and fine textured soils (i.e. clay and/or silt).

5. *Recharge Zone* - Coarse-textured soils described as sand and/or gravel have been confirmed through field verification; majority of potential flow will be infiltrated. These features may have ill-defined channels as a relic of past flows; however the key function is groundwater recharge and maintenance of downstream aquatic functions via groundwater connections to streams. No direct fish habitat or indirect contributions through surface flow conveyance, allochthonous or sediment transport provided.

During the late summer/early fall of 2007 headwater drainage features were examined to determine the upstream extent of flow and standing water. Of particular interest was how the dry conditions in 2007 compared to the conditions in the summer of 1998, also a fairly dry year, when the field work for the Subwatershed Study (Phase 3 and Business Park 2 areas) was conducted. In contrast, 2008 was a relatively wet year when the bulk of field investigations for the SUS were conducted.

Drainage features in the Phase 3 and Business Park 2 areas were examined on April 14, 15, and 16, 2008, with staff from Conservation Halton (Jennifer Wilson) and Fisheries and Oceans Canada (Jody Wingfield). The extent of permanent fish habitat was reasonably well defined, based on the September 2007 field investigations and the earlier subwatershed studies. Therefore the April 14 – 16, 2008 field investigations focussed on headwater features that were upstream of permanent fish habitat. The drainage features were classified in the field, using the criteria described in the aforementioned guidelines (2007 version), based on the observed flow and channel conditions and the participants' knowledge of conditions from previous investigations. Digital photographs, georeferenced using a handheld GPS, were taken at representative locations.

Electrofishing was conducted at six locations in the Phase 3 and Business Park 2 areas, identified as locations of interest during the earlier field investigations, on April 18, 2008. Two additional sites were electrofished on July 7, 2008. In all cases a single pass was made through the reach with a Halltech backpack electrofisher.

LGL Limited provided data from fish sampling that was conducted in the Phase 3 study area by their staff in 2007 and 2008 (Ken Glasbergen, Personal communication, October 2008) and additional data were available from sampling conducted by C. Portt and Associates in 2005. All historic fish sampling data on file with Conservation Halton were also examined.

Three sites were selected as potential future monitoring sites. Two of these were electrofished on October 22, 2008, while the third was not electrofished because it was nearly dry and had clearly been dry during the summer based on the terrestrial vegetation that was present.

Benthic invertebrate samples were collected, following the Ontario Benthic Bio-monitoring Protocol, at the one site where the watercourse was flowing.

On April 16, 2009, an additional watercourse that is included in Business Park 2 area, but is immediately north of Subwatershed 7 within Subwatershed 3, was examined and characterized. On April 15, 2010, all watercourses within the study area that cross Britannia Road, Sixth Line, and Derry Road between Fifth and Sixth Lines, were examined. The two Indian Creek watercourses that originate within the study area and cross Britannia Road between Tremaine Road and First Line, were examined at selected locations downstream of Britannia Road with representatives of the Town of Milton, Conservation Halton, and Fisheries and Oceans Canada, on May 7, 2010.

Based on the observations made during the field investigations and the additional fish sampling data that were available, a draft classification of the headwater drainage features was prepared. This draft classification was presented to and discussed with Conservation Halton (Jennifer Wilson) and Fisheries and Oceans Canada (Jody Wingfield) staff on July 10, 2008, and minor modifications were made to reflect the most current knowledge.

3.5.3 Results

Figure 3.5.1 shows which stream reaches in the Phase 3 and Business Park 2 areas that were flowing or contained standing water, or were dry, in September of 2007. It is considered highly unlikely, but it is possible, that standing water (i.e. a pool in a farm culvert) may have been present between two dry reaches. It was assumed, during the preparation of the map, that if flow was present at two locations then the watercourse was flowing through the entire reach between those two locations. Generally, the conditions in September, 2007, with respect to the presence of flow and standing water, were very similar to those observed in the late summer of 1998, when the field work for the subwatershed study was conducted. The principal difference was that the duration of flow has been extended in a number of the watercourses originating in the Phase 1 area. In some cases, it appears that flow is now permanent in watercourses that were intermittent prior to development in the Phase 1 area, based on the fact that the watercourses were flowing in September of 2007.

The drainage features classification for the Phase 3 and Business Park 2 areas, resulting from all field investigations conducted over 2007 to 2010, is presented in Figure 3.5.2. A subset of watercourse reaches, classified as “Permanent” and “Seasonal”, were identified which had a high potential to benefit from habitat rehabilitation. Photographs of representative or key locations are provided in Appendix ‘G’. The results of fish sampling conducted by C. Portt and Associates staff during this study and during an audit of the interim condition in the centre tributary in 2005 (ref. Aquafor Beech Limited and C. Portt and Associates, 2005) are presented in Table 3.5.1, and the results of fish sampling by LGL Limited in 2007 and 2008 are presented in Table 3.5.2. The corresponding sampling locations are shown in Figure 3.5.3. Fish sampling data from other sources, on file with Conservation Halton are presented in Table 3.5.3, and the corresponding sampling locations are shown in Figure 3.5.4. The fish communities and habitats in each of the major branches in the Phase 3 and Business Park 2 areas are summarized for each branch below.

Figure 3.5.1: Reaches of watercourses that were flowing or where standing water was present (blue), or that were dry (light brown) in the autumn of 2007. The Phase 1 urban expansion lands are shown with a yellow border.

Results of fish collections within or adjacent to the Milton Phase 3 and Business Park #2 lands conducted by C. Portt and Associates. Station locations are provided in Figure 3.5.3. Stations BA1-BA6 were collected during the Bristol Survey audit in 2005. Stations CP1-CP11 were collected during the present study in 2008.

Table 3.5.1: Fish Sampling Summary (ref. Aquafor Beech Limited and C. Portt and Associates, 2005)

Station	BA1	BA2	BA3	BA4	BA5	BA6	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11
Date (d/m/y)	**19/7/05**	**19/7/05**	**19/7/05**	**19/7/05**	**19/7/05**	**19/7/05**	**18/4/08**	**18/4/08**	**15/4/08**	**18/4/08**	**18/4/08**	**7/7/08**	**7/7/08**	**18/4/08**	**18/4/08**	**22/10/08**	**22/10/08**
Number of fish species collected	2	4	2	3	4	1	0	1	1	1	0	5	1	1	2	0	5
pumpkinseed (*Lepomis gibbosus*)	40	5	37	2	5							21			1		
fathead minnow (*Pimephales promelas*)	4	YOY 500+	11	YOY 45	YOY 37	YOY 500+		1		4				1			2
brown bullhead (*Ameiurus nebulosus*)		1										5					
brook stickleback (*Culaea inconstans*)		1							✓								1
common carp (*Cyprinus carpio*)				1											4 (koi)		
creek chub (*Semotilus atromaculatus*)					1							2					1
goldfish (*Carassius auratus*)					1												
largemouth bass (*Micropterus salmoides*)												1					
white sucker (*Catostomus commersonii*)												YOY 13	YOY 1				2
bluntnose minnow (*Pimephales notatus*)																	3

Results of electrofishing collections within or adjacent to the Milton Phase 3 and Business Park #2 lands conducted by LGL Limited in 2007 and 2008. Station locations are provided in Figure 3.5.3. A check mark indicates that one individual of that species was captured. For stations at which two collection attempts were made, but fish were found on only one attempt, the date on which fish were collected is indicated.

Table 3.5.2: Fish Sampling Summary (ref. LGL Limited 2007 and 2008)

Station	LGL1	LGL2	LGL3	LGL4	LGL5	LGL6	LGL7	LGL8	LGL9
Dates (d/m/y)	**6/6/07 23/4/08**	**23/4/08**	**6/6/07 23/4/08**	**23/4/08**	**6/6/07 23/4/08**	**23/4/08**	**6/6/07 24/4/08**	**23/4/08**	**24/4/08**
Number of fish species collected	1	0	1	0	1	0	1	0	0
Approximate length of watercourse fished	690 m	unknown	1200 m	unknown	unknown	586 m	703 m	375 m	1250 m
pumpkinseed , (*Lepomis gibbosus*)									
fathead minnow, (*Pimephales promelas*)							✓2008		
brook stickleback, (*Culaea inconstans*)	✓2007				✓2007				
creek chub , (*Semotilus atromaculatus*)			✓2008						
white sucker , (*Catostomus commersonii*)									

Table 3.5.2: Fish Sampling Summary (ref. LGL Limited 2007 and 2008) Con't

Station	LGL10	LGL11	LGL12	LGL13	LGL14	LGL15	LGL16	LGL17	LGL18	LGL19
Date (d/m/y)	**24/4/08**	**6/6/07 24/4/08**	**24/4/08**	**6/6/07 24/4/08**	**24/4/08**	**6/6/07 24/4/08**	**24/4/08**	**6/6/07 24/4/08**	**23/4/08**	**7/6/07 23/4/08**
Number of fish species collected	0	0	1	0	1	1	0	0	4	0
Approximate length of watercourse fished	1075 m	420 m	unknown	860 m (2008 only)	unknown	850 m	160 m	620 m	unknown	1565 m
Pumpkinseed, (*Lepomis gibbosus*)									5	
fathead minnow, (*Pimephales promelas*)			✓						2	
brook stickleback, (*Culaea inconstans*)					✓					
creek chub, (*Semotilus atromaculatus*)						✓2008			6	
white sucker, (*Catostomus commersonii*)									3	

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4. Shaded species are likely misidentifications and may not occur in the study area.

Table 3.5.3: Fish Sampling Summary from Conservation Halton Files

Station	B-35	B-36	B-37	B-37	B-97	S-25	S-25	S-25	S-26	S-26	S-26	S-35
Date (d/m/y)	20/11/01	20/11/01	16/8/79	20/11/01	20/11/01	9/7/73	1975	26/5/99	4/7/73	1975	26/5/99	25/6/73
Number of fish species collected	3	3	8	4	0	5	4	10	4	3	5	14
alewife (*Alosa pseudoharengus*)												1
black crappie (*Pomoxis nigromaculatus*)												
blacknose dace (*Rhinichthys atratulus*)						4		12	2		2	
bluntnose minnow (*Pimephales notatus*)	✓	✓		✓								
brook stickleback (*Culaea inconstans*)												
brown bullhead (*Ameiurus nebulosus*)												
carps and minnows (Cyprinidae)								1				
common carp (*Cyprinus carpio*)												
common shiner (*Luxilus cornutus*)			16					16		✓		8
creek chub (*Semotilus atromaculatus*)		✓	3			4		32	7			
fantail darter (*Etheostoma flabellare*)								1				1
fathead minnow (*Pimephales promelas*)	✓							1				8
golden redhorse (*Moxostoma erythrurum*)												
goldfish (*Carassius auratus*)												
johnny darter (*Etheostoma nigrum*)			1	✓								1
largemouth bass (*Micropterus salmoides*)												
longnose dace (*Rhinichthys cataractae*)						18	✓	22	23	✓	61	3
river or hornyhead chub (*Nocomis* sp.)								27			7	
northern hog sucker (*Hypentelium nigricans*)			2									5
northern pike (*Esox lucius*)												
pumpkinseed (*Lepomis gibbosus*)	✓	✓	1									✓
rainbow darter (*Etheostoma caeruleum*)				✓		4	✓	9		✓	1	11
rainbow trout (*Oncorhynchus mykiss*)												
river chub (*Nocomis micropogon*)							✓					11
rock bass (*Ambloplites rupestris*)			5								1	8
rosyface shiner (*Notropis rubellus*)												6
sea lamprey (*Petromyzon marinus*)												
silver shiner (*Notropis photogenis*)												
smallmouth bass (*Micropterus dolomieu*)			2				✓	1				3
stonecat (*Noturus flavus*)						1						
striped shiner (*Notropis chrysocephalus*)												
white sucker (*Catostomus commersonii*)			1	✓					2			3
yellow bullhead (*Ameiurus natalis*)												

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4. Shaded species are likely misidentifications and may not occur in the study area.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-35	S-38	S-38	S-67	S-68	S-68	S-68	S-69	S-69	S-69	S-75	S-79
Date (d/m/y)	22/8/84	22/6/73	15/8/05	11/6/75	1957	11/6/75	14/8/98	2/7/75	5/8/98	6/6/01	1979	23/8/84
Number of fish species collected	10	10	10	7	1	7	10	7	9	1	8	10
black crappie (*Pomoxis nigromaculatus*)												
blacknose dace (*Rhinichthys atratulus*)	✓		2									
bluntnose minnow (*Pimephales notatus*)	✓		26	✓		✓	9		1			✓
brook stickleback (*Culaea inconstans*)												
brown bullhead (*Ameiurus nebulosus*)							2	✓				
carps and minnows (Cyprinidae)												
common carp (*Cyprinus carpio*)						✓			1	✓		
common shiner (*Luxilus cornutus*)	✓	7		✓		✓			27		✓	✓
creek chub (*Semotilus atromaculatus*)		4									✓	✓
emerald shiner (*Notropis atherinoides*)												✓
fantail darter (*Etheostoma flabellare*)	✓	3									✓	✓
fathead minnow (*Pimephales promelas*)									37			
golden redhorse (*Moxostoma erythrurum*)							4					
goldfish (*Carassius auratus*)												
johnny darter (*Etheostoma nigrum*)			1				17		17		✓	
largemouth bass (*Micropterus salmoides*)			2				2	✓				
longnose dace (*Rhinichthys cataractae*)	✓	2	6									
river or hornyhead chub (*Nocomis* sp.)												
northern hog sucker (*Hypentelium nigricans*)		8		✓		✓		✓				✓
northern pike (*Esox lucius*)			1									
pumpkinseed (*Lepomis gibbosus*)						✓	16		5			
rainbow darter (*Etheostoma caeruleum*)	✓	3	1				1					✓
rainbow trout (*Oncorhynchus mykiss*)												
river chub (*Nocomis micropogon*)	✓	11		✓							✓	✓
rock bass (*Ambloplites rupestris*)	✓	2	4		✓	✓	3	✓	6			✓
rosyface shiner (*Notropis rubellus*)		1		✓		✓					✓	
sea lamprey (*Petromyzon marinus*)												
silver shiner (*Notropis photogenis*)												
smallmouth bass (*Micropterus dolomieu*)	✓						1	✓	1		✓	✓
stonecat (*Noturus flavus*)	✓	1	1	✓								
striped shiner (*Notropis chrysocephalus*)												
white sucker (*Catostomus commersonii*)			4	✓			16	✓	8		✓	
yellow bullhead (*Ameiurus natalis*)								✓				

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4. Shaded species are likely misidentifications and may not occur in the study area.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-79	S-103	S-103	S-103	S-103	S-110	S-110	S-112	S-115	S-132	S-133	S-134	S-141	S-149
Date (d/m/y)	1984	10/8/92	16/8/05	15/09/09	27/07/11	14/9/93	11/8/05	14/9/93	14/9/93	17/5/96	1996	17/5/96	1973	31/12/84
Number of fish species collected	7	15	9	6	4	5	6	7	5	4	1	3	1	8
black crappie (*Pomoxis nigromaculatus*)														
blacknose dace (*Rhinichthys atratulus*)		270	1					✓						
bluntnose minnow (*Pimephales notatus*)	✓		1							1				✓
brook stickleback (*Culaea inconstans*)										8				
brown bullhead (*Ameiurus nebulosus*)		28						✓						
carps and minnows (Cyprinidae)		56												
common carp (*Cyprinus carpio*)							1							
common shiner (*Luxilus cornutus*)	✓							✓						
creek chub (*Semotilus atromaculatus*)		2			1			✓	✓	35		14		
emerald shiner (*Notropis atherinoides*)	✓					✓	19							
fantail darter (*Etheostoma flabellare*)														✓
fathead minnow (*Pimephales promelas*)														
golden redhorse (*Moxostoma erythrurum*)														
goldfish (*Carassius auratus*)				1										
johnny darter (*Etheostoma nigrum*)		2		1	58				✓					
largemouth bass (*Micropterus salmoides*)							2							
longnose dace (*Rhinichthys cataractae*)		1182	87	49				✓					✓	✓
river or hornyhead chub (*Nocomis* sp.)														
ninespine stickleback (*Pungitius pungitius*)		2												
northern hog sucker (*Hypentelium nigricans*)	✓	4	1			✓	4							
northern pike (*Esox lucius*)														
pumpkinseed (*Lepomis gibbosus*)		1					1		✓	3	2	1		
rainbow darter (*Etheostoma caeruleum*)		46	11					✓						✓
rainbow smelt (*Osmerus mordax*)		55												
rainbow trout (*Oncorhynchus mykiss*)		2												
river chub (*Nocomis micropogon*)	✓		8	1										✓
rock bass (*Ambloplites rupestris*)	✓					✓	2		✓					✓
rosyface shiner (*Notropis rubellus*)														
sea lamprey (*Petromyzon marinus*)														
silver shiner (*Notropis photogenis*)														
smallmouth bass (*Micropterus dolomieu*)	✓	10	1			✓		✓						✓
spottail shiner (*Notropis hudsonius*)						✓								
stonecat (*Noturus flavus*)		12	10	5	5		1							✓
striped shiner (*Notropis chrysocephalus*)														
white sucker (*Catostomus commersonii*)		92	2	6	6				✓			1		
yellow bullhead (*Ameiurus natalis*)														

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-155	S-158	S-160	S-160	S-161	S-163	S-164	S-165	S-166	S-172	S-177	S-177
Date (d/m/y)	8/9/05	30/7/98	1957	05/8/98	05/8/98	29/7/98	29/7/98	29/7/98	29/7/98	9/10/05	29/7/98	30/9/02
Number of fish species collected	12	13	3	12	7	1	1	7	1	1	2	1
black crappie (*Pomoxis nigromaculatus*)				1								
blacknose dace (*Rhinichthys atratulus*)												
bluntnose minnow (*Pimephales notatus*)	7	1		10	3			✓				
brook stickleback (*Culaea inconstans*)						✓	✓	✓			✓	31
brown bullhead (*Ameiurus nebulosus*)												
carps and minnows (Cyprinidae)									✓	10		
common carp (*Cyprinus carpio*)				2								
common shiner (*Luxilus cornutus*)	7	1						✓				
creek chub (*Semotilus atromaculatus*)	13		✓		1			✓			2	
fantail darter (*Etheostoma flabellare*)	17	14										
fathead minnow (*Pimephales promelas*)								✓				
golden redhorse (*Moxostoma erythrurum*)												
goldfish (*Carassius auratus*)												
johnny darter (*Etheostoma nigrum*)	3	32		17				✓				
largemouth bass (*Micropterus salmoides*)												
longnose dace (*Rhinichthys cataractae*)		4		1	2							
river or hornyhead chub (*Nocomis* sp.)												
northern hog sucker (*Hypentelium nigricans*)	1	8		4								
northern pike (*Esox lucius*)												
pumpkinseed (*Lepomis gibbosus*)		2		1				✓				
rainbow darter (*Etheostoma caeruleum*)	18	11		1	7							
rainbow trout (*Oncorhynchus mykiss*)												
river chub (*Nocomis micropogon*)	3											
rock bass (*Ambloplites rupestris*)	25	32	✓	8								
rosyface shiner (*Notropis rubellus*)		4			3							
sea lamprey (*Petromyzon marinus*)			✓									
silver shiner (*Notropis photogenis*)												
smallmouth bass (*Micropterus dolomieu*)	3	6		3	3							
stonecat (*Noturus flavus*)	4	1		1	2							
striped shiner (*Notropis chrysocephalus*)												
white sucker (*Catostomus commersonii*)	13	19		2								
yellow bullhead (*Ameiurus natalis*)												

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-178	S-179	S-205	S-205	S-216	S-216	S-216	S-216	S-216	S-216	S-216	S-216	S-217	S-218	S-236
Date (d/m/y)	29/7/98	5/8/98	19/7/06	3/7/07	14/8/98	11/8/05	31/7/06	4/7/07	07/07/08	30/07/09	29/06/11	30/07/13	14/8/98	14/8/98	14/8/98
Number of fish species collected	1	0	12	13	10	10	10	11	9	9	10	10	9	2	2
black crappie (*Pomoxis nigromaculatus*)			1												
blacknose dace (*Rhinichthys atratulus*)					✓	7		4			8	2			
bluntnose minnow (*Pimephales notatus*)				2									✓		
brook stickleback (*Culaea inconstans*)	✓		7							1					
brown bullhead (*Ameiurus nebulosus*)															
carps and minnows (Cyprinidae)								56							
common carp (*Cyprinus carpio*)															
common shiner (*Luxilus cornutus*)				2	✓	1	2			18	2		✓		
creek chub (*Semotilus atromaculatus*)			2	5	✓	20	7	17	18	49	4	5			✓
fantail darter (*Etheostoma flabellare*)			10	22			1		2	2	4	1			
fathead minnow (*Pimephales promelas*)															
golden redhorse (*Moxostoma erythrurum*)															
goldfish (*Carassius auratus*)									1						
johnny darter (*Etheostoma nigrum*)			3	1									✓		
largemouth bass (*Micropterus salmoides*)				9	✓	2	1	4							
longnose dace (*Rhinichthys cataractae*)			2	5	✓	12	32	17	50	108	57	40	✓	✓	
river or hornyhead chub (*Nocomis* sp.)															
northern hog sucker (*Hypentelium nigricans*)					✓	5	1	3					✓		
northern pike (*Esox lucius*)															
pumpkinseed (*Lepomis gibbosus*)			1						2		1	2			
rainbow darter (*Etheostoma caeruleum*)			37	27	✓	3	9	11	38	44	10	11	✓		
rainbow trout (*Oncorhynchus mykiss*)									1					✓	
river chub (*Nocomis micropogon*)			1	3	✓	21	11	19	35	7	13	16			
rock bass (*Ambloplites rupestris*)			42	16			2						✓		
rosyface shiner (*Notropis rubellus*)															
sea lamprey (*Petromyzon marinus*)															
silver shiner (*Notropis photogenis*)															
smallmouth bass (*Micropterus dolomieu*)				1				2				1			
stonecat (*Noturus flavus*)			3	4	✓	8	9	8		3	3	4	✓		
striped shiner (*Notropis chrysocephalus*)															
white sucker (*Catostomus commersonii*)			3	7	✓	8		4	10	10	1	1	✓		✓
yellow bullhead (*Ameiurus natalis*)															

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-237	S-238	S-239	S-239	S-239	S-239	S-239	S-240	S-241	S-242	S-254	S-395	S-412
Date (d/m/y)	14/8/98	14/8/98	14/8/98	30/07/07	09/09/10	18/09/11	23/09/12	14/8/98	14/8/98	14/8/98	26/6/01	17/6/03	25/6/04
Number of fish species collected	4	1	5	7	5	2	4	2	1	3	1	1	6
black crappie (*Pomoxis nigromaculatus*)													
blacknose dace (*Rhinichthys atratulus*)													
bluntnose minnow (*Pimephales notatus*)				✓									
brook stickleback (*Culaea inconstans*)			✓	✓	112	41	11		✓	✓			
brown bullhead (*Ameiurus nebulosus*)													6
carps and minnows (Cyprinidae)											✓		
common carp (*Cyprinus carpio*)													
common shiner (*Luxilus cornutus*)													
creek chub (*Semotilus atromaculatus*)	✓		✓	✓	24	19	17			✓			7
fantail darter (*Etheostoma flabellare*)													5
fathead minnow (*Pimephales promelas*)	✓	✓	✓	✓	110		1	✓					
golden redhorse (*Moxostoma erythrurum*)													
goldfish (*Carassius auratus*)													
johnny darter (*Etheostoma nigrum*)													
largemouth bass (*Micropterus salmoides*)				✓									1
longnose dace (*Rhinichthys cataractae*)													17
river or hornyhead chub (*Nocomis* sp.)													
northern hog sucker (*Hypentelium nigricans*)													
northern pike (*Esox lucius*)													
pumpkinseed (*Lepomis gibbosus*)	✓		✓	✓	8		1	✓					
rainbow darter (*Etheostoma caeruleum*)													
rainbow trout (*Oncorhynchus mykiss*)													1
river chub (*Nocomis micropogon*)													
rock bass (*Ambloplites rupestris*)													
rosyface shiner (*Notropis rubellus*)													
sea lamprey (*Petromyzon marinus*)													
silver shiner (*Notropis photogenis*)													
smallmouth bass (*Micropterus dolomieu*)													
stonecat (*Noturus flavus*)													
striped shiner (*Notropis chrysocephalus*)													
white sucker (*Catostomus commersonii*)	✓		✓	✓	15					✓		100	
yellow bullhead (*Ameiurus natalis*)													

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-416	S-488	S-489	S-490	S-491	S-492	S-493	S-494	S-495	S-496	S-497	S-510	S-511
Date (d/m/y)	18/9/08	8/8/13	8/8/13	8/8/13	8/8/13	8/8/13	8/8/13	8/8/13	8/8/13	8/8/13	5/9/13	13/9/13	13/9/13
Number of fish species collected	10	2	1	2	3	1	2	2	2	1	1	4	2
black crappie (*Pomoxis nigromaculatus*)													
blacknose dace (*Rhinichthys atratulus*)													
bluntnose minnow (*Pimephales notatus*)													
brook stickleback (*Culaea inconstans*)													
brown bullhead (*Ameiurus nebulosus*)													
carps and minnows (Cyprinidae)	1												
common carp (*Cyprinus carpio*)													
common shiner (*Luxilus cornutus*)	1	12	8	14	3		3		2			✓	✓
creek chub (*Semotilus atromaculatus*)	1				1								
fantail darter (*Etheostoma flabellare*)	29												
fathead minnow (*Pimephales promelas*)													
golden redhorse (*Moxostoma erythrurum*)													
johnny darter (*Etheostoma nigrum*)													
goldfish (*Carassius auratus*)													
largemouth bass (*Micropterus salmoides*)	1												
longnose dace (*Rhinichthys cataractae*)	24									1			
river or hornyhead chub (*Nocomis* sp.)													
northern hog sucker (*Hypentelium nigricans*)	1												
northern pike (*Esox lucius*)													
pumpkinseed (*Lepomis gibbosus*)								10			2	✓	
rainbow darter (*Etheostoma caeruleum*)	80												
rainbow trout (*Oncorhynchus mykiss*)													
river chub (*Nocomis micropogon*)	2				1				6				✓
rock bass (*Ambloplites rupestris*)													
rosyface shiner (*Notropis rubellus*)													
sea lamprey (*Petromyzon marinus*)													
silver shiner (*Notropis photogenis*)		6		7		1	2	2				70	
smallmouth bass (*Micropterus dolomieu*)													
stonecat (*Noturus flavus*)	2												
striped shiner (*Notropis chrysocephalus*)													
white sucker (*Catostomus commersonii*)												✓	
yellow bullhead (*Ameiurus natalis*)													

Fish collection records held by Conservation Halton for portions of Sixteen Mile Creek Subwatersheds 2 & 7 (S-*n*) and Indian Creek subwatershed in Bronte Creek (B-*n*), within or downstream of the Milton Phase 3 and Business Park #2 lands. Station locations are provided in Figure 3.5.4.

Table 3.5.3 Fish Sampling Summary from Conservation Halton Files (Con't)

Station	S-512	S-513	S-514	S-515	S-516
Date (d/m/y)	13/9/13	13/9/13	13/9/13	13/9/13	13/9/13
Number of fish species collected	2	6	4	3	3
black crappie (*Pomoxis nigromaculatus*)					
blacknose dace (*Rhinichthys atratulus*)					
bluntnose minnow (*Pimephales notatus*)					
brook stickleback (*Culaea inconstans*)					
brown bullhead (*Ameiurus nebulosus*)					
carps and minnows (Cyprinidae)					
common carp (*Cyprinus carpio*)					
common shiner (*Luxilus cornutus*)		✓	✓	✓	✓
creek chub (*Semotilus atromaculatus*)		✓	✓		
fantail darter (*Etheostoma flabellare*)					
fathead minnow (*Pimephales promelas*)					
golden redhorse (*Moxostoma erythrurum*)					
goldfish (*Carassius auratus*)					
johnny darter (*Etheostoma nigrum*)					
largemouth bass (*Micropterus salmoides*)					
longnose dace (*Rhinichthys cataractae*)	✓				
river or hornyhead chub (*Nocomis* sp.)					
northern hog sucker (*Hypentelium nigricans*)		✓			
northern pike (*Esox lucius*)					
pumpkinseed (*Lepomis gibbosus*)					
rainbow darter (*Etheostoma caeruleum*)					
rainbow trout (*Oncorhynchus mykiss*)					
river chub (*Nocomis micropogon*)				✓	
rock bass (*Ambloplites rupestris*)					
rosyface shiner (*Notropis rubellus*)					
sea lamprey (*Petromyzon marinus*)					
silver shiner (*Notropis photogenis*)		28	12	28	60
smallmouth bass (*Micropterus dolomieu*)					
stonecat (*Noturus flavus*)					
striped shiner (*Notropis chrysocephalus*)		✓	✓		✓
suckers (Catostomidae)	✓				
white sucker (*Catostomus commersonii*)		✓			
yellow bullhead (*Ameiurus natalis*)					

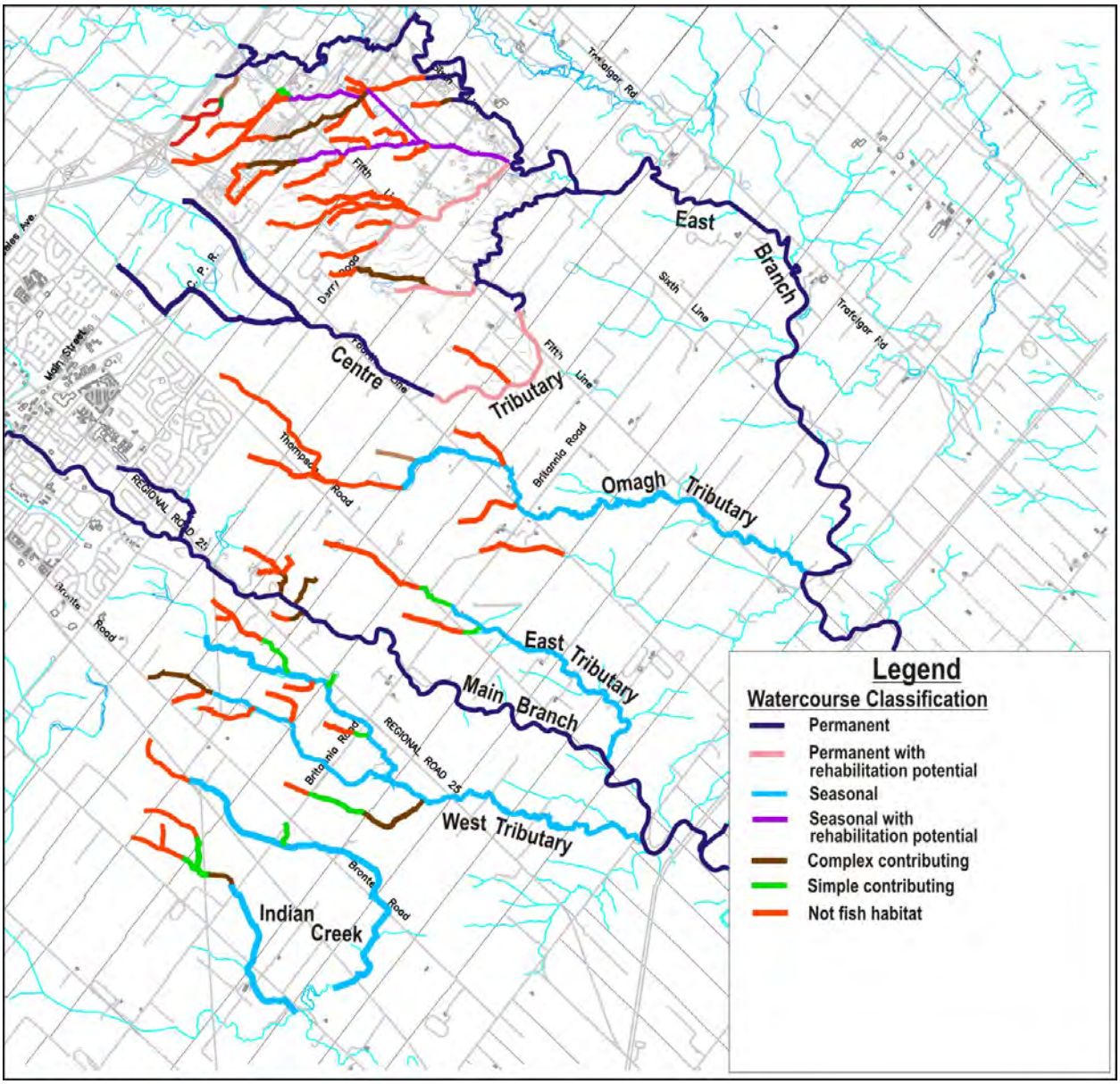

Figure 3.5.2: Drainage features classification, based on the interim guidelines for the evaluation, classification and management of headwater drainage features (ref. CVC and TRCA, March 2009).

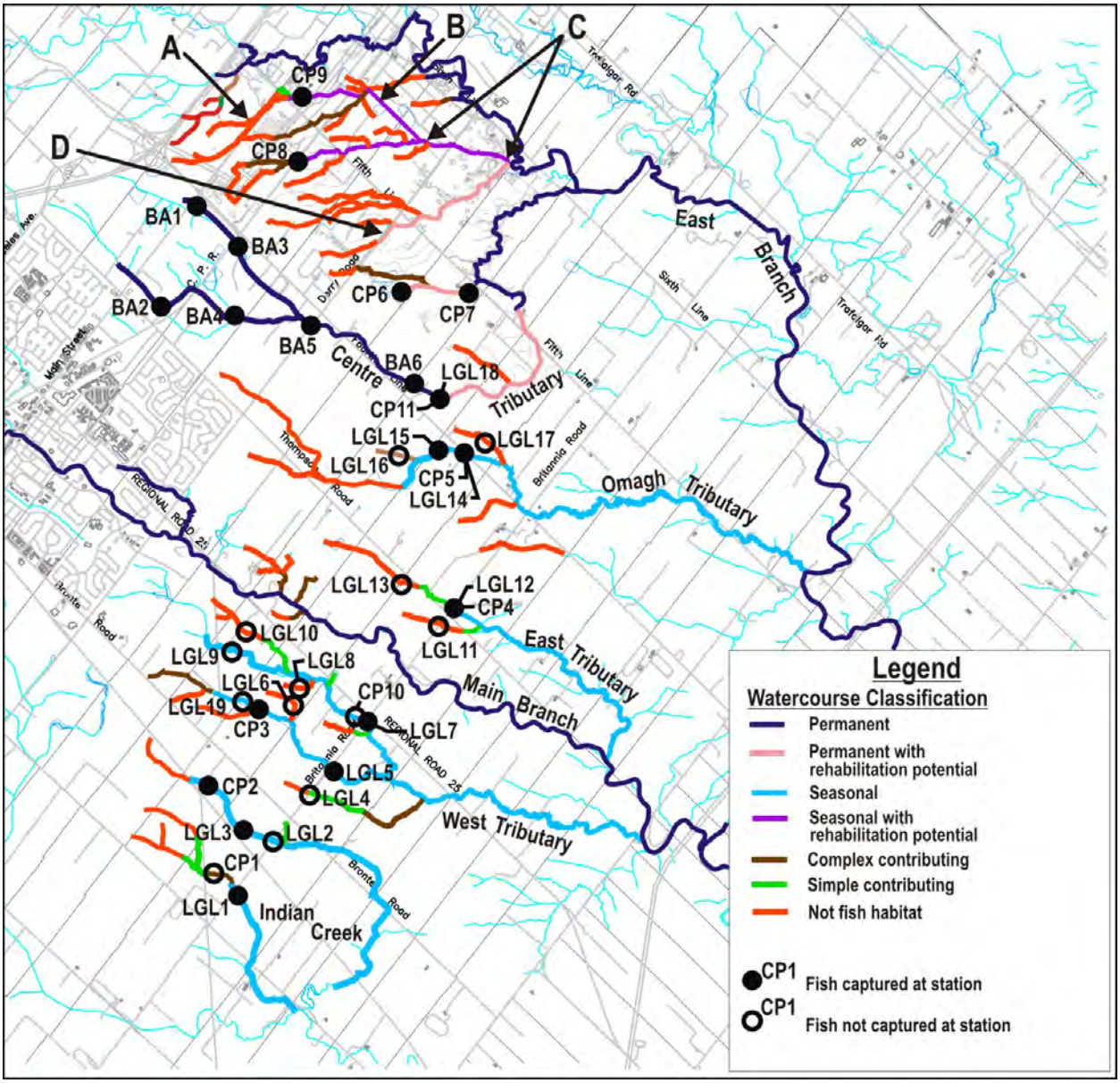

Figure 3.5.3: Locations of recent fish sampling conducted by C. Portt and Associates (2005 and 2008) and LGL Limited (2007, 2008), superimposed on the watercourse classifications. The capture data are presented in Tables 3.5.1 and 3.5.2.

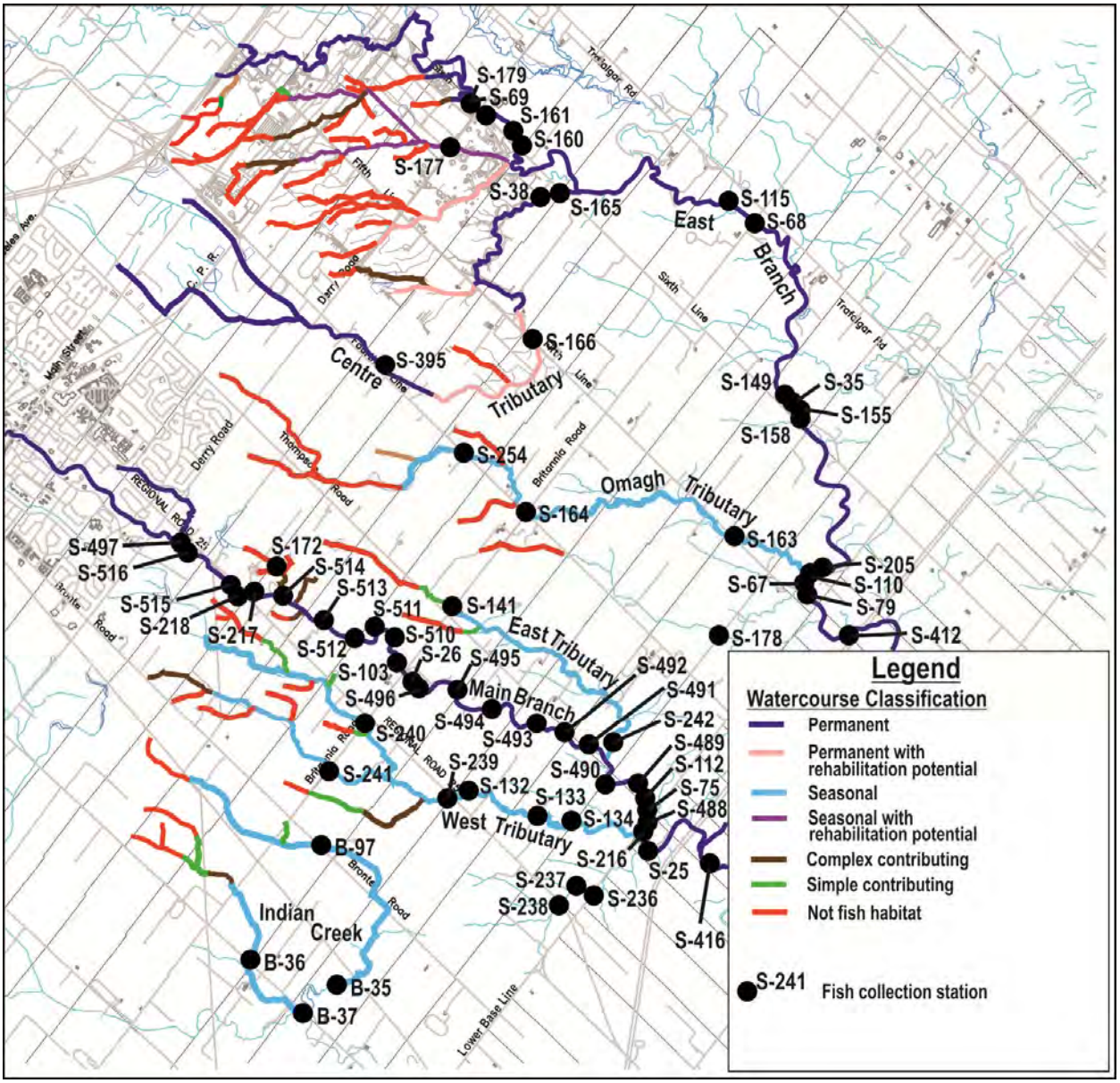

Figure 3.5.4: Locations of fish sampling data from other sources, on file with Conservation Halton, superimposed on the watercourse classifications. The capture data are presented in Table 3.5.3.

Phase 3 (Boyne Survey) and Business Park 2 (Derry Green)

Main Branch (Subwatershed Area 2)

The Main Branch of Sixteen Mile Creek begins at the confluence of the Kelso Branch and the North Branch in downtown Milton. Conditions within the Main Branch proper are not thought to have changed materially since the Subwatershed Area 2 & 7 Study was completed, and it was not re-examined during this update study. The Main Branch is contained within a concrete channel from the downstream end of the Milton Pond to approximately 500 m downstream of the Milton Wastewater Treatment Plant (WWTP), which discharges into the concrete channel. Downstream for another 450 m to Laurier Avenue, the channel is lined with interlocking concrete structures and buried gabion baskets and provides somewhat better habitat than the upstream concrete channel. Downstream of Laurier Avenue to its confluence with the East Branch of Sixteen Mile Creek, the Main Branch typically has a pool/riffle/run structure. No evidence of significant groundwater inputs were observed during the field investigation of this section of creek. A total of 22 fish species were reported from this section of Sixteen Mile Creek in the subwatershed study (Philips, 2000), and it continues to support a diverse community of fishes. Of the fish species present, only the Silver Shiner (*Notropis photogenis*) is considered at risk. It is listed as "Special Concern" in Schedule 3 of the Species at Risk Act (SARA), and therefore is not currently provided legal protection under SARA (http://www.sararegistry.gc.ca, May 12, 2015). However, it and its habitat is provided legal protection under the Ontario Endangered Species Act, where it is listed as "Threatened" (http://www.ontario.ca/environment-and-energy/species-risk-ontario-list, May 12, 2015). Based upon recent (2013) fish collections (ref. Table 3.5.3.: S-488, S-490, S-492 to S-494, S-510, and S-513 to S-516), the Silver Shiner seems to have become more common within the study area in recent years. While the fish community is generally that of a warmwater stream, this portion of Sixteen Mile Creek is an important migratory route for Rainbow Trout, Brown Trout, and Chinook Salmon from Lake Ontario, which mainly spawn from the vicinity of Regional Road 25 upstream to the Kelso Dam. However, some spawning by these species has been observed at specific locations within the study area downstream of Regional Road 25 to below Lower Base Line (Andrea Dunn, Conservation Halton. Personal communication). The extent to which these salmonids utilize Sixteen Mile Creek downstream of Regional Road 25 to Lake Ontario for spawning likely depends upon annual conditions of water levels (access) and the physical fitness of the spawning fish (Andrea Dunn, Conservation Halton. Personal communication). Higher water temperatures downstream of Regional Road 25 may adversely impact salmonid spawning success.

All tributaries discharging to the Main Branch of the Sixteen Mile Creek between downtown Milton and its confluence with the East Branch, with the exception of one tributary from the east that crosses Derry Road, were dry to standing pools in 1998 during summer field investigations for the subwatershed study (Philips, 2000). The re-examination of this area in September 2007 (ref. Figure 3.5.1) found the stream habitat conditions essentially unchanged from 1998. The one tributary with permanent base flow originates from a storm sewer under Regional Road 25, a short distance upstream from Derry Road, which evidently intercepts a groundwater source. The other, seasonally dry stream channels within the flat Peel Plain physiographic region were

typically heavily impacted by agriculture and past ditching activities, except at locations near the Main Branch channel where their gradient increases and they become more incised as they descend into the valley occupied by the Main Branch. The upstream limit of seasonal fish habitat in these tributaries was determined by examining the habitat at the farthest upstream location where fish were present, and then extending upstream to where that type of habitat changed to something less likely to support fish. Permanent fish habitat was determined to be all contiguous watercourses with permanent flow, in which fish were collected at selected locations.

The West Tributary to the Main Branch of Sixteen Mile Creek was totally dry within the Phase 3 lands during the summer of 1998, except for the Britannia Road culverts at fish stations LGL5 and LGL7 (ref. Figure 3.5.3). In September 2007 the instream conditions were essentially identical to those observed in 1998, except that the culvert at station LGL7 was also dry. The watercourses of this tributary within the Phase 3 lands have mainly soil substrate, and are poorly defined (ref. Appendix 'G': Photographs 1 to 6). Fish (brook stickleback) have only been observed in this tributary within Phase 3 at one location (ref. Table 3.5.1: CP3), but have been collected at the downstream limit of Phase 3, in the Britannia Road culverts (ref. Table 3.5.2: LGL5 – brook stickleback, and LGL7 – fathead minnow; Table 3.5.3: S-240 – fathead minnow and pumpkinseed, and S-241 – brook stickleback). The number of fish species present increases closer to the Main Branch, with white sucker and creek chub also present at most sites (ref. Table 3.5.3: stations S-132 to S-134, S-236 to S-239).

The East Tributary to the Main branch of Sixteen Mile Creek was dry to a few standing pools, usually at road culverts, within the Phase 3 lands during the summer of 1998. In September 2007 the instream conditions were essentially identical to those observed in 1998 (ref. Figure 3.5.1). The watercourses of this tributary within the Phase 3 lands have mainly soil substrate, and are poorly defined (ref. Appendix 'G': Photographs 7 to 8). Fish have only been collected as far upstream as Britannia Road in this tributary, which is the downstream boundary of Phase 3. During this study only fathead minnows were captured there (ref. Table 3.5.1: CP4; Table 3.5.2: LGL12), but a 1973 record indicates that longnose dace were captured there (ref. Table 3.5.3: S-141). In streams, longnose dace are a riffle-dwelling species, typically found in permanently flowing watercourses with coarse substrate. At station S-141 the flow is intermittent and the substrate is soil. We suspect that this record is a result of either an incorrect species identification or an incorrect station location.

East Branch (Subwatershed Area 7)

During the summer of 1998, the East Branch of Sixteen Mile Creek was the only permanently flowing stream within the portion of Subwatershed Area 7 within the study area. The East Branch is a meandering channel with few riffle sections upstream of Britannia Road. Downstream of Britannia Road it is more typically pool/riffle/run, as the stream becomes entrenched within a deepening valley. The East Branch was not explicitly examined during this study, but fish sampling since the subwatershed studies indicates that it continues to support a diverse warmwater fish community (ref. Figure 3.5.4 and Table 3.5.3).

North Tributaries of the East Branch

All tributaries of the East Branch within the study area were dry to standing pools at the time of the 1998 field investigation, however, the 2007 and 2008 investigations have found that permanent flow now occurs in watercourses that are in, or originate in, the Phase 1 urban expansion lands (ref. Figure 3.5.1). The only location of apparently natural groundwater input to a watercourse within the Business Park 2 and Phase 3 areas is within Reach BP-1-M, which is located in the first watercourse north of Derry Road, east of Sixth Line to the East Branch of Sixteen Mile Creek.

The watercourses that originate north of Derry Road, within the BP2 lands, were dry except for on-line ponds or within road culverts when examined during the summer of 1998 (Philips, 2000). In September 2007 the flow conditions were essentially identical to those observed in 1998. Observations during the spring of 2008, when the watercourses were flowing, revealed that the roadside ditches along Main Street, excavated to below the invert of the natural watercourses, have resulted in flow being diverted along Main Street to Fifth Line (ref. Figure 3.5.3: location A). Downstream from the C.P.R. the watercourse has been diverted by a low berm, so that it flows south-east along the property line to join another watercourse (ref. Figure 3.5.3: location B). A reach of that watercourse is diverted to an underground pipe that conveys flow under normal conditions (ref. Figure 3.5.3: location C), although high flows still are conveyed overland.

The watercourses in this area of the BP2 lands have mainly soil substrate, and are poorly defined (ref. Appendix 'G': Photographs 9 to 14). One fathead minnow was collected at CP8 (ref. Table 3.5.1; Figure 3.5.3) where a culvert beneath the railway tracks provides a low-flow refuge. Four koi (carp bred specifically for their bright colours) and a pumpkinseed were captured at CP9 (ref. Table 3.5.1; Figure 3.5.3), which is just downstream of an on-line pond at a garden centre, the likely source of these fish. Creek chub and brook stickleback were collected at S-177 (ref. Table 3.5.3; Figure 3.5.4) where a culvert beneath Derry Road, situated between upstream and downstream sections of piped watercourse, provides a low-flow refuge.

One tributary that originates from the vicinity of Derry Road (ref. Figure 3.5.3: location D) was dry in 1998, but now flows throughout the summer because it is fed by water seeping from the storm sewer system that has since been installed. The upstream limit of seasonal fish habitat in these tributaries was determined by examining the habitat at the farthest upstream location where fish were present, and then extending upstream to where that type of habitat changed to something less likely to support fish. Permanent fish habitat was simply considered to be present where there was permanent flow (ref. Figure 3.5.2).

Centre Tributary

The Centre Tributary begins as two watercourses near Hwy. 401, which converge 200 m upstream of Derry Road. This watercourse generally flows in a south direction until exiting the Phase 1 development area, where it turns east, winding approximately 4.5 km before discharging to the East Branch of the Sixteen Mile Creek. At the time of the 1998 field investigations most of the upper reaches of this watercourse existed as swales or ditches with soil substrate through cropland and pasture, while downstream of the Fifth Line it occupied a

defined 'valley' feature (ref. Appendix 'G': Photograph 15). In 1998 there was no flow throughout the Centre Tributary, and water only occurred in isolated pools or road culverts.

Since 1998, approximately the upper half of the Centre Tributary watershed has undergone urban residential development, and almost all of the watercourses within this new urban area have been reconstructed using natural channel design principles. When examined at the end of the dry summer, in September 2007, the main branch of the Centre Tributary and all its tributaries that originate within the new urban area, with the exception of some extreme headwater watercourses near Hwy 401, were flowing. Up to four fish species were captured at sampling locations in the centre tributary in 2005 (Sites BA1 to BA6, Table 3.5.1). Four (LGL18, Table 3.5.2) or five (CP11, Table 3.5.1) fish species were captured at Louis St. Laurent Boulevard in 2007 and 2008. Juvenile northern pike (*Esox lucius*) have also been reported from this watercourse in recent years (Cory Harris, Conservation Halton. Personal communication). Two collections undertaken in 2008 (CP6 and CP7, Table 3.5.1) in a small tributary of the Centre Tributary found a community of fish of at least five species, including young-of-the-year (YOY) white sucker, indicating that migratory white sucker enter this watercourse to spawn. Ten fish species were captured in the Centre Tributary near its confluence with the East Branch in 1973 and 2005 (Site S-38, Table 3.5.3), although several of the species differed between the two years.

The rehabilitated stream habitat in conjunction with the permanent flow (ref. Appendix 'G': Photograph 16), provides a significant improvement in the quality and quantity of fish habitat in the upper reaches of the Centre Tributary, which in turn should contribute significantly to fish habitat productivity. Permanent fish habitat was determined to be all contiguous watercourses with permanent flow, in which fish were collected at selected locations. No seasonal fish habitat was observed within the Phase 3 or BP2 lands.

Omagh Tributary

The Omagh Tributary arises at the south border of the present Milton urban area, then flows generally southeast through the Phase 3 lands and beyond, to the East branch of Sixteen Mile Creek. Throughout most of the upper reaches, this watercourse exists as a swale or ditch with soil substrate through cropland and pasture (ref. Appendix 'G': Photographs 17 and 18). Within the Phase 3 lands, just upstream of Britannia Road, it exists as a roadside ditch (ref. Appendix 'G': Photographs 19 and 20). Only downstream of Britannia Road, outside of the Phase 3 lands, does it occupy a shallow valley feature. At all locations examined within the Phase 3 area, with the exception of the culvert at Britannia Road, this watercourse was completely dry when examined in both 1998 and 2007 (ref. Figure 3.5.1). Brook stickleback and creek chub have been captured in the Omagh Tributary within the Phase 3 lands (ref. Table 3.5.2: stations LGL14, LGL15; Table 3.5.3: station S-164), and unidentified minnows were reported from station S-254 (ref. Table 3.5.3). The upstream limit of seasonal fish habitat in this tributary was determined by examining the habitat at the farthest upstream location where fish were present, and then extending upstream to where that type of habitat changed to something less likely to support fish.

Indian Creek (Bronte Creek watershed)

In September 2007, the two tributaries of Indian Creek that drain the Phase 3 lands were completely dry at Britannia Road and upstream within Phase 3 (ref. Figure 3.5.1). These watercourses have mainly soil substrate, and are poorly defined (ref. Appendix 'G': Photographs 21 to 24). Fathead minnow, brook stickleback and creek chub have each been collected from one site in these two tributaries (ref. Table 3.5.1: CP2; Table 3.5.2: LGL1 and LGL3; Table 3.5.3: B-35 to B-37 and B97). The upstream limit of seasonal fish habitat was determined by examining the habitat at the farthest upstream location where fish were present, and then extending upstream to where that type of habitat changed to something less likely to support fish.

3.5.4 Analysis

Phase 3 (Boyne Survey) and Business Park 2 (Derry Green)

Instream habitat conditions observed during the field component of this subwatershed review in September 2007, covering the Phase 3 and BP2 lands, were essentially identical to that observed during the summer field work for the original subwatershed study in July and August 1998, with one significant exception. Watercourses that were within, or originated from, the Phase 1 lands, were dry to standing pools in 1998, but were flowing in 2007. As in 1998, drought conditions prevailed during the summer and autumn of 2007, so it is likely that watercourses that were flowing in September of 2007 are perennial streams. As a result, some of the watercourses draining the Phase 1 development area have been reclassified to permanent fish habitat.

The mechanism by which the period of flow has been extended is not precisely known. Potential factors include the construction of stormwater management facilities that retain and then slowly release water within this portion of the watershed; discharges of imported water through the watering of gardens and lawns, washing of cars, etc., and the granular material typically backfilled around infrastructure such as sewers and water mains acting as a conduit to store and deliver intercepted groundwater or infiltrated surface water to local watercourses.

The watercourse reaches classified as seasonal fish habitat have been extended farther upstream in some tributaries, based on the results of spring fish sampling conducted during this study and by LGL Limited in 2007 and 2008. These extensions are typically due to the capture of one or two individuals of brook stickleback or fathead minnow. There are no criteria that, if met, result in previous fish captures being disregarded in the determination of what is and what is not fish habitat. Therefore, when additional sampling leads to a change in what is considered fish habitat, it will inevitably result in an increase in the area considered fish habitat.

As described previously, the interim guidelines for the evaluation, classification and management of headwater drainage features (CVC and TRCA, 2009) identify two classes of contributing fish habitat: complex contributing and simple contributing. These categories explicitly consist of watercourses where fish do not occur. The distinction between the two types (complex and simple) is based primarily on the amount of substrate sorting observed and the types of vegetation present in and adjacent to the drainage feature, and is somewhat subjective. The premise is that complex contributing habitat has a greater positive effect on water quality,

sediment supply, organic matter, food supply (invertebrates) and nutrients than simple contributing habitat.

3.5.5 Assessment

The Main Branch and East Branch of Sixteen Mile Creek in the Phase 3 and Business Park 2 lands, are high quality fish habitats with diverse fish communities, and the protection of these resources is a high priority. The main factor limiting the productivity of aquatic habitat in the headwater systems is the amount and duration of water flow. Most of the headwater drainage features are dry for most of the year, and thus cannot support fish or other aquatic organisms requiring water on a continuous basis, even when fish migrate into these drainage features, as observations in the spring of 2008 confirmed that they do,

When fish are captured in these intermittent watercourses, they are usually either fathead minnows or brook sticklebacks and their abundance is very low (ref. Tables 3.5.1 and 3.5.2). The productive capacity is limited by the temporary nature of the habitats, and the fish must either move back downstream as conditions become dryer, or perish. Also, because the habitat is often dry or limited to refuge pools for some distance downstream, the number of fish available to move into the headwaters when flow does occur is low.

In the intermittent tributaries, the absence of base flow is the most significant factor limiting fish productive capacity and the fish communities in the Phase 3 and Business Park 2 development areas. Where base flow has been extended, as it has in the Centre Tributary, there are usually between two and five fish species present and fish abundance is higher. The fish productive capacity of these watercourses has increased following development, as was predicted in the Conceptual Fisheries Compensation Plan that was prepared for those developments.

3.6 Terrestrial Resources

3.6.1 Scope/Purpose

Study Area

The content in this terrestrial characterization reflects the Work Plan for the Sixteen Mile Creek Areas 2 & 7 Subwatershed Update Study which was finalized in November 2007 with input from the Technical Steering Committee, with representation by the Town of Milton, Conservation Halton, and the Region of Halton. Detailed field studies were completed between fall 2007 and fall 2008 as per the Terms of Reference, to further characterize terrestrial resources in the Derry Green (Business Park 2) study area, and on the Boyne Survey (Phase 3) lands. These lands are primarily within the original Sixteen Mile Creek Subwatersheds 2 & 7 study area; however a portion of the Boyne Survey lands (i.e. lands located between Regional Road 25 and Tremaine Road, between Britannia Road and future Louis St. Laurent Blvd) are located within the Indian Creek Subwatershed, which is a tributary to Bronte Creek. Therefore the background review and field studies have addressed both areas to an equivalent level of detail.

[Note: The terrestrial characterization included lands west of Tremaine Road. The content of this SUS reflects background and field data collected between 2007 and 2011 for this area. These lands are undergoing a separate planning study (Milton Educational Village), and for the most

current data and assessments, the reader should refer to the *Milton Educational Village Functional Servicing Environmental Management Strategy* (Draft) (AMEC 2013). Other data collection has occurred under the Town of Milton Phase 2 Holistic Monitoring Program since 2010 and includes data for select features in Boyne and west of Tremaine Road; this data has not been incorporated into the SUS but is being accessed in ongoing SIS peer reviews. All the annual monitoring reports (2010 onward) are on file with the Town of Milton and Conservation Halton.]

Importance of the Resources

Terrestrial ecosystems encompass upland and wetland vegetation of natural and/or cultural origin, providing habitat for wildlife which may utilize features on a transitory, seasonal or permanent basis. Terrestrial ecosystems provide intrinsic functions or services in terms of photosynthesis, storage and processing for carbon, minerals and nutrients as well as moisture. The above- and below-ground structure provided by vegetation interacts with air and water to promote conservative management and cycling of water and soil resources, manage a more stable microclimate, and in the process helps to sustain other reliant biota such as wildlife species, fish and invertebrates. The vertical and horizontal structure of vegetation systems, in conjunction with physical attributes of soil and water, is potentially capable of sustaining many species and populations of plants and animals as habitat structure evolves in extent, age and complexity over decades and longer periods. At watershed and larger scales these services are integral to sustaining the fundamental hydrologic and chemical cycles.

Purpose

The purpose of this terrestrial characterization is to further document and refine understanding of existing conditions in the Derry Green and Boyne Survey lands in terms of vegetative cover, flora and fauna, and ecosystem functions. The Study Area includes lands extending into the Indian Creek Subwatershed. The understanding of this system, in the context of the broader landscape beyond the urban boundary that was assessed by the Region of Halton through the Sustainable Halton project, will help inform decisions on future development including configuration of a sustainable Natural Heritage System for the Study Area as required under Provincial, Regional and Town policies.

The terrestrial field studies undertaken in the Study Area were initiated in the late summer and fall of 2007 prior to finalization of the Work Plan (November 2007) to ensure the availability of current seasonal data. In the spring and summer of 2008, additional data collection was focused on key wildlife groups, as well as refinement of vegetation data. The 2008 fieldwork encompassed the lands west of Tremaine Road as well as continued study of the Derry Green and Boyne Survey lands. All properties were accessed for a series of vegetation and wildlife surveys. The 2007–2008 data supplements data collected between 1998 for the Sixteen Mile Creek Subwatershed Areas 2 & 7 area (Philips Planning and Engineering Ltd., 2000), and data collected in 2001–2002 for the Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2003).

A related component of terrestrial study identified in the November 2007 Work Plan is a desktop review of the developed areas of the Sixteen Mile Creek 2 & 7 subwatersheds. This work has progressed through discussions in December 2008 with Town and Conservation Halton staff. In

particular, Conservation Halton commented on deficiencies in the implementation of the Phase II Natural Heritage System, and has recommended that a more systems-based NHS approach be adopted in the Subwatershed Update Study. This report details updated mapping of the NHS within the developed areas to a consistent ELC level of detail.

3.6.2 Methods

Background Review

Literature and background data pertaining to terrestrial resources in the three component study areas (Derry Green, Boyne Survey and lands west of Tremaine Road) was obtained from the Region of Halton, Conservation Halton, Ministry of Natural Resources, and the Natural Heritage Information Centre (Peterborough) and evaluated for relevant information on terrestrial resources. Additional background information was assembled including published documents, data from other consultant studies, and literature relevant to resources in the study area. A list of primary source individuals and documents consulted for the purposes of this study is presented in the References.

Digital ELC mapping was obtained from Conservation Halton for the overall Sixteen Mile Creek Subwatersheds 2 & 7 and Indian Creek area. This was utilized in conjunction with the 2000 Subwatersheds 2 & 7 and Indian Creek Subwatershed mapping, and the most current detailed ELC mapping of the Derry Green and Boyne areas, and lands west of Tremaine Road to generate an overall subwatershed vegetation map, at the ELC Community Series level of detail.

Field Studies

Vegetation

All natural and semi-natural vegetation communities within the Derry Green and Boyne Survey study areas and lands west of Tremaine Road were visited during the 2007 and 2008 field seasons, with the exception of the Sixteen Mile Creek ESA as per the terms of reference. Active agricultural lands were assessed from roadsides/laneways and in conjunction with examination of key features such as watercourses, woodlots, wetlands, cultural features and hedgerows. Vegetation communities were mapped as polygons onto orthogonally rectified digital base provided by the Town of Milton. The Boyne Survey lands and portions of the Derry Green lands were initially mapped onto 2005 photography, and subsequently on 2007 ortho photos which became available from the Town in the early fall of 2008. The remainder of Derry Green and lands west of Tremaine Road located beyond the available 2007 coverage were reliant on 2005 photography.

Vegetation and disturbance data were collected from natural and cultural communities; detailed data on community structure, composition and soils was collected from natural communities. This information was used to classify natural vegetation communities to the Vegetation Type level (where feasible) according to the ELC (Ecological Land Classification) methodology for Southern Ontario (Lee *et al*., 1998).

Some supplementary field study occurred in the summer and autumn of 2009 to complete the wetland evaluations in the detailed study areas as per the Terms of Reference, and to

document existing conditions in the Phase 1 (Bristol Survey) lands. This is discussed later in the report.

Wildlife

Wildlife surveys were initiated and completed in 2008 to document breeding birds, calling amphibians, snakes and odonates (damselflies and dragonflies). Nocturnal amphibian call surveys were conducted in the vicinity of all wetland and aquatic features during the spring and summer of 2008. Calling levels were documented according to the Marsh Monitoring Program protocol (BSC, 2003). Breeding birds were documented from all natural and semi-natural communities that showed potential for diverse bird habitat during the late spring and summer of 2008 according to the Ontario Breeding Bird Atlas protocols (OBBA, 2001), with the exception of the Sixteen Mile Creek ESA as per the terms of reference. The timing (June through early July) corresponded with the peak singing for most songbirds. Earlier visits in the spring also yielded additional breeding bird observations. All of the existing woodlots were surveyed, as were smaller successional areas. Given the predominance of agricultural lands within the survey area, careful attention was also paid to documenting open country species, a bird category showing significant declines across North America.

Searches for snakes were conducted during the fall of 2008 when they show increased activity prior to hibernation. Surveys for odonates were conducted during the summer and fall of 2008. Field guides prepared by Mead (2003), Nikula *et al.* (2003), Lam (2004), DuBois (2005) Jones *et al*. (2008) were all used to assist with odonate identification when necessary. All other wildlife species observed during vegetation and wildlife surveys were recorded incidentally. No winter surveys were conducted. Details of the various wildlife survey visits are summarized in Table 3.6.1.

Table 3.6.1: Summary Of Survey Dates, Times And Weather – Wildlife

	Date	Observer	Time	Person Hrs	Weather Conditions	Purpose
1	April 25, 2008	K. Konze	2030 - 0100	4.250	Partly cloudy, 12–9 ºC. Winds NE, 6 – 2 km/hr.	Roadside and walk-in amphibian call survey
2	April 26, 2008	K. Konze	2130 – 0030	3.000	Clear, 13–9 ºC. Winds mostly calm (W, 5 – 0 km/hr.)	Roadside and walk-in amphibian call survey
3	April 27, 2008	K. Konze & H. Pankhurst	2000 – 2330	3.500	Cloudy, 12.5 –9.8 ºC. Winds N @ 7 – 12 km/hr.	Roadside and walk-in amphibian call survey
4	May 23, 2008	K. Konze	2115– 0100	3.750	Mostly clear, 13.4–12.0 ºC. Winds west, 0 – 10 km/hr.	Roadside and walk-in amphibian call survey
5	May 24, 2008	K. Konze	2105– 2355	2.833	Clear and calm, 13.4 –11ºC.	Roadside and walk-in amphibian call survey
6	May 25, 2008	K. Konze	1915 – 0000	2.750	Mostly cloudy, 17.4 –12ºC. Winds south, 5 km/hr.	Roadside and walk-in amphibian call survey
7	May 27, 2008	K. Konze	1700 – 1730	0.500	Mainly clear, 12 ºC. Winds NW, 14 km/hr.	Breeding bird and daytime amphibian survey
8	June 5, 2008	H. Pankhurst	2230 – 2240	0.166	Partly cloudy/hazy, 17 ºC. Calm.	Roadside amphibian call survey
9	June 21, 2005	K. Konze	0545 – 1045	5.000	Mostly to partly sunny, 15–20 ºC. Mostly calm.	Breeding bird & miscellaneous wildlife survey
10	June 29, 2008	K. Konze	0530 – 1210	6.666	Mix of sun & cloud. Light showers @ 0945. 19–22ºC. Winds SW, 4–8 km/hr.	Breeding bird, odonate and miscellaneous wildlife survey

Table 3.6.1: Summary Of Survey Dates, Times And Weather – Wildlife						
	Date	**Observer**	**Time**	**Person Hrs**	**Weather Conditions**	**Purpose**
11	June 30, 2008	K. Konze	0530 – 1300	7.500	Mostly clear – cloudy, 15–22 ºC. Winds west, 4–13 km/hr.	Breeding bird & miscellaneous wildlife survey
12	July 1, 2008	K. Konze	0935 – 1145	2.166	Sunny & clear, 21–24 ºC. Winds west, 11–13 km/hr.	Breeding bird & miscellaneous wildlife survey
13	July 3, 2008	K. Konze	0530 – 1215	6.750	Cloudy, overcast with occ. showers, becoming sunny, 20–21 ºC. Winds NNW, 10–20 km/hr.	Breeding bird, odonate and miscellaneous wildlife survey
14	July 8, 2008	K. Konze	0545 – 1145	6.000	Cloudy, 23–31 ºC. Very humid. SSW breeze, 6–13 km/hr.	Breeding bird, odonate and miscellaneous wildlife survey
15	July 10, 2008	K. Konze	0530 – 1210	6.666	Sunny & clear, 14–25 ºC. Winds west, 2–15 km/hr.	Breeding bird, odonate and miscellaneous wildlife survey
16	August 14, 2008	K. Konze & H. Pankhurst	1045 – 1610	4.916	Mostly sunny, 22–23 ºC. Winds SE, 8 km/hr.	Odonate & miscellaneous wildlife survey
17	August 19, 2008	K. Konze	1010 – 1810	7.750	Sunny, 15 –20 ºC. Winds variable direction, 4–10 km/hr.	Odonate & miscellaneous wildlife survey
18	September 17, 2008	K. Konze	1100 – 1800	6.750	Mix of sun and cloud, 22–23 ºC. Winds west, 10–18 km/hr.	Odonate & snake survey
19	September 24, 2008	K. Konze & I. Richards	1025 - 1725	6.333	Sunny-hazy all day, 20–25 ºC. Winds south, 4–11 km/hr.	Odonate & snake survey
			Total hours	**87.25 hrs**		

All wildlife species documented in the Subwatershed Update Study area in 2007 (*i.e.* incidental observations gathered during vegetations surveys) and 2008 were entered into a wildlife database created for this study. As of October 24, 2008 this represented 1665 records, including negative data where no species were detected (*e.g*. roadside amphibian call survey stop). The database was created primarily to facilitate analysis of results, but could also potentially serve as a foundation for additional observations to be added later in the planning process or in conjunction with future monitoring. Where available, the following information was entered into the database for each record:

- Wildlife Observation Number
- Polygon Number
- Fauna Code (which populates Common & Scientific Name)
- Observer
- Observation Date
- UTM coordinates
- Data Source
- Comments
- Amphibian Call Code
- Breeding Status
- Breeding Bird Evidence
- Local Breeding Status
- Number of Individuals

Other Update Tasks

In late April 2008, members of the Dougan and Associates team coordinated a site walk of natural areas within the Derry Green, Boyne Survey and lands west of Tremaine Road with Town and Conservation Halton staff in attendance. Many features including woodlands, wetlands and stream corridors were reviewed, and discussion occurred on the potential natural heritage strategies for the various areas. Data has subsequently been received from LGL Ltd. related to some portions of the Boyne Survey and Milton lands west of Tremaine Road.

The terrestrial study team met with Conservation Halton and Town of Milton staff in March 2009 to consider the approaches to wetland evaluations, NHS opportunities, and identified species at risk. Some supplementary field study occurred in the summer and autumn of 2009 to complete the wetland evaluations in the detailed study areas as per the Terms of Reference. This is discussed later in the report.

3.6.3 Results

Background Review

Existing Forest Cover and Significant Woodlands

The vegetation of the Sixteen Mile Creek Watershed is representative of the Deciduous Forest Region - Niagara Section and the Great Lakes – St. Lawrence Forest Region – Huron - Ontario Section (Rowe, 1972). The study area occupies a transition area between the two forest regions, with the south-north gradient accentuated by the Niagara Escarpment (Crins, 1986). Vegetative species richness as represented in designated Environmentally Sensitive Areas (ESA's) includes Escarpment, southern Carolinian and prairie-savanna habitats and species. In their study of Significant Woodlands in Halton, Riviere and McInnes (1999) determined that loss of forest cover continued between 1978 and 1995 in both urban and rural areas of Milton.

The Region of Halton has mapped all woodlands greater than 0.5 hectares within the Region as Significant Woodland candidates under Halton Region Official Plan policy (Halton Region, 2006). Section 3.6.4.1 provides detail regarding the updating of the Significant Woodlands data for the study area, confirming features that meet the detailed criteria, and those that do not meet the Region's criteria (ref. Appendix 'H' Figure T5).

Previous Watershed and Subwatershed Studies

The Sixteen Mile Creek Watershed Plan (Ecoplans Ltd., 1996) listed more than 100 additional plant species considered rare in Halton Region by various authorities. The distribution of these species within Subwatershed 2 & 7 was not defined in the Plan. The Watershed Plan documented woodlots located below the Niagara Escarpment using a woodlot polygon classification system developed by Geomatics International (1993) for the Oak Ridges Moraine within the boundaries of the Greater Toronto Area. Woodlot documentation was principally reliant on background data sources; limited field study of woodlots was conducted. Information for 171 discrete woodlots was summarized; this included 21 woodlots in Subwatershed 2, and 18 woodlots in Subwatershed 7.

The Sixteen Mile Creek Subwatershed Areas 2 & 7 Study (Philips Planning and Engineering Ltd., 2000) and the Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2004) provided site-specific terrestrial information for the entire detailed Study Area. Relevant data from these two studies has been incorporated into the current Subwatershed Update Study.

Wetlands

There are three wetlands evaluated under the Ontario Wetland Evaluation System that are recognized in Ministry of Natural Resources (MNR) data in the vicinity of the Subwatershed Areas 2 & 7 and Indian Creek lands. These include the Mill Pond Wetland Complex located in downtown Milton, the Milton Heights Wetland Complex located north of Highway 401, and the Indian Creek Wetland Complex Provincially Significant Wetland, which is located along the western periphery of the proposed lands west of Tremaine Road. The MNR data identifies several unevaluated wetlands, three located within the Phase 1 lands (of which two were evaluated as part of the previous Sixteen Mile Creek Areas 2 & 7 Study), three within the Sixteen Mile Creek ESA, two within the Derry Green lands, and three small features in the Boyne Survey lands (ref. Appendix 'H' Figure T5).

Conservation Halton staff provided hard copy mapping of potential wetlands from its database. These were subjected to field investigations within the Derry Green and Boyne Survey lands during the present study, and are discussed later in this report. Some of the identified wetlands were verified, while others were determined not to be wetlands. The Subwatershed Update Study also identified other wetlands that have not been previously mapped by either MNR or Conservation Halton.

Snell (1987) estimated that between the time of European settlement and 1982, there was a loss of 63.9% of original wetland cover in Halton Region, and nearly 3% loss occurred between 1967 and 1982 alone. Of the historic loss, she attributed 58.6% to agriculture, 24.1% to development, and 17.3% to extractive uses. Given the relative extent of remaining wetland cover above the Niagara Escarpment, it is clear that the preponderance of wetland loss occurred below the Escarpment. Coventry (1940) has documented residents' accounts of changes in streamflow for streams located between Dundas and Toronto; their comments suggest that there was substantial marsh cover present within the present agricultural landscape after the turn of the century.

Environmentally Sensitive Areas and Areas of Natural and Scientific Interest

Four ESA's extend into Sixteen Mile Creek Subwatersheds 2 & 7, including the Sixteen Mile Creek ESA (#16), Milton Heights ESA (#17), Crawford Lake – Rattlesnake Point Escarpment Woods ESA (#18) and Hilton Halls Complex ESA (#25). The Sixteen Mile Creek ESA (#16) extends into the detailed Subwatershed Update Study Area, located within the Boyne Survey lands. A portion of the Sixteen Mile Creek Valley ESA (#16) is also designated as a Regional and Candidate Provincial Life Science Area of Natural and Scientific Interest (ANSI) (status reconfirmed with MNRF, May 2015); MNR (2006) mapping indicates that this candidate designation does not extend north of Britannia Road. There is also an Earth Science ANSI located downstream of Britannia Road.

The lands west of Tremaine Road, which are in the Indian Creek Subwatershed, include a small portion of Indian Creek Subwatershed ESA (#11), which is a large ESA located adjacent to that study area; it contains portions of the Indian Creek PSW Complex.

In the Region of Halton's Environmentally Sensitive Area Study (Geomatics, 1993), vegetation communities in ESA's were originally classified according to *A Classification of the Natural Communities Occurring in Ontario* (Kavanagh and McKay-Kuja, 1992) which pre-dated the current Ecological Land Classification system. A total of 111 nationally, provincially or regionally significant plant species were on record within the four ESA's extending into Subwatersheds 2 & 7; however a substantial portion of these ESA's extend beyond the subwatershed 2 & 7 limit and therefore only a portion of the species can be expected to occur within the immediate study area.

As part of the *Halton Natural Areas Inventory* (Dwyer, 2006a), vegetation communities in ESA's were classified according to the Community Series level of Ecological Land Classification for Southern Ontario (Lee *et al.* 1998). A total of 38 nationally, provincially or regionally significant plant species are now on record within the Sixteen Mile Creek Valley ESA; however the majority of the ESA extends beyond the study area limit and therefore only a portion of the species can be expected to occur within the immediate study area. The updated NAI study has also recommended that this ESA be extended further northward, encompassing woodlands and valley associated features up to Derry Road. The management strategy for the Boyne Survey will consider the opportunities for this extension as part of the Natural Heritage System planning for this detailed study area.

Consultant Studies

LGL Limited Assessments

LGL Limited conducted natural heritage inventories and analysis of the Boyne Survey lands for the current landowners between 2007 and 2008. This work is independent of the comprehensive vegetation and wildlife fieldwork completed throughout this study area by Dougan & Associates in 2008. The purpose of the LGL assessment was to "describe, evaluate and map the natural heritage features" within the properties. Inventories were multi-season in nature and included terrestrial, wetland and aquatic features. Vegetation community polygons were mapped and classified according to the Ecological Land Classification system for southern Ontario (Lee *et al.,* 1998). Amphibian and breeding bird surveys were also carried out in 2007 and 2008.

Although all of the lands in Boyne Survey lands have been surveyed by LGL Limited, only data on vegetation and wildlife (amphibians, breeding birds, mammals, reptiles and fisheries) collected in 2007 for the lands owned by Mattamy Homes was provided to Dougan & Associates. Natural and semi-natural vegetation communities were identified within these lands including Deciduous Forest, Deciduous Swamp, Meadow, Meadow Marsh, Cultural Plantation, Woodland and Savannah. Nine plant species were identified within the Mattamy lands (in Boyne Survey) that are considered to be locally significant in Halton according to Crins *et al.*, 2006. This information has been considered in the current Subwatershed Update Study (ref. Appendix 'G').

Fifty-three (53) species of wildlife were documented by LGL from within or directly adjacent to the Boyne Survey lands in 2007; 2008 data was not provided for review. The 2007 records included 4 species of amphibians, 42 species of birds and 7 species of mammals.

Of these 53 species of wildlife, five are designated as 'Species at Risk' in Canada or Ontario (*i.e*. designated as "Special Concern", "Threatened", or "Endangered" federally or provincially).

Western Chorus Frog (*Pseudacris triseriata*) was documented from within and immediately adjacent to the Boyne Survey lands. The Great Lakes - St. Lawrence population of the Western Chorus Frog, to which these individuals are thought to belong, was designated "Threatened" federally by COSEWIC in April 2008. Its status was reviewed provincially in the spring of 2009 and was determined to be "Not at Risk" in Ontario. Since there are no federally owned lands within the SUS area, habitat supporting this species only receive protection if they are designated as "Significant Wildlife Habitat" (SWH) under the Provincial Policy Statement.

Eastern Wood Pewee (*Contopus virens*) and Wood Thrush (*Hylocichla mustelina*) are typically forest-dwelling bird species. Eastern Wood-Pewee is designated Special Concern in Canada (COSEWIC, 2014) and Wood Thrush is designated Threatened in Canada (COSWIC, 2014). In Ontario, the Committee on the Status of Species at Risk in Ontario (COSSARO) reviewed their provincial conservation status in January 2013. They were both subsequently designated "Special Concern" and added to the Species at Risk in Ontario List on June 27, 2014. Eastern Wood-Pewee was recorded from two different locations in 2007, one in a hedgerow east of First Line and the other from a woodland fragment immediately south of Louis Saint Laurent Blvd. (east of Thompson Road). Wood Thrush was documented three times from the same forest fragment situated along the main branch of Sixteen Mile Creek, north of Britannia Road.

Barn Swallow (*Hirundo rustica*) and Bobolink (*Dolichonyx oryzivorus*) are open-country breeding bird species, and both are designated Threatened in Ontario (OMNRF, 2015) and Canada (COSEWIC, 2014). LGL recorded Barn Swallow on 11 different occasions from the Boyne Survey Lands in 2007. Although mostly observed foraging over fields, these observations were not far from potential breeding sites such as barns or rural residences. Bobolink was documented twice by LGL. One observation was from the fields NW of the intersection of Britannia Road and R.R. 25. It is not clear exactly where the observation as made or how many birds were involved. The second observation was from the fields NW of the intersection of Britannia Road and Thompson Rd. South. Likewise, more detailed information that indicates how many birds were present and exactly where they were was not provided.

At the regional level, eight (8) species of breeding birds documented by LGL are considered significant (OPIF, 2008). This includes Hairy Woodpecker (*Picoides villosus*), Eastern Wood-Pewee (*Contopus virens*), Eastern Kingbird (*Tyrannus tyrannus*), Wood Thrush (*Hylocichla mustelina*), Brown Thrasher (*Toxostoma rufum*), Field Sparrow (*Spizella pusilla*), Savannah Sparrow (*Passerculus sandwichensis*) and Bobolink (*Dolichonyx oryzivorus*). Only one locally significant species was recorded, Horned Lark (*Eremophila alpestris*). It is listed as an "uncommon summer resident" by Curry (2006).

Data and designations in the LGL studies which were provided to date have been considered in the present report, and incorporated where appropriate.

Louis St. Laurent Crossing Terrestrial Resources Impact Analysis prepared by Dougan & Associates for Philips Engineering Limited Class EA (2008) for Louis St. Laurent Blvd. Crossing of Sixteen Mile Creek

The vegetation communities in the vicinity of the Louis St. Laurent Avenue crossing of Sixteen Mile Creek were documented in 2007 as part of a Class EA for a bridge crossing of the creek. Some locally uncommon plant species were observed but no regionally or provincially rare species or Species at Risk were documented. Elements of a previously reported Fresh-Moist Black Walnut Lowland Deciduous Forest were encountered in the creek tributary and to some extent in the floodplain, however, based on the absence of some of the associated species with affinities for floodplains, and the presence of a patchy mixtures of common native and introduced upland species, it was determined that none of the identified communities should be considered S2S3 habitat.

Principal constraints identified in the project included a) steep slopes which are susceptible to erosion, b) pockets of mature canopy cover, c) a small wetland in the vicinity of the proposed bridge pier, and d) the presence of Giant Hogweed (*Heracleum mantegazzianum*), a highly noxious introduced species in the floodplain.

The Louis St. Laurent study area yielded a number of significant animal species. Most were of local or regional significance but a few others were also recognized as significant at the provincial and national scales. No Eastern Milksnakes were observed despite dedicated sampling and surveys which were requested by Conservation Halton staff. The significant species documented at this site in 2007 included River Bluet (*Enallagma anna*) and Painted Skimmer (*Libellula semifasciata*), which have a provincial rank of S2 or “Imperiled” (NHIC, 2015), and Monarch (*Danaus plexippus*), which is designated “Special Concern” in Ontario (OMNRF, 2015) and Canada (COSEWIC, 2014). Another species which we previously listed (Eastern Amberwing - *Perithemis tenera*) was subsequently lowered in status from S3 to S4.

Up to eight River Bluets were observed along Sixteen Mile Creek, suggesting that a local population is established. This species appears to be expanding its range eastward in Ontario, and its status may be upgraded eventually. A single male Painted Skimmer was observed along the edge of the field not far from Sixteen Mile Creek. However, it is not clear whether this species is resident in Halton Region or whether it was a vagrant (Rothfels, 2006). Prior to the 2007 observation, it had only been reported twice before from Halton, and both records were from 2004, a year that featured a large incursion of this species into the province (Rothfels, 2006). Catling and Brownell (2000) list marshy bay, ponds and streams as its breeding habitat. Nikula *et al*. (2004) also includes slow streams. Based on these descriptions, it is at least possible that Sixteen Mile Creek could be considered potentially suitable breeding habitat. Monarch has a provincial conservation rank of S4. Although the three individuals documented in 2007 were only observed nectaring, one of its larval food plants, Common Milkweed (*Asclepias syriaca*), was observed nearby.

Data and designations from the Louis St. Laurent study have been incorporated into the present report.

Monitoring Studies

Trent University Monitoring of Phase 1 and 2 Lands

Phase 1 and 2 monitoring was undertaken in 2006 and 2007 by Trent University, focused primarily on fisheries, stormwater management, and water quality. Terrestrial monitoring (calling amphibians, breeding birds, ELC of specific sites associated with permanent vegetation plots) was undertaken related to development of the Phase 2 (Sherwood Survey) lands. In 2009 Conservation Halton requested that the overall monitoring work for Phase 2 be re-assigned due to concerns with the quality and reliability of the data; subsequently the SUS study team was assigned to continue the monitoring. We reviewed the Trent terrestrial data and found inconsistencies in the identification of plant species and birds, including records that are clearly incompatible with the regional biota. Therefore we have not placed any reliance on this data for the purposes of the SUS. Due to deficiencies in the original design of the terrestrial component, a new array of monitoring sites was identified and is being surveyed in 2010 to create the baseline data for future monitoring cycles.

Natural Heritage Information Centre (NHIC) Data Queries

A query of the Natural Heritage Information Centre (NHIC) database was initiated in 2008 to obtain rare species element occurrence data for the entire Sixteen Mile Creek Study Area (NHIC, 2008). Approximately 12 tracked species have occurrence records within the Subwatershed Study Update area; we have been in communication with NHIC staff to further clarify the extent and relevance of the records. Several relevant species records that we are aware of are as follows:

- Redside Dace (*Clinostomus elongatus*) (Srank S3, MNR Threatened and COSEWIC Endangered) is documented in the North Tributary to Sixteen Mile Creek, located in Milton Heights close to Highway 401.Halloween Penant (*Celithemis eponina*), a dragonfly species, was reported near Britannia Road in 1974. Since June 2000, this species was ranked as S3; however, the status was recently changed to S4 and it is no longer provincially significant.
- Jefferson X Blue-spotted Salamander ‘hybrid’, with a Jefferson genome dominant (Srank S3) was reported in 1984. We did not encounter any suitable habitat (i.e. meeting criteria established by Beriault 2008) in the vicinity; not listed as occurring in the Regional and Candidate Provincial Sixteen Mile Creek Life Scieince ANSI (MNR 2006).
- Eastern Milksnake (*Lampropeltis triangulum triangulum*) a species currently designated “Special Concern” in Canada (COSEWIC, 2014) and Ontario (OMNRF, 2015) was documented from the vicinity of Regional Road 25 south of the future Louis St. Laurent Blvd in 1984. The Halton Natural Areas Inventory (Dwyer, 2006a) also listed this species for the area for the same year. We believe they are referring to the same observation. Two other records for this species on record at NHIC (they have the same Element Occurrence ID – 91083) were determined to be just northwest of the Derry Green study area, on the opposite side of Hwy. 401 (S. Brinker pers. comm., 2009). This species was

not detected during site specific snake cover board studies for the Louis St. Laurent crossing of the Main Branch (Philips Engineering Ltd. 2008). However, based on available habitats it could be present in the valley and tableland areas.

Other Relevant Wildlife Background Information

Prior to the Subwatershed Areas 2 & 7 Study, the study area was relatively under-documented with respect to wildlife outside of the Environmentally Sensitive Areas. The Watershed Plan was reliant on breeding bird and herpetofaunal data summarized from the first (1981–1985) Ontario Breeding Bird Atlas (OBBA) and Ontario Herpetofaunal Survey (OHS) for the UTM grid squares that encompass the watershed. The Subwatershed Update Study area (comprised of Derry Green, Boyne Survey and lands west of Tremaine Road) is covered by two 10 x 10 km UTM grid squares: 17NJ91 and 17NJ92.

The total number of breeding bird species documented in these squares during the first atlas was 113, including 8 species of provincial or regional significance at the time (OMNR, 1993). A total of 29 reptile and amphibian species, including 1 species of provincial significance (OMNR, 1993), were documented on this basis. The grid squares extend beyond the subwatershed limits and therefore the data is not specific to Subwatersheds 2 & 7. As part of the Watershed Plan studies, bird surveys were conducted in one woodlot in Subwatershed 2 (part of the Sixteen Mile Creek Valley ESA) and two woodlots within Subwatershed 7 (SMCWP, 1996).

The second Ontario Breeding Bird Atlas was conducted over a five year period between 2001 and 2005. It culminated in the publication of the “Atlas of the Breeding Birds of Ontario 2001 to 2005” (Cadman *et al*., 2007). All locations in Ontario, including the Sixteen Mile Creek Subwatershed Update Study (SUS) area, were included in the analysis. More specifically, the Sixteen Mile Creek SUS area falls entirely within two 10 x 10 km atlas squares, 17NJ91 and 17NJ92. Coincidentally, the two atlas squares roughly divide Derry Green from the Boyne Survey and lands west of Tremaine Road. Eighty-eight species were documented between 2001 and 2005 during the breeding season in 17NJ91 and 76 species in 17NJ92. All but one of the species, the Merlin (*Falco columbarius*), exhibited breeding evidence. This accounts for a combined total of 95 bird species. Six Species at Risk were documented: Chimney Swift (*Chaetura pelagic*), Eastern Wood-Pewee, Barn Swallow, Wood Thrush, Bobolink, and Eastern Meadowlark. All are designated Threatened in Canada by COSEWIC except Eastern Wood-Pewee, which is designated Special Concern. In Ontario, all of the species listed are designated Threatened, except Wood Thrush and Eastern Wood-Pewee, which are designated Special Concern. All six species were documented from both 17NJ91 and 17NJ92. Both of the atlas squares are also roughly similar to one another with respect to the type of land cover. Neither includes any portion of the Niagara Escarpment but 17NJ91 includes more of the Sixteen Mile Creek valley which is the most significant natural heritage feature within the area. Both atlas squares can be generally characterized as agricultural landscapes with scattered/isolated small woodlots and often narrow and sometimes discontinuous creek corridors. Atlas square 17NJ91 includes a higher percentage of developed lands (mostly residential) than does 17NJ92. Although encompassing significantly more land area than the study area, the atlas squares provide an excellent source of information by which to compare the findings of the breeding bird surveys conducted in 2008. All six of the species were documented from the 2008 surveys

except Chimney Swift. Similarly, all of the species were documented from the 1999 surveys expect Chimney Swift and Bobolink.

At the time of the previous Sixteen Mile Creek Subwatershed Areas 2 & 7 Study, the Hamilton Herpetofaunal Atlas (HHA) database represented the most recent and extensive source of background information on herpetofauna for the area. In 1998 it contained 186 records, representing 17 species (Lamond, 1998). Species considered significant in Halton were defined according to Geomatics (1991), which included any species designated 'uncommon' or 'rare' in the MNR's former 'Central Region' by Plourde *et al.,* (1989). However, with the preparation of the Halton Natural Areas Inventory, additional field studies were carried out and revised conservation status ranks were derived (Curry, 2006). However, it is not clear whether any of the field surveys were conducted in the Subwatershed Update Study area being considered as part of this study.

Ontario Mammal Atlas data records (Dobbyn 1998) were also reviewed at the time of the previous Sixteen Mile Creek Subwatershed Areas 2 & 7 Study. No species considered to be provincially significant were on file. Since then, the Ontario Mammal Atlas has not been updated and it is our understanding that only Conservation Halton is accepting new observations for Halton Region. A detailed mammal inventory was not undertaken for the Halton Natural Areas Inventory (Dwyer *et al*., 2006) and it is therefore unlikely that any significant mammal records have been overlooked in the Subwatershed Update Study area.

No deer wintering areas or other significant wildlife habitats have been identified below the Escarpment or outside the Sixteen Mile Creek ESA in available background documents (OMNR 1989).

Sustainable Halton Plan

Although the Sustainable Halton NHS plan, adopted by the Region in December 2009, does not apply directly to all of the detailed Study Areas for the Subwatershed Update Study (portions of which were included within the current urban boundaries of the Region in a previous growth study, the Halton Urban Structure Plan), it does provide some guidance on the principles currently considered important for natural heritage system planning in the Region of Halton. The Sustainable Halton plan represents a 'high level' systems approach and does not reflect site specific surveys of most features outside of Environmentally Sensitive Areas. Detailed NHS planning studies for new development such as those within Derry Green, Boyne Survey, and the lands west of Tremaine Road will be informed by the Sustainable Halton NHS, however ultimately refine its application using more detailed site specific data and analysis through subwatershed studies, Functional Stormwater and Environmental Management Strategies and Subwatershed Impact Studies.

Information Gaps

The Subwatershed Update Study provides the most comprehensive consolidated information for the detailed study areas comprised by Derry Green, Boyne Survey and lands west of Tremaine Road. As of the time of preparation of this version of the characterization, background data on status has been updated.

Vegetation Resources

A total of 141 distinct Ecological Land Classification vegetation polygons were documented during the 2007 and 2008 field work in the 16 Mile Creek Subwatershed Update detailed study areas. Botanical and disturbance data were collected from the majority of accessible polygons, and detailed ELC data was collected from the natural communities.

Eleven different ELC Community Series were documented. These were further classified into ELC Ecosites, or Vegetation Types. Vegetation Type is the most detailed category of the ELC Classification system and is based on the dominant vegetation species in the polygon. It was not possible to classify all of the polygons to Vegetation Type, as the number of Vegetation Types previously documented in the ELC system (Lee *et al* 1998) was relatively limited, particularly for the Cultural Communities, and in some cases there was no existing category which describes the dominant vegetation encountered in some of the site. A more detailed catalogue of Vegetation Types was produced by MNR's ELC development staff in 2007.

The breakdown of the ELC polygons by Community Series and Ecosite/Vegetation Types for each of the study areas is shown in Tables 3.6.2, 3.6.3, and 3.6.4. When a Vegetation Type was classified using the 2007 ELC update, the equivalent community classification from Lee et al 1998 is provided in brackets. None of the ELC communities documented have been rated as provincially rare (Bakowsky 1996).

Table 3.6.2: Derry Green - Summary of Polygons by Cover Type and Ecosite/Vegetation Type					
BREAKDOWN OF POLYGONS BY GENERAL COVER TYPE					
Cover Type			**# of Polygons**	**Area (ha)**	**% Study Area**
Agriculture			49	484.72	64.4%
Anthropogenic			27	146.06	19.4%
Forest			18	18.18	2.4%
Cultural			38	75.71	10.1%
Wetland (swamps, marshes)			14	5.12	0.7%
Hedgerow			38	21.93	2.9%
Open Aquatic			2	0.39	0.1%
TOTAL STUDY AREA			186	752.12	100%
BREAKDOWN OF POLYGONS BY ELC ECOSITE/VEGETATION TYPES					
ELC Community	**ELC Code**	**ELC Ecosite/Vegetation Types**	**# of Polygons**	**Area (ha)**	**% Study Area**
Cultural Meadow	CUM1, 2, 3, 4, 5, 6, 7	Mineral Cultural Meadow Ecosite	23	59.24	7.9%
Cultural Plantation	CUP3	Coniferous Plantation Ecosite	2	0.79	0.1%
Cultural Thicket	CUT1	Mineral Cultural Thicket Ecosite	5	9.09	1.2%
Cultural Savannah	CUS1	Mineral Cultural Savannah Ecosite	2	3.17	0.4%
Cultural Woodland	CUW	Cultural Woodland	2	0.25	0.0%
Cultural Woodland	CUW1	Mineral Cultural Woodland Ecosite	4	3.17	0.4%
		Total Cultural Communities	**38**	**75.71**	**10.1%**
Deciduous Forest	FOD4	Dry-Fresh Deciduous Forest Type	2	0.25	0.0%
Deciduous Forest	FOD4-2	Dry-Fresh White Ash Deciduous Forest Type	1	0.52	0.1%
Deciduous Forest	FOD6-1	Fresh-Moist Sugar Maple-Lowland Ash Deciduous Forest	1	0.98	0.1%
Deciduous Forest	FOD7	Fresh-Moist Lowland Deciduous Forest Type	1	0.05	0.0%
Deciduous Forest	FOD7-2	Fresh-Moist Ash Lowland Deciduous Forest Type	3	1.20	0.2%
Deciduous Forest	FOD7-3	Fresh-Moist Willow Lowland Deciduous Forest Type	1	0.32	0.0%
Deciduous Forest	FOD8-1	Fresh-Moist Poplar Deciduous Forest	1	0.10	0.0%
Deciduous Forest	FOD9	Fresh-Moist Oak-Maple-Hickory Deciduous Forest Ecosite	2	6.05	0.8%
Deciduous Forest	FOD9-2	Fresh-Moist Oak-Maple Deciduous Forest Type	1	1.56	0.2%
Deciduous Forest	FOD9-3	Fresh-Moist Bur Oak Deciduous Forest Type	2	2.94	0.4%
Deciduous Forest	FOD9-4	Fresh-Moist Shagbark Hickory Deciduous Forest Type	3	4.20	0.6%
		Total Deciduous Forest Communities	**18**	**18.18**	**2.4%**
Deciduous Swamp	SWD	Deciduous Swamp	1	0.00	0.0%
Deciduous Swamp	SWD3-3	Swamp Maple Deciduous Swamp	1	0.55	0.1%
Deciduous Swamp	SWT2-9	Gray Dogwood Mineral Thicket Swamp	2	0.94	0.1%
		Total Deciduous Swamp Communities	**4**	**1.49**	**0.2%**

Table 3.6.2: Derry Green - Summary of Polygons by Cover Type and Ecosite/Vegetation Type					
Meadow Marsh	MAM	Meadow Marsh	2	0.00	0.0%
Meadow Marsh	MAM2	Mineral Meadow Marsh Ecosite	4	1.87	0.2%
Meadow Marsh	MAM2-10	Forb Mineral Meadow Marsh	3	0.59	0.1%
Shallow Marsh	MAS2-1	Cattail Mineral Shallow Marsh	1	1.17	0.2%
		Total Marsh Communities	**10**	**3.63**	**0.5%**
Open Water	OAO	Open Aquatic	2	0.39	0.1%
		Total Open Water Communities	**2**	**0.39**	**0.1%**

Table 3.6.3: Boyne Survey - Summary of Polygons by Cover Type and Ecosite/Vegetation Type					
BREAKDOWN OF POLYGONS BY GENERAL COVER TYPE					
Cover Type			**# of Polygons**	**Area (ha)**	**% Study Area**
Agriculture			45	763.76	78.94
Anthropogenic			39	77.52	8.01
Forest			9	30.30	3.13
Cultural			34	52.48	5.42
Wetland (swamps, marshes)			19	11.73	1.21
Hedgerow			42	31.22	3.23
Thicket			1	0.58	0.06
		TOTAL STUDY AREA	**189**	**967.59**	**100.00**
BREAKDOWN OF POLYGONS BY ELC ECOSITE/VEGETATION TYPES					
ELC Community	**ELC Code**	**ELC Ecosite/Vegetation Types**	**# of Polygons**	**Area (ha)**	**% Study Area**
Cultural Meadow	CUM	n/a	3	0.82	0.08
Cultural Meadow	CUM1	Mineral Cultural Meadow Ecosite	21	40.97	4.23
Cultural Plantation	CUP3	Coniferous Plantation Ecosite	2	1.25	0.13
Cultural Savannah	CUS1	Mineral Cultural Savannah Ecosite	1	1.93	0.20
Cultural Thicket	CUT	n/a	1	1.39	0.14
Cultural Woodland	CUW1	Mineral Cultural Woodland Ecosite	6	6.13	0.63
		Total Cultural Communities	**34**	**52.48**	**5.42**
Deciduous Forest	FOD	n/a	3	21.19	2.19
Deciduous Forest	FOD4	Dry-Fresh Deciduous Forest Ecosite	2	3.37	0.35
Deciduous Forest	FOD7-3	Fresh-Moist Willow Lowland Deciduous Forest Type	1	0.45	0.05
Deciduous Forest	FOD9	Fresh-Moist Oak-Maple-Hickory Deciduous Forest Ecosite	1	1.43	0.15
Deciduous Forest	FOD9-3	Fresh-Moist Bur Oak Deciduous Forest Type	1	2.09	0.21
Deciduous Forest	FOD9-4	Fresh-Moist Shagbark Hickory Deciduous Forest Type	1	1.78	0.18
		Total Deciduous Forest Communities	**9**	**30.30**	**3.13**
Deciduous Swamp	SWD1-2	Bur Oak Mineral Deciduous Swamp Type	1	3.55	0.37
Deciduous Swamp	SWD3-3	Swamp Maple Mineral Deciduous Swamp Type	1	2.73	0.28
		Total Deciduous Swamp Communities	**2**	**6.28**	**0.65**

Table 3.6.3: Boyne Survey - Summary of Polygons by Cover Type and Ecosite/Vegetation Type					
Meadow Marsh	MAM	n/a	6	1.32	0.14
Meadow Marsh	MAM2	Mineral Meadow Marsh Ecosite	1	0.62	0.06
Meadow Marsh	MAM2-2	Reed Canary Grass Mineral Meadow Marsh Type	3	1.89	0.19
Meadow Marsh	MAM2-10	Forb Mineral Meadow Marsh Type	1	0.15	0.02
Shallow Marsh	MAS2	Mineral Shallow Marsh Ecosite	1	0.27	0.03
Shallow Marsh	MAS2-1	Cattail Mineral Shallow Marsh Type	2	0.22	0.02
		Total Marsh Communities	**14**	**4.47**	**0.46**
Thicket Swamp	SWT	n/a	2	0.65	0.07
Thicket Swamp	SWT2-2	Willow Mineral Thicket Swamp Type	1	0.33	0.03
		Total Thicket Swamp Communities	**3**	**0.98**	**0.1**
Thicket	THDM2-4 (CUT1-4)	Gray Dogwood Deciduous Shrub Thicket Type (Gray Dogwood Cultural Thicket Type)	1	0.58	0.06
		Total Thicket Communities	**1**	**0.58**	**0.06**

Table 3.6.4: Lands West of Tremaine Road - Summary of Polygons by Cover Type and Ecosite/Vegetation Type					
BREAKDOWN OF POLYGONS BY GENERAL COVER TYPE					
Cover Type			**# of Polygons**	**Area (ha)**	**% Study Area**
Agriculture			6	143.60	85.53
Anthropogenic			4	10.21	6.08
Forest			0	0	0
Cultural			2	3.21	1.91
Wetland (swamps, marshes)			2	4.59	2.73
Hedgerow			11	6.29	3.75
TOTAL STUDY AREA			**25**	**167.89**	**100.00**
BREAKDOWN OF POLYGONS BY ELC ECOSITE/VEGETATION TYPES					
ELC Community	**ELC Code**	**ELC Ecosite/Vegetation Types**	**# of Polygons**	**Area (ha)**	**% Study Area**
Cultural Meadow	CUM1	Mineral Cultural Meadow Ecosite	2	3.21	1.91
		Total Cultural Communities	**2**	**3.21**	**1.91**
Meadow Marsh	MAM2	Mineral Meadow Marsh Ecosite	1	1.84	1.10
Shallow Marsh	MAS2-1	Cattail Mineral Shallow Marsh Type	1	2.74	1.63
		Total Marsh Communities	**2**	**4.59**	**2.73**

A total of 72 ELC vegetation polygons were documented within the Derry Green study area (ref. Appendix 'H' Figure T1). Nine ELC community series, including 23 different ELC ecosite and vegetation types were observed. In total 13 vegetation polygons were found to be wetlands, totalling 7.8 ha and representing 0.9% of the study area.

A total of 73 ELC vegetation polygons were documented from the Boyne Survey study area (ref. Appendix 'H' Figure T2). Eleven ELC community series, including 23 different ELC ecosite and vegetation types were observed. In total 19 vegetation polygons were found to be wetlands, totalling 11.73 ha and representing 1.21% of the study area.

A total of 4 ELC vegetation polygons were documented from the lands west of Tremaine Road (ref. Appendix 'H' Figure T3). Three ELC community series, including 3 different ELC ecosite and vegetation types were observed. In total 2 vegetation polygons were found to be wetlands, totalling 4.59 ha and representing slightly less than 3% of the study area. One of these wetlands is part of the Provincially Significant Indian Creek Wetland Complex.

A total of 218 vascular plant species were documented to genus or species level in the 16 Mile Creek detailed study areas, outside of the 16 Mile Creek ESA (ref. Appendix 'H'). Twenty-three species (10.6%) are considered significant (i.e. uncommon or rare) in the Halton Region according to Crins *et al.,* 2006 or Varga *et al.,* 2005 (ref. Table 3.6.5). No provincially or federally significant species were documented.

Table 3.6.5: List of Significant Plant Species Documented in the Subwatershed Update Study Area

Scientific Name	Common Name	Halton Status*		Habitat Where Found In Study Area
		Crins *et al.*[1]	Varga *et al.*[2]	
Ambrosia trifida	Great Ragweed	HU	---	Deciduous Forest, Woodland, Meadow
Bidens vulgata	Tall Beggar's Ticks	HU	U	Meadow Marsh
Carex bebbii	Bebb's Sedge	---	U	Deciduous Forest/ Marsh
Carex crinita	Fringed Sedge	HU	U	Deciduous Forest/ Meadow Marsh
Carex grayi	Gray Sedge	HU	R4	Deciduous Swamp/Forest
Carex lacustris	Lake-bank Sedge	---	U	Meadow Marsh
Carya ovata var. ovata	Shagbark Hickory	---	U	Deciduous Forest
Carex projecta	Necklace Sedge	HU	U	Deciduous Forest
Carex scoparia	Pointed Broom Sedge	HR	R1	Deciduous Swamp/Forest
Chelone glabra	Turtlehead	---	U	Meadow Marsh
Claytonia virginica	Narrow-leaved Spring Beauty	HU	U	Deciduous Swamp/Forest, Cultural Savannah
Cornus canadensis	Bunchberry	HU	U	Deciduous Forest
Elymus riparius	River-bank Wild-rye	HR	R4	Deciduous Swamp
Geranium maculatum	Wild Geranium	---	U	Deciduous Forest/Cultural Savannah
Hackelia virginiana	Virginia Stickseed	HU	U	Deciduous Forest
Juniperus communis	Ground Juniper	HR	---	Cultural Meadow*
Penthorum sedoides	Ditch-stonecrop	HU	U	Meadow Marsh
Picea glauca	White Spruce	HU	U	Deciduous Forest, Cultural Plantation, Hedgerow*
Salix exigua	Sandbar Willow	---	U	Deciduous Woodland/Thicket
Salix lucida	Shining Willow	HU	U	Meadow Marsh
Sparganium eurycarpum	Large Bur-reed	HU	R4	Meadow Marsh
Stellaria longifolia	Longleaf Stitchwort	HU	U	Meadow Marsh
Waldsteinia fragarioides	Barren Strawberry	---	U	Deciduous Forest

[1]Status based on *The Vascular Plants of Halton Region, Ontario* (Crins *et al*., 2006).
HR = Rare in Halton (known from 5 or fewer sites)
HU = Uncommon in Halton (known from 6 to 15 sites)
[2]Status based on *Status of the Vascular Plants of the Greater Toronto Area* (Varga *et al*., 2005 [Draft]).
RX = X is the number of stations for a rare species in Halton Region
U = Uncommon in Halton Region
*Species was found in cultural unit and was likely planted.

All of the lands in the total Subwatershed Update Study area were covered in the original Sixteen Mile Creek Subwatersheds 2 & 7 Study (Philips Planning and Engineering Ltd. 2000) and the Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd. 2003). However, these studies were conducted several years ago, and numerous changes to the landscape have occurred since that time. A number of refinements were therefore made to update the original community mapping from these studies to the level of detail required for the present study (ref. Appendix 'H' Figures T1 – T3). Changes to mapping included updated ELC vegetation classifications, modified polygon boundaries due to the building of roads, and refinement of polygons to reflect the heterogeneity of a community.

Overall, the detailed Subwatershed Update Study Areas are dominated by agricultural and anthropogenic land uses (70 to 91%). These areas consist of current and former homesteads, roads, plowed fields, pastures and hedgerows. Of the remaining lands the majority are represented by semi-natural features such as cultural woodlands, plantations, savannahs, thickets, and meadows. Deciduous Forests and Marshes are the most numerous natural habitats in the study area. Lowland Forests and Meadow Marshes are the most common, the majority of which are associated with Sixteen Mile Creek and its tributaries. Of the forested communities documented all but one are associated with just 3 ELC Ecosites including Dry-Fresh Deciduous Forest (FOD4), Fresh-Moist Oak-Maple-Hickory Deciduous Forest (FOD9) and Fresh-Moist Lowland Deciduous Forest (FOD7). Polygon 374 is the only forest dominated by Sugar Maple (Fresh-Moist Sugar Maple- Lowland Ash Deciduous Forest, FOD6-1).

Five Deciduous Swamp polygons were identified in the study area and are primarily dominated by Bur Oak and Swamp Maple. Green Ash is dominant in one polygon and present as an understory and groundcover species in the other polygons.

Less common natural habitats in the study area include Shallow Marshes (4 Polygons), Thickets (3 Polygons) and Swamp Thickets (3 Polygons).

Wildlife

One hundred and sixty-one (161) species of wildlife were documented across the three parts of the study area (*i.e*. Derry Green, Boyne Survey, and lands west of Tremaine Road) by Dougan & Associates staff during the 2008 breeding season (ref. Appendix 'H'). This included 34 species of odonates (damselflies and dragonflies), 28 species of butterflies, 1 species of crayfish, 8 species of amphibians and reptiles, 80 species of birds, and 10 species of mammals. Appendix 'H' Figure T4 summarizes locations were wildlife data was collected.

Species at Risk

Of the identified species, ten are designated 'Species at Risk' (*i.e.* designated "Special Concern", "Threatened" or "Endangered" in Ontario (OMNRF, 2015) or Canada (COSEWIC, 2014). This included:

1. Monarch (*Danaus plexippus*) – “Special Concern” in Ontario and Canada
2. Western Chorus Frog (*Pseudacris triseriata*) – “Not at Risk” in Ontario, “Threatened” in Canada
3. Snapping Turtle (*Chelydra serpentina*) – "Special Concern" in Ontario and Canada
4. Common Nighthawk (*Chordeiles minor*) – "Special Concern" in Ontario, “Threatened” in Canada
5. Eastern Wood-Pewee (*Contopus virens*) – "Special Concern" in Ontario and Canada
6. Barn Swallow (*Hirundo rustica*) – "Threatened" in Ontario and Canada
7. Wood Thrush (*Hylocichla mustelina*) – "Special Concern" in Ontario and “Threatened” in Canada
8. Grasshopper Sparrow (*Ammodramus savannarum*)– "Special Concern" in Ontario and Canada
9. Bobolink (*Dolichonyx oryzivorus*) – “Threatened” in Ontario and Canada
10. Eastern Meadowlark (*Sturnella magna*) – "Threatened" in Ontario and Canada

A eleventh species at risk that was recorded as breeding in 1999 in Derry Green, Red-headed Woodpecker *(Melanerpes erythrocephalus)*, was not observed in surveys in 2008. It is currently designated Special Concern in Ontario and Threatened in Canada.

Monarchs were observed at various locations with the study areas. While some may have been migrants passing through, Common Milkweed (*Asclepias syriaca*) and Swamp Milkweed (*Asclepias incarnata*), their primary larval food source, were observed throughout the study areas in appropriate habitats and both caterpillars and a chrysalis were documented. They were also observed nectaring on a variety of other plants, including Spotted Joe-pye Weed (*Eupatorium maculatum ssp. maculatum*).

Western Chorus Frog was documented at a half dozen locations during the spring of 2008. All records were from the Boyne Survey or lands west of Tremaine Road and immediate vicinity. This information was integrated with records from earlier studies for the purposes of understanding the habitats and levels of occurrence in the study area. This is discussed later in this report.

A single Snapping Turtle was documented on August 19th 2008 in a flooded field near watercourse BP-2 in the Derry Green lands. On Nov. 2nd, 2011, a Snapping Turtle carcass was observed at the edge of a farm field just west of the Main Branch of Sixteen Mile Creek, south of Louis St. Laurent Blvd., in the Boyne lands. This species is still common in southern Ontario, although under significant stress largely due to the effects of road kill on the age and sexual composition of its populations.

A single Common Nighthawk was heard calling at night on May 24th 2008. Based on this date, it is not clear if this was a migrant passing through or a local breeder. Curry (2007) lists the average arrival date in spring (over the past 20 years) in Hamilton as May 18. Nevertheless, suitable habitat is present within the study area (Sandilands, 2008) and it was historically common in summer in Milton (Brooks, 1906 as per Curry, 2007). This was the only time that this species was documented in the study area by Dougan and Associates staff in 2008 and it was not encountered again in the final nocturnal survey. This species is most readily documented between dusk and dawn.

Eastern Wood-Pewee was recorded a total of 14 times. All observations were made in June or July 2008, except for one on September 17, 2008. Seven observations (representing four locations) were made in the Derry Green lands, five observations (representing three locations) were from the Boyne Survey, and two observations (representing one location) were from the lands west of Tremaine Road. All observations were associated with the largest remaining blocks of deciduous forest cover. This did not include the largest forest block present along the Sixteen Mile Creek main branch, which was not surveyed as part of this study.

Barn Swallow was documented a total of 15 times during the 2008 breeding season, including two observations from the Derry Green lands, six observations from the Boyne Survey lands, and seven observations the lands west of Tremaine Road. Two additional observations were made directly west of the lands west of Tremaine Road. Most of the observations pertained to single birds observed foraging over farm fields. A few others had higher breeding evidence where birds were observed near or actually entering buildings thought to support nesting. Observations were generally scattered throughout the three areas and since they were not regarded as Species at Risk at the time, no effort was made to confirm nesting sites.

Wood Thrush was documented three times during the breeding season in 2008. All three observations were in close proximity to one another; all occurred in a large block of deciduous forest in the Derry Green Lands, just east of Fifth Line (south of the Trafalgar Golf & Country Club).

A single Grasshopper Sparrow was documented from the Boyne Survey lands on July 10, 2008. It was initially heard singing and then observed in a 25 m band of shorter maintained grass right behind the 300 yard marker of the "Up to Par Golf Range" located at the northeast corner of Bronte Street and Britannia Road.

Bobolink was recorded at 8 locations contained within 3 areas of concentration, all within the Boyne survey lands. The first area of concentration was in fields on the east side of the CP railway tracks, west of First Line. The second area was midway between First Line and Regional Road #25, directly east of the main tributary that passes through the area. The third area was located in the southwest quadrant of the block of land bordered by Thompson Road South and Fourth Line. Numbers at each location varied from a single individual to as many as 12. One other site was directly west of the lands studied on the west side of Tremaine Road, just outside the study area boundary. This area-sensitive open field species is reliant on agricultural fields; it is a ground-nesting species subject to disturbance from farming operations and from nest predation.

Eastern Meadowlark was documented on two occasions in 2008, once from the Derry Green lands and once from the Boyne Survey lands. The first observation was on June 29, 2008. A single bird was observed on a small grassy ridge immediately east of the James Snow Parkway and just south of Main Street East. A second bird was observed from along a hedgerow approximately 470 m SE of the future Louis Saint Laurent Avenue and 470 m southwest of R.R. 25 on July 10, 2008.

Red-headed Woodpecker was detected as breeding in a woodlot in Derry Green in 1999; it was not detected in 2008 breeding surveys. According to COSEWIC (2010), this species has experienced a significant population decline over the long-term associated with habitat loss and the removal of dead trees in which it nests. The 2008 survey included examination of the tree where it was seen nesting in 1999. The increased availability of older growth cover would assist this species.

Provincial Status

Two "provincially rare" species (*i.e.* with a conservation rank of S1 [critically imperilled], S2 [imperilled] or S3 [vulnerable]) were recorded in 2008 (NHIC 2015). The two species were Giant Swallowtail (*Papilio cresphontes*) [a butterfly] ranked S2, and the Great Lakes/St. Lawrence - Canadian Shield population of the Western Chorus Frog (*Pseudacris triseriata*), ranked S3. All other wildlife species were designated S4 (apparently secure) or S5 (secure).

The adult Giant Swallowtail was observed in the valley by Sixteen Mile Creek Environmentally Sensitive Area (ESA). It was observed foraging on a variety of flowers but quickly departed from the area. Given the fact that the most commonly utilized larval host plants in southern Ontario (which corresponds with the northern edge of its geographic range) are Hop-tree (*Ptelea trifoliata*) and Prickly-ash (*Xanthoxylum americanum*) (Layberry *et al.,* 1998; Glassberg, 1999; Douglas and Douglas, 2005), neither of which have been recorded from the study area as part of this study, it is likely that the observation pertained to a stray or vagrant. Wormington (2006) lists only three known occurrences of Giant Swallowtail in Halton, all pertaining to apparent immigrants. In Hamilton, it is considered a permanent resident and on record from 16 locations (Wormington, 2006).

As mentioned earlier, Western Chorus Frog was documented at a half dozen locations during the spring of 2008. All records were from the Boyne Survey or lands west of Tremaine Road and immediate vicinity. This information was integrated with records from earlier studies for the purposes of understanding the habitats and levels of occurrence in the study area. This is discussed later in this report.

Regional Status (Lower Great Lakes – St. Lawrence Plain Bird Conservation Region)

Eighteen (18) species of wildlife documented from the study area in 2008 by Dougan & Associates are considered regionally significant (ref. Table 3.6.6). All 18 are landbirds and correspond with BCR 13, the Lower Great Lakes - St. Lawrence Plain Bird Conservation Region (OPIF, 2008). It is worth noting that comparable regional status lists do not exist for other wildlife species groups, with the exception of Plourde *et al.* (1989), which covers amphibians and reptiles. However, the area covered by Plourde *et al.* (1989) is not defined ecologically; rather it is based on OMNR's former "Central Region" jurisdiction. In addition, the list prepared by Ontario Partners in Flight (OPIF, 2008) only covers a subset of birds (albeit a large one), i.e. landbirds. Waterbirds (including waterfowl) and shorebirds are not included.

Eight of the 18 identified regionally significant landbird species are associated with grasslands or agriculture, four with successional areas, five with forests, and two with other miscellaneous habitats (OPIF, 2008). This reflects the fact that the majority of the study area is dominated by

agricultural land, successional areas associated with local drainage features and scattered, isolated and relatively small wooded areas. Breeding habitat descriptions are based on those used in the Ontario Breeding Bird Atlas (Cadman *et al.,* 2007).

Table 3.6.6: Regionally Significant Wildlife Species Documented from the Subwatershed Study Update Area by Dougan & Associates In 2008

No.	Common Name	Scientific Name	Breeding Habitat
1	Northern Harrier	*Circus cyaneus*	Wetlands
2	American Kestrel	*Falco sparverius*	Grassland/Agriculture/Open
3	Black-billed Cuckoo	*Coccyzus erythropthalmus*	Shrub and Early Succession
4	Belted Kingfisher	*Ceryle alcyon*	Wetlands
5	Northern Flicker	*Colaptes auratus*	Woods and Forests
6	Eastern Wood Pewee	*Contopus virens*	Woods and Forests
7	Willow Flycatcher	*Empidonax traillii*	Shrub and Early Succession
8	Eastern Kingbird	*Tyrannus tyrannus*	Grassland/Agriculture/Open
9	Wood Thrush	*Hylocichla mustelina*	Woods and Forests
10	Brown Thrasher	*Toxostoma rufum*	Shrub and Early Succession
11	Field Sparrow	*Spizella pusilla*	Shrub and Early Succession
12	Vesper Sparrow	*Pooecetes gramineus*	Grassland/Agriculture/Open
13	Savannah Sparrow	*Passerculus sandwichensis*	Grassland/Agriculture/Open
14	Grasshopper Sparrow	*Ammodramus savannarum*	Grassland/Agriculture/Open
15	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Woods and Forests
16	Bobolink	*Dolichonyx oryzivorus*	Grassland/Agriculture/Open
17	Eastern Meadowlark	*Sturnella magna*	Grassland/Agriculture/Open
18	Baltimore Oriole	*Icterus galbula*	Woods and Forests

Local Status (Halton Region)

At the local scale (*i.e*. Halton Region), 37 of the resident species of wildlife documented in 2008 (16 odonates, 2 butterflies, and 19 birds) are considered significant (*i.e*. casual, uncommon, or rare) (ref. Table 3.6.7).

Table 3.6.7: Locally Significant Resident Wildlife Species Documented from the Subwatershed Study Update Area by Dougan & Associates In 2008

	Common Name	Scientific Name	Local (Halton) Status	Breeding Habitat
Damselflies and Dragonflies				
1	River Jewelwing	*Calopteryx aequabilis*	Uncommon Permanent Resident (11 stations)	Streams & rivers (moderate flow)
2	American Rubyspot	*Hetaerina americana*	Rare Permanent Resident (4 stations)	Streams & rivers
3	Spotted Spreadwing	*Lestes congener*	Uncommon Permanent Resident (6 stations)	Still-water habitats, slow streams
4	Lyre-tipped Spreadwing	*Lestes unguiculatus*	Uncommon Permanent Resident (14 stations)	Ponds & slow streams
5	Violet Dancer	*Argia fumipennis violacea*	Uncommon Permanent Resident (13 stations)	Lakes & streams
6	Powdered Dancer	*Argia moesta*	Rare Permanent Resident (4 stations)	Streams & rivers, often at riffles
7	Rainbow Bluet	*Enallagma antennatum*	Rare Permanent Resident (2 stations)	Slow moving streams & rivers

Table 3.6.7: Locally Significant Resident Wildlife Species Documented from the Subwatershed Study Update Area by Dougan & Associates In 2008				
	Common Name	**Scientific Name**	**Local (Halton) Status**	**Breeding Habitat**
8	Stream Bluet	*Enallagma exsulans*	Rare Permanent Resident (5 stations)	Streams & rivers, ponds & lakes
9	Fragile Forktail	*Ischnura posita*	Rare Permanent Resident (3 stations)	Small, slow streams & ponds
10	Shadow Darner	*Aeshna umbrosa*	Uncommon Permanent Resident (6 stations)	Forest streams & ponds
11	Fawn Darner	*Boyeria vinosa*	Rare Permanent Resident (4 stations)	Shaded parts of streams & rivers
12	Halloween Pennant	*Celithemis eponina*	Rare Permanent Resident (5 stations)	Ponds, lakes & slow streams
13	Wandering Glider	*Pantala flavescens*	Rare Permanent Resident (2 stations)	Temporary pools & ponds
14	Eastern Amberwing	*Perithemis tenera*	Uncommon Permanent Resident (8 stations)	Ponds & slow streams
15	Band-winged Meadowhawk	*Sympetrum semicinctum*	Uncommon Permanent Resident (11 stations)	Marshes, ponds & slow streams
16	Autumn Meadowhawk	*Sympetrum vicinum*	Uncommon Permanent Resident (6 stations)	Ponds, marshes & slow streams
Butterflies				
1	Meadow Fritillary	*Boloria bellona*	Uncommon Permanent Resident	Grassy fields, (moist) meadows
2	Compton Tortoiseshell	*Nymphalis vaualbum*	Uncommon Permanent Resident	Wide variety of woodlands
Birds				
1	Wild Turkey	*Meleagris gallopavo*	Uncommon Resident	Woods and Forests
2	Northern Harrier	*Circus cyaneus*	Uncommon Summer Resident	Wetlands
3	Cooper's Hawk	*Accipiter cooperii*	Uncommon Local Resident	Woods and Forests
4	Upland Sandpiper	*Bartramia longicauda*	Rare Summer Resident	Grassland/Agricultural/Open
5	Wilson's Snipe	*Gallinago delicata*	Uncommon Summer Resident	Wetlands
6	Yellow-billed Cuckoo	*Coccyzus americanus*	Rare Summer Resident	Shrub/Early Succession
7	Black-billed Cuckoo	*Coccyzus erythropthalmus*	Uncommon Summer Resident	Shrub/Early Succession
8	Common Nighthawk	*Chordeiles minor*	Rare Local Summer Resident	Grassland/Agricultural/Open
9	Red-bellied Woodpecker	*Melanerpes carolinus*	Uncommon Resident	Woods and Forests
10	Willow Flycatcher	*Empidonax traillii*	Uncommon Summer Resident	Shrub/Early Succession
11	Horned Lark	*Eremophila alpestris*	Uncommon Summer Resident	Grassland/Agricultural/Open
12	Purple Martin	*Progne subis*	Uncommon Summer Resident	Shrub/Early Succession
13	N. Rough-winged Swallow	*Stelgidopteryx serripennis*	Uncommon Summer Resident	Grassland/Agricultural/Open
14	Sedge Wren	*Cistothorus platensis*	Casual Resident	Wetlands
15	Marsh Wren	*Cistothorus palustris*	Uncommon Local Summer Resident	Wetlands
16	Northern Mockingbird	*Mimus polyglottos*	Uncommon Resident	Shrub/Early Succession
17	Vesper Sparrow	*Pooecetes gramineus*	Uncommon Summer Resident	Grassland/Agricultural/Open
18	Grasshopper Sparrow	*Ammodramus savannarum*	Uncommon Summer Resident	Grassland/Agricultural/Open
19	Orchard Oriole	*Icterus spurius*	Rare Summer Resident	Woods and Forests

Area-sensitive Birds

Ten bird species that were encountered are described as "area-sensitive" (OMNR 2000). This includes:

1. Northern Harrier (*Circus cyaneus*) – open-country species
2. Cooper's Hawk (*Accipiter cooperii*) – woodland species
3. Upland Sandpiper (*Bartramia longicauda*) – open-country species
4. Hairy Woodpecker (*Picoides villosus*) – woodland species
5. White-breasted Nuthatch (*Sitta carolinensis*) – woodland species
6. American Redstart (*Setophaga ruticilla*) – woodland species
7. Savannah Sparrow (*Passerculus sandwichensis*) – open-country species
8. Grasshopper Sparrow (*Ammodramus savannarum*) – open-country species
9. Bobolink (*Dolichonyx oryzivorus*) – open-country species
10. Eastern Meadowlark (*Sturnella magna*) – open-country species

Area-sensitive species require larger areas of suitable habitat in order to sustain their populations and are therefore considered more sensitive to habitat loss and fragmentation. Six (6) of these species are associated with open-country habitats and four are associated with woodlands. The remaining wooded areas support a greater diversity of species and act as the principal refuge for many species. Many species were recorded in low numbers and are at risk of being displaced as the landscape becomes urbanized. The future Natural Heritage System will need to account for the needs of these species through consolidated natural cover and adequate buffers if they are to be sustained in the local landscape. This is addressed in Section 7.6.2 and in the FSEMS reports for Boyne and Derry Green, under separate cover.

Odonates

Thirty-five (35) species of odonates (damselflies and dragonflies) were documented by Dougan & Associates staff from the Derry Green Survey and Boyne Survey areas in 2008. Two other species were discovered in these areas in 2007 as part of another study (Dougan & Associates, 2008). Eight visits were made to the Derry Green Survey and Boyne Survey areas between late June and late September 2008 where the documentation of odonates was a focus (ref. Table 3.6.1). Data was also contributed incidentally during other visits. The lands west of Tremaine Road did not receive any specific coverage with respect to odonates but given the low extent of natural features present there, it is considered unlikely that any additional significant species (*i.e.* not already listed in Appendix 'H') would likely utilize the area. The largest wetland feature in the area (polygon #193), which is situated along the western boundary of the study area, is part of a provincially significant wetland (PSW) complex and of the Greenbelt natural heritage system, therefore subject to corresponding protection.

The number of odonate species recorded in 2007 and 2008 (37) is thought to be a relatively accurate reflection of the community of species present in this largely agricultural landscape. Breeding habitats for this group were generally small in size and isolated. No extensive wetlands or bodies of open water were present. Upland areas containing natural habitats (*i.e.* old fields, successional thickets, and woodlands) suitable for foraging purposes were also poorly represented. Important features corresponded with the Main and Middle branches of Sixteen Mile Creek, some of its lesser tributaries, as well as isolated wetland pockets and dug ponds.

No 'Species at Risk' were documented, but two provincially significant species were documented in 2007, River Bluets (*Enallagma anna*) and Painted Skimmer (*Libellula semifasciata*). Both are described earlier in the Background section. Both were associated with the main branch of Sixteen Mile Creek at the north end of the study area.

As indicated in Table 3.6.7, 16 of the 35 species of odonates (almost 46%) documented in 2008 are currently considered either uncommon or rare with the Regional Municipality of Halton (ref. Appendix 'H'). This seems like a relatively high percentage but the designations are somewhat conservative, artificially exaggerating the percentage. Despite the recent survey work conducted as part of the Halton Natural Areas Inventory, relatively little is still known about the community of species present. In time, it is likely that some of the species currently listed as uncommon or rare will be determined to be more common. It is also not clear whether the locations where the locally significant species recorded in 2008 by Dougan & Associates staff were previously documented by others, or whether these represent new locations and/or populations.

Butterflies

Twenty-eight (28) species of butterflies were documented within the three study areas; these are summarized in Appendix 'H'. These include one Species at Risk (Monarch – "Special Concern" in Canada and Ontario - see discussion under Background) and one S2-ranked species, Giant Swallowtail. We believe that the Giant Swallowtail was a vagrant passing through, as NHIC staff indicated that they were recorded in 2008 outside their typical core range. As this species is typically reliant on host plants (*i.e*. hop tree and prickly ash) which do not occur within in the study area, it is considered unlikely that the species would be sustained here. Two (2) locally significant butterfly species were also documented in 2008 (ref. Appendix 'H').

As discussed under odonates, natural habitats within the three study areas are relatively sparse, and overall butterfly diversity is reflective of this condition. Those species that we did document were not always common. This group would benefit from a more diverse natural heritage system and the protection of more extensive open habitats along watercourses. Provision of diverse native plant composition in the future landscape would assist these pollinator specialists.

Amphibians and Reptiles

Two (2) turtle species (Snapping Turtle and Midland Painted Turtle) have been documented. Snapping Turtle was documented in a flooded field near a stream channel in Derry Green; and in the vicinity of the Main Branch of Sixteen Mile Creek in Boyne; this species is designated "Special Concern" in Ontario (OMNRF, 2015) and Canada (COSEWIC, 2014). There are few natural aquatic habitats/ponds where turtles would occur in the three study areas. However there are numerous isolated farm ponds as well as golf course ponds that may be providing a significant role for this group in terms of sustaining their presence in the rural landscape.

Two (2) snake species (Dekay's Brownsnake and Eastern Gartersnake) were observed during the field studies, despite supplementary field searches which were undertaken in the late

summer/fall 2008 as per the Terms of Reference. It is likely that further species could occur, particularly in the vicinity of abandoned building foundations, and within the larger natural corridors. As discussed under Background, Eastern Milksnake (Status: Special Concern in Ontario) has been documented previously in the Sixteen Mile Creek main branch, as well as northwest of the Derry Green study area. Cover board surveys were conducted in 2007 in conjunction with the Class EA for the Louis St. Laurent Blvd. crossing of Sixteen Mile Creek, but no snakes were encountered.

Six (6) species of amphibians were encountered within the study areas; all are considered common to abundant in Halton Region. Western Chorus Frog was documented within the Boyne Survey lands by both LGL Ltd. and Dougan & Associates. It was also documented by Dougan & Associates in ESA #11 just west of the lands studied on to the west of Tremaine Road. The Great Lakes - St. Lawrence population of the Western Chorus Frog, to which these individuals are thought to belong, was designated “Threatened” federally by COSEWIC in April 2008. Its status was reviewed provincially in the spring of 2009 and was determined to be “Not at Risk” in Ontario. It should be noted that the listed population is not readily distinguished from more common populations based on morphological features; therefore the status of the individuals detected at the several sites cannot be ascertained without detailed genetic studies of samples. MNR Aurora District biologists have advised that all Western Chorus Frogs encountered should be considered the listed population.

This species was documented predominantly within small farm ponds located in the agricultural landscape, in small wetlands associated with some upland cover, and in one larger natural feature. Based on discussions with staff from Conservation Halton and the Town of Milton, we initiated further field investigations in 2009 to analyse specific ponds and features that are associated with records for this species. This information will be used to support strategies to address this species of concern in the formulation of a Natural Heritage System for that area. This is discussed later in this report.

3.6.4 Analysis

Terrestrial

General Comments

With respect to Derry Green, the most extensive natural communities (ref. Appendix ‘H’ Figure T1) are associated with the valley lands of the East/Middle Branches of 16 Mile Creek which are already protected under Regional and Town policies, Conservation Halton’s Regulation (ref. Section 5.4), and mostly included in the Greenbelt. Most of these features are heavily degraded by human encroachment (farming and residential uses) and exotic species invasions. This area therefore represents a key opportunity area for enhancement and restoration to create a more functional corridor along the East/Middle Branches of Sixteen Mile Creek. Although the majority is located outside the Derry Green Secondary Plan area, they are within the Town of Milton, providing opportunity for enhancement and restoration through partnering initiatives with landowners, the Region of Peel and Conservation Halton.

Natural communities in Derry Green outside the Middle Branch corridor are predominantly isolated pockets within the landscape. Protection of major features and the creation of linkages between them will be necessary to retain their current function and to achieve a net gain of habitat and ecological functions. Two existing land uses, including the Union Gas pipeline corridor, and the Ontario Power Generation transmission corridor, are conducive to linkage purposes and also support a key species guild i.e. area-sensitive open country birds.

With respect to the Boyne Survey lands, the most extensive natural communities (ref. Appendix 'H' Figure T2) are associated with the 16 Mile Creek ESA which is already protected under Regional and Town policies. The balance of the landscape, apart from some riparian cover which is in a semi-natural condition, is highly fragmented by farming and associated residential uses. There are limited opportunities for linkages that would connect remnant natural features of any size within or beyond these lands. The area therefore represents a key opportunity area for enhancement and restoration to reinforce the primary functional corridor along the Main Branch of Sixteen Mile Creek.

Significant Woodlands

Forests and woodlands meeting Halton Region's Significant Woodland criteria were identified in the Derry Green and Boyne Survey lands, and immediately west of the lands studied to the west of Tremaine Road. These have been considered for protection under Region of Halton policies. Candidate features were assessed using the Halton Region significant woodland criteria; these are identified in Table 3.6.8 according to polygon numbers. Any woodlands that were found to meet one or more of the four criteria set out by Halton Region (i.e. (a) forest patches over 99 years old, (b) greater than 2 ha in the urban area, (c) greater than 4 ha of interior core area, or (d) within 50 m of a major creek or certain headwater creeks) have been mapped as Significant Woodlands (ref. Appendix 'H' Figure T5 – Significant Features). With respect to older growth woodlands, there are sporadic individual older growth trees within features, but there were no features identified that support concentrated forest patches greater than 99 years in age. Older growth specimens of Bur Oak occur in some agricultural field areas and hedgerows. Any of the woodlands that contain individual trees greater than 99 years old, are already assigned Significant Woodland status based on feature size or stream proximity criteria.

A Significant Woodland complex located within Derry Green was subjected to partial clearing in June 2008 prior to completion of the full suite of site-specific terrestrial studies. There had also been previous clearing of heritage trees in the vicinity of this feature. Portions of this feature prior to the illegal clearing met the criteria for Significant Woodland, and the overall complex of habitats was identified in the preliminary NHS considered in February 2008 as a key feature to be integrated. Appendix 'H' Figure T1 includes the complex of features in this area, and also indicates the approximate extent of the woodlot clearing.

There are no woodland features within the lands studied to the west of Tremaine Road, however a major natural system identified in the Halton NAI as the Indian Creek Subwatershed Environmentally Sensitive Area #11, which also meets the Region of Halton criteria for Significant Woodlands, is located immediately west of the lands studied to the west of Tremaine Road. This area also contains a portion of the Indian Creek PSW Complex.

Table 3.6.8: Woodlands Meeting Halton Region Significant Woodland Criteria (Section 277 of the Regional Official Plan)

Single Wood-land Unit (SWU)	ID	Description	ELC	Area (ha) Within Study Area	Area (ha) Total	Forest Patches Over 99 Years Old	> 2ha in an Urban Area	Interior Core Area > 4ha	Within 50m of a Major Creek or Certain Headwater Creek
DERRY GREEN	**Total Significant Woodland Area Within Study Area 27.85 ha**								
	BP-56	Dry-Fresh Deciduous Forest Ecosite	FOD4	0.17	0.67	No*	No	No	Yes
	BP-57	Fresh-Moist Manitoba Maple Lowland Deciduous Forest	FODM 7-7	2.09	2.09	No*	Yes	No	Yes
	BP-58	Mineral Cultural Woodland Ecosite	CUW1	1.08	1.08	No*	No	No	Yes
	134	Fresh-Moist Ash Lowland Deciduous Forest	FOD7-2	0.38	1.96	No*	No	No	Yes
SWU	137a	Fresh-Moist Oak-Maple-Hickory Deciduous Forest Ecosite	FOD9	4.66	4.66	No*	Yes	No	No
	137b	Fresh-Moist Bur Oak Deciduous Forest	FOD9-3	2.08	3.96	No*	Yes	No	Yes
	137c	Fresh-Moist Ash Lowland Deciduous Forest	FOD7-2	0.29	7.86	No*	Yes	No	Yes
SWU	374	Fresh-Moist Sugar Maple-Lowland Ash Deciduous Forest	FOD6-1	0.98	0.98	No*	No	No	Yes
	381	Fresh-Moist Shagbark Hickory Deciduous Forest	FOD9-4	4.20	4.20	No*	Yes	No	Yes
	465a	Swamp Maple Deciduous Swamp	SWD3-3	0.55	0.55	No*	No	No	Yes
	465c	Fresh-Moist Bur Oak Deciduous Forest	FOD9-3	0.87	0.87	No*	No	No	Yes
SWU	474	Fresh-Moist Oak-Maple Deciduous Forest	FOD9-2	1.59	1.56	No*	No	No	Yes
	485	Fresh-Moist Ash Lowland Deciduous Forest	FOD7-2	0.52	0.52	No*	No	No	Yes
	475b	Mineral Cultural Woodland Ecosite	CUW1	1.74	1.74	No*	No	No	Yes
	476	Fresh-Moist Native Deciduous Regeneration Thicket	THDM 4-1	2.39	2.39	No*	Yes	No	Yes
	480g	Mineral Cultural Woodland Ecosite	CUW1	0.02	3.07	No*	Yes	No	Yes
	489	Fresh-Moist Lowland Deciduous Forest	FOD7	0.05	3.41	No*	Yes	No	Yes
	1012	Dry-Fresh White Ash Deciduous Forest	FOD4-2	0.52	0.56	No*	No	No	Yes
SWU	1112	Deciduous Woodland-Gray Dogwood Deciduous Thicket Complex	WODM/ THDM 2-4	2.32	2.65	No*	Yes	No	Yes
	1129	Fresh-Moist Oak-Maple-Hickory Deciduous Forest Ecosite	FOD9	1.39	1.39	No*	No	No	Yes

Table 3.6.8: Woodlands Meeting Halton Region Significant Woodland Criteria (Section 277 of the Regional Official Plan)

Single Wood-land Unit (SWU)	ID	Description	ELC	Area (ha) Within Study Area	Area (ha) Total	Forest Patches Over 99 Years Old	> 2ha in an Urban Area	Interior Core Area > 4ha	Within 50m of a Major Creek or Certain Headwater Creek
BOYNE Total Significant Woodland Area Within Study Area 36.95 ha									
	31c	Fresh-Moist Oak-Maple-Hickory Deciduous Forest Ecosite	FOD9	1.43	1.43	No*	No	No	Yes
	124	Swamp Maple Mineral Deciduous Swamp	SWD3-3	2.73	2.73	No*	Yes	No	Yes
SWU	108a	Dry-Fresh Deciduous Forest Ecosite	FOD4	1.77	1.84	No*	No	No	Yes
	108b	Mineral Cultural Woodland Ecosite	CUW1	0.97	1.05	No*	No	No	Yes
	125a	Mineral Cultural Woodland Ecosite	CUW1	2.63	2.87	No*	Yes	No	Yes
	216a	Bur Oak Mineral Deciduous Swamp	SWD1-2	3.55	3.55	No*	Yes	No	Yes
	227a	Fresh-Moist Bur Oak Deciduous Forest	FOD9-3	2.22	2.22	No*	Yes	No	No
SWU	P3-82	Deciduous Forest	FOD	6.74	6.74	No*	Yes	No	Yes
	P3-84	Deciduous Forest	FOD	14.34	14.34	No*	Yes	No	Yes
	P3-91	Thicket Swamp	SWT	0.57	0.57	No*	No	No	Yes

* None of the woodlands identified in this table is considered older than 99 years, based on information collected for ELC.

Wetlands

In early 2008 Dougan and Associates received preliminary mapping of potential wetland features in the study area from Conservation Halton. In April 2008 a site walk was conducted by Town and Conservation Halton staff, accompanied by Dougan & Associates ecologists, to review natural areas within the Derry Green, Boyne Survey and lands west of Tremaine Road. During that review it was established that some of the areas mapped as 'potential wetlands' by Conservation Halton do not qualify as wetlands, while Dougan & Associates staff noted additional features that meet ELC criteria for wetlands. Dougan & Associates has also reviewed ELC mapping from LGL Ltd. for portions of the Boyne Survey lands.

Based on field assessments conducted in 2007 and 2008, the most significant wetland features within the detailed study areas are those associated with the Indian Creek Wetland Complex PSW, located along the western periphery of the proposed lands west of Tremaine Road, which was previously evaluated by MNR.

Several unevaluated wetland features were identified in the Derry Green and Boyne Survey landscapes (ref. Appendix 'H' Figure T5). These are all relatively small and generally isolated. In March 2009, Dougan & Associates met with staff of Conservation Halton and the Town of Milton to discuss the approach to evaluating these features.

Unevaluated wetlands were considered for evaluation. The assessment was completed by Dougan and Associates staff certified under the Ontario Wetland Evaluation System (OMNR

1993). Vegetation communities, flora and fauna of these areas were previously characterized using the Ecological Land Classification system (Lee et. al., 1998). All wetlands identified in the ELC data were screened for potential evaluation. This assessment included a review of wetland size and distance from other wetlands within and beyond the detailed study areas. The size of each wetland polygon was estimated using GIS, and the distance between each wetland polygon was estimated using Google Earth ™.

Two small wetlands were determined to be close enough to the Indian Creek PSW Complex, that they have potential to be added to that complex. The initial assessment also included an examination for significant functions. The Indian Creek PSW Complex data record summarized 9 criteria were used to determine significant function. If a wetland met at least one of these criteria it could be considered for inclusion in the complex. The same criteria were applied to determine which of the study area wetlands have significant function. These criteria include:

a) Support wetland types not well represented elsewhere in the wetland complex;
b) Sustain significant flora species or communities (i.e. conservation priority , or rare or uncommon species);
c) Sustain significant fauna (i.e. conservation priority bird species or reptile/amphibian species of concern, or rare or uncommon species /communities in site district 7E4, site region 7, provincial or national);
d) Amphibian breeding ponds;
e) Function as migratory waterfowl stopovers, summer feeding areas or breeding areas;
f) Headwater sources or contribute base flows;
g) Hydrologically connected to larger wetlands;
h) Provide intervening wetland habitat between larger wetlands;
i) Occur along corridors.

Several wetlands were determined to be inappropriate for evaluation since they were less than 2 ha in size and were not found to have significant functions according to the criteria. Catchment mapping was reviewed to assist in determining which wetlands could potentially be complexed.

In 2010 the wetland evaluations were discussed with MNR technical staff and draft data records were circulated to MNR. It was noted at that time that some of the wetlands being evaluated have the potential to be included as part of the existing Indian Creek Provincially Significant Wetland Complex. A site walk was carried out on April 18, 2011 to further examine the wetlands undergoing evaluation. Staff from the Town of Milton, MNR, LGL Ltd, TMIG, Savanta and Dougan & Associates attended this site walk. The wetlands in the Boyne Survey and lands west of Tremaine Road were reviewed and resulted in some revisions to the wetland evaluations.

A site walk was carried out on Oct 26, 2011 stake the boundaries of several wetlands under evaluation in the Boyne Survey and lands west of Tremaine Road. Staff from MNR, Savanta, Conservation Halton and Dougan and Associates attended this site walk. Land surveyors, working on behalf of landowners, were also present to record the wetland boundary as staked. One small wetland feature that had not previously been mapped was identified during this site walk, west of Tremaine Road. This site walk resulted in some adjustment of vegetation communities and wetland boundaries. Dougan and Associates submitted draft wetland data

records for MNR review on November 29, 2011 with the understanding that they will need to be revised once MNR has confirmed the wetland staking mapping.

The final screening assessment identified three separate wetland evaluations including one stand-alone wetland, and two wetland complexes. The wetland pocket identified as ELC polygon C-14 was also identified as a candidate to be added to the existing Indian Creek Wetland Complex. Wetland evaluations were completed following OWES 1993 protocols. Since existing data was available from 2007- 2008, these evaluations were initially intended to be completed as a desk-top exercise, however additional field data was collected during 2010 and 2011 site walks that was factored into the evaluation scoring. Table 3.6.9 provides a summary of the subject wetlands and Appendix 'H' Figure T5 highlights their locations. The findings are subject to review and acceptance by MNR.

Table 3.6.9: Wetland Evaluations

Evaluation #	Detailed Study Area	ELC polygons included	Total Wetland Area (ha)	Evaluation Status and Recommendations
Boyne Complex	Lands west of Tremaine Road & Boyne Survey/Phase 3	216a, 216b, 216c, 216d, 216h, 216i, 216j, 216k, 225a, 225c, 227b, 229a, 229b	4.64	Potentially[1] Provincially Significant (Meets complexing minimum distance triggers and Special Features score >200)
SMC-1	Boyne Survey/Phase 3	124	2.73	Locally Significant
SMC-2	Derry Green	1081a, 1099b, 137f, 143a, BP-98	6.69	Locally Significant

* Potential to link with the Indian Creek PSW Complex

Wetland Evaluation Boyne Complex (Boyne Survey/Phase 3)

The wetland information included in this evaluation has been revised several times since the beginning of the evaluation process due to the addition of new data and discussions with MNR. The current evaluation includes several wetland pockets in the Boyne Survey study area (ELC polygons 216a, 216b, 216c, 216d, 216h, 216i, 216j, 216k, 225a, 225c, 227b, 229a, 229b) located within the Indian Creek Subwatershed.

Two provincially significant wildlife species are on record in this wetland including Monarch (*Danaus plexippus*) (ranked SC by COSEWIC, SC by COSSARO, S2NS4B by MNR); and Western Chorus Frog *(Pseudacris triseriata) (*ranked THR by COSEWIC, S3 by MNR, and tracked by the NHIC). Four locally significant species were also noted within this wetland including Star Duckweed (*Lemna trisulca*), Swamp Rose (*Rosa palustris*), Blunt Broom Sedge (*Carex tribuloides*), and Halloween Pennant (*Celithemis eponina*).

These wetlands are within 750 m of, and could be considered for addition to the Indian Creek PSW Complex, however these isolated wetlands are separated from the remainder of the Indian Creek PSW by Tremaine Road and do not function as part of this larger wetland complex. MNR and Dougan and Associates staff met on March 16, 2011 to discuss MNR opinions on complexing these wetlands with the Indian Creek PSW. MNR staff suggested that even if

[1] Yet to be confirmed by MNR staff

considered as a separate unit, these wetlands may merit PSW status on their own. MNR staff recommended that an evaluation be done to determine if this is the case. The draft data record indicates that even as a stand-alone evaluation, this complex could be considered provincially significant; however the final assignment of status has not been released by MNR. The recommended Natural Heritage System for Boyne in the FSEMS includes consideration of alternative treatment of some wetland features, should MNR confirm that they are not part of a PSW.

Wetland Evaluation SMC-1 ((Individual Wetland Feature; Boyne Survey/Phase 3)

This evaluation included one wetland feature located within the Sixteen Mile Creek Watershed, a Swamp Maple Mineral Deciduous Swamp (polygon 124). The evaluation scoring indicated that the wetland is locally significant. This wetland is located along the corridor of the Centre Tributary of Sixteen Mile Creek. No rare or uncommon flora or fauna species were noted within the wetland.

Wetland Evaluation SMC-2 (Complex; Derry Green Industrial)

This evaluation includes a complex of small riverine wetland pockets, located within the Sixteen Mile Creek Watershed, dominated by marsh with some localized swamp. The complex scored locally significant. Two provincially significant wildlife species are on record in the vicinity of this wetland including Snapping Turtle (*Chelydra serpentina)* (ranked SC by COSSARO; and S3 by MNR, tracked by the NHIC); and Red-headed Woodpecker *(Melanerpes erythrocephalus)* ranked SC by COSSARO, THR by COSEWIC and tracked by the NHIC). Also noted within this wetland complex was the Fawn Darner (*Boyeria vinosa*), which, although not affecting the wetland score, is considered to be rare in Halton. Polygons BP-98, 137f and 143a are noted as amphibian breeding ponds. Polygons 1081a, 1099b and BP-98 closely connected hydrologically.

Other Wetlands (Lands West of Tremaine Road)

There are three wetlands in the lands west of Tremaine Road that, although discussed during the process were not included in these evaluations. These wetlands include ELC polygons C-14a, 193, and an un-numbered wetland located in the farm field to the east of 193.

Polygon C-14 is located immediately adjacent to the Indian Creek PSW complex and has the potential to be added to that complex. During the April 18, 2011 site walk this wetland was identified by MNR for staking later in the year. However, during the subsequent wetland boundary staking on October 26, 2011 this wetland could not be delineated as all vegetation had been cleared from the polygon. MNR staff advised that the approximate wetland boundary lines drawn during the April 18, 2011 site visit would be applied to this feature. Wetland polygon C-14a is located immediately adjacent to the existing Indian Creek PSW Complex; we will recommend to MNR that it be added to that complex.

Polygon 193 is a substantial wetland in the landscape and did not require evaluation as it is already designated as part of the Indian Creek PSW complex. The un-numbered wetland in the

field to the east of polygon 193 was identified, mapped, and staked during the October 26, 2011 site visit. This wetland has the potential to be added to the Indian Creek PSW complex.

Note: The SUS terrestrial characterization included lands west of Tremaine Road. The content of this SUS reflects background and field data collected between 2007 and 2011 for this area. These lands are undergoing a separate planning study (Milton Educational Village), and for the most current data and assessments, the reader should refer to the *Milton Educational Village Functional Servicing Environmental Management Strategy* (Draft) (AMEC 2013).

Significant Wildlife Habitat (and Other Significant Wildlife Issues)

Significant Wildlife Habitat (SWH) is protected under the Provincial Policy Statement (2014). This section summarizes our interpretation of SWH based on the MNR's Significant Wildlife Habitat Technical Guide (OMNR, 2000). Upper tier municipalities are encouraged to develop their own geographically-focused interpretations, but to date the Region of Halton has not completed this exercise. Threshold criteria have been developed for the Oak Ridges Moraine (OMNR, 2007) and the Region of Peel/Town of Caledon (NSE *et al*., 2008). In 2012, MNR also refined the technical guidelines for Significant Wildlife Habitat that pertain specifically to Ecological Site Regions 6E and 7E (OMNR, 2012a,b).

While the identification of Significant Wildlife Habitat was not the specific focus for the field studies, the analysis results described below provide guidance related to key SWH categories and criteria that are potentially met based on a review of occurrences against the general MNR guidelines for SWH identification. Additional field studies for certain identified biota should help define which features or functions actually qualify as SWH and better document their extent. General recommendations are provided below, management strategies for specific SWH are discussed in the FSEMS.

SWH Category - Seasonal Concentrations of Animals

- A1 - Deer wintering area (16 Mile Creek ESA); deer wintering usage not confirmed by MNR, who must confirm this category. Recommendation - Assess further in detailed site studies.

SWH Category - Rare Vegetation Communities or Specialized Habitats for Wildlife

- B2 - Habitat for area-sensitive species - hydro corridor and CP rail corridor in Derry Green; provides a relatively large open country habitat area with a high level of connectivity to the Greenbelt. Existing land uses offer consistency of habitat management. Other areas used by open country birds are irregular related to shifting agricultural practices. Recommendation – identify open hydro corridor lands as SWH; advise OPG; encourage stewardship and consider in future development applications. (Note: In April 2013, the SUS team advised Patricia Staite, Environmental Planner for Hydro One Networks Inc., that this area was identified as SWH)
- B5 - Foraging areas with abundant mast - woodlots in Derry Green & Boyne Survey containing abundant oak and hickory; meets SWH guidelines but general lack of forest cover limits availability of this specialized habitat. Recommendation – Protect within NHS (all sites are Significant Woodlands); manage for sustained mast production.

SWH Category - Species of Conservation Concern

- C1 - Species identified as Nationally Endangered or Threatened by COSEWIC which are not listed as Endangered or Threatened under Ontario's *Endangered Species Act*
  - Western Chorus Frog - Boyne Survey and lands west of Tremaine Road; pond habitats are very small and disturbed, with limited summer habitat available; two small features could qualify as SWH; much larger, less disturbed, higher quality habitat is present in adjoining Greenbelt. Recommendations – Only one site in lands west of Tremaine Road clearly qualifies as SWH as it is relatively large, has several habitats with the species present, has substantial non-breeding habitat available, and is well linked. Two smaller features in Boyne should be further studied as potential SWH to better confirm population presence and abundance. (Locations not provided in this report to protect the species in question; Conservation Halton staff and MNR are in possession of the data on these locations.)
  - Common Nighthawk - Derry Green; single observation outside breeding season; habitat suitable but potentially a migrant. Recommendation - insufficient occurrence to warrant consideration for SWH. Assess possible breeding in detailed site studies.
  - Red-headed Woodpecker *(Melanerpes erythrocephalus)* – Derry Green; recorded as breeding in 1999 but not observed during surveys of the same woodlot in 2008. Recommendation – does not qualify as SWH based on available data.
  - Wood Thrush (*Hylocichla mustelina*) – Derry Green; three birds recorded from one large woodland fragment. Recommendation – Protect the woodland that supports the only known breed location for the species within the study areas.
- C2 - Species identified as Special Concern under Ontario's *Endangered Species Act*
  - Snapping Turtle – single individual observed in Derry Green; potential breeding and feeding habitats exist in Derry Green, Boyne and lands west of Tremaine Road but species presence and abundance not established. Recommendation - no site specific habitats identified to date would qualify as SWH. Asses further in detailed field studies.
  - Common Nighthawk – Derry Green; single observation outside breeding season; habitat suitable but potentially a migrant. Recommendation - insufficient occurrence to warrant consideration for SWH. Assess possible breeding in detailed site studies.
  - Red-headed Woodpecker *(Melanerpes erythrocephalus)* – Derry Green; recorded as breeding in 1999 but not observed during surveys of the same woodlot in 2008. Recommendation – does not qualify as SWH based on available data.
  - Eastern Wood-Pewee (*Contopus virens*) – Derry Green; four birds recorded from four locations, three from woodland fragments and one from a hedgerow. Boyne; three birds recorded from three woodlots. Recommendation – All locations merit consideration as SWH with the exception of the hedgerow. Most, if not all, will be protected through other NHS triggers.
  - Monarch – observed throughout; warrants consideration but habitat is generalized in association with agricultural uses. Recommendation – does not trigger SWH. Address feeding and breeding habitat through NHS design.

- C3 - Species that are listed as rare (S1–S3) or historical in Ontario based on records kept by the Natural Heritage Information Centre in Peterborough
  - River Bluets [a damselfly] – 16 Mile Creek ESA; inadequate understanding of its general and local occurrence. Recommendation - Assess status further in detailed site specific studies. ESA is considered SWH based on other categories.
  - Giant Swallowtail (*Papilio cresphontes*) [a butterfly] ranked S2. Observed in Sixteen Mile Creek ESA, which is recommended as SWH based on other categories.
- C6 - Species rare within the Regional Municipality of Halton, even though they may not be provincially rare
  - Regionally listed plants and wildlife (ref. Appendix 'H'); may warrant consideration dependent on location. Recommendation – current habitats are generally small and isolated, and do not warrant SWH status. Protect existing habitats where the species occur. The Main and East/Middle Branches of Sixteen Mile Creek represents major habitat for odonates (damselflies and dragonflies) and are recommended as SWH under this and other categories.

SWH Category - Animal Movement Corridors

- Sixteen Mile Creek Main and East/Middle Branch corridors; major corridors, warrant consideration, however not all contained within study area. Recommendation – qualify as SWH; protect, enhance and restore major corridors within limits of mandate of SUS.

A key issue with respect to identification of SWH on these lands is the high degree of fragmentation, and therefore the stability of the current populations of species under existing conditions. From the standpoint of wildlife habitat specialists observed, the habitats present are in a 'sink' condition from a population biology standpoint; that is, the small remnant habitats are of insufficient size to sustain more than a few individuals of species, and these tend to be less successful at breeding and contributing to a stable population over time. Repeated failures at breeding result in 'winking' out of species in habitats, sometimes replaced at a later date by migrants from areas where habitat is more abundant, but sometimes permanently lost from the landscape. The cyclical nature of agricultural practices contributes to this instability. This condition can be addressed by focused strategies to expand core habitats, and provide supplementary habitat elements such as wetlands, throughout the landscape.

Regionally significant plants (ref. Table 3.6.5) were observed predominantly in wetlands and riparian areas; a few species with forest and woodland affinities were also observed. While these have some opportunity to persist despite fragmentation, displacement by invasive species is a concern. Utilization of these and other native species in habitat restoration works, and in landscaping of supportive uses such as stormwater management facilities, would increase their presence throughout the system, and ensure that they are part of the natural 'seed rain' within the future Natural Heritage System.

Damselflies and dragonflies (odonates) were documented scattered throughout the study areas and are generally associated with pond or watercourse features. Almost 50% of the species documented from the study areas are currently designated locally uncommon or rare but it is believed that the number of significant species may be artificially high, a reflection of the

relatively poor understanding of this group in the Region. Maintaining local odonate diversity will be contingent upon protecting the number and quality of breeding sites currently present. Nearby foraging areas will also need protection. Odonates will benefit from potential wetland creation initiatives.

Amphibians and reptiles, although widely distributed in discreet locations across the study areas, are present in relatively low numbers. Most observations were associated with small, isolated dug ponds/wetland pockets, or wetlands along drainage swales and/or creeks. A few are also located in remnant woodlots. The functions of the disturbed features could be readily recreated within a future natural heritage system, however, success will depend on creating alternative habitats prior to destruction of small isolated habitats, and maintaining or improving existing connectivity where this is feasible (ref. Section 7.6). Success may also be dependent on transplanting amphibians from one habitat to another via coordinated rescue efforts. Installing wildlife-friendly eco-passages under intersecting roads should be considered in the design of the natural heritage system (ref. Section 5.2.1 of both the Derry Green and Boyne FSEMS).

Several regionally and locally significant open-country breeding bird species, some of which are locally common, are prone to being displaced when the majority of existing agricultural lands and small cultural meadows are converted to urban uses. Some species are area-sensitive and will not persist in smaller, fragmented habitat patches. Urban stressors including increased predation and road kill can only be mitigated in substantial open space, such as that afforded by the Main and East/Middle Branches of Sixteen Mile Creek, or the hydro corridor. Opportunities to target lands where these species may persist include habitat management within the major corridors of Sixteen Mile Creek (Main and East/Middle Branches), the major hydro/utility and rail corridors, and through habitat restoration and site-specific complementary land-uses developed in conjunction with these areas.

Species at Risk

Nine Species at Risk were confirmed as residents in the study areas. These included:

1. Monarch (*Danaus plexippus*) – “Special Concern” in Canada and Ontario
2. Western Chorus Frog (*Pseudacris triseriata*) – “Threatened” in Canada, “Not at Risk” in Ontario
3. Snapping Turtle (*Chelydra serpentina*) – "Special Concern" in Canada and Ontario
4. Eastern Wood-Pewee (*Contopus virens*) – "Special Concern" in Canada
5. Barn Swallow (*Hirundo rustica*) – "Threatened" in Canada and Ontario
6. Wood Thrush (*Hylocichla mustelina*) – "Threatened" in Canada
7. Grasshopper Sparrow (*Ammodramus savannarum*) – "Special Concern" in Canada and Ontario
8. Bobolink (*Dolichonyx oryzivorus*) – “Threatened” in Canada and Ontario
9. Eastern Meadowlark (*Sturnella magna*) – "Threatened" in Canada and Ontario

Red-headed Woodpecker *(Melanerpes erythrocephalus)*, was observed during breeding season in 1999, but was not observed again in breeding surveys in 2008. Red-headed Woodpecker is designated “Special Concern” in Canada and Ontario.

Monarch

Monarch butterfly (*Danaus plexippus)* was listed as Special Concern federally in 1997, and has the same ranking in Ontario. Monarchs were observed at various locations with the study areas, and are considered common in southern Ontario. The species is threatened by loss of overwintering habitats in central Mexico and coastal California (COSEWIC 2010). Food sources and suitable nesting locations are abundant in southern Ontario. This species can benefit from naturalized meadow cover where its key food plants, Common Milkweed (*Asclepias syriaca*) and Swamp Milkweed (*Asclepias incarnata*), are common species that are the primary larval food source.

Western Chorus Frog

The eastern sub-population of Western Chorus Frog (WCF) (*Pseudacris triseriata*) was recommended in 2008 for "Threatened" federal status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2008a). WCF was discovered at locations directly within and adjacent to the Boyne Survey and lands west of Tremaine Road study areas. Most of the observations were in disturbed habitats or dug farm ponds that are relatively isolated from natural features and stream corridors. The critical habitat requirements (size, cover, hydrology and connectivity) of this species are not well documented. Although considerable efforts could be made to protect smaller existing breeding sites in situ, it is also recognized that given the proposed change from a rural, agricultural matrix to an urban landscape matrix, the creation of new breeding habitats within a future natural heritage system would be more likely to ensure long-term viability than protecting small farm ponds. Maintaining or improving connectivity between remaining and/or future sites will be a priority.

Dougan & Associates engaged in discussions with Conservation Halton staff in March 2009 regarding the potential approach for Western Chorus Frog and Snapping Turtle. While both species are relatively common in Halton Region, neither has been regularly considered in the planning of Natural Heritage Systems as part of recent subwatershed studies in southern Ontario.

The consensus outcome of the discussion was that a) attempts should be made where feasible to integrate habitats known to support WCF; b) further ecological study of the subwatershed sites where WCF is currently recorded would assist in the development of strategies to integrate these or replacement habitats within the NHS; c) MNR input on the possibility of sampling to assess the genetic composition of individuals at the known sites should be solicited; d) the most likely integration approach would be to consider the creation of diversified wetland and pool habitats within the future NHS to accommodate WCF and Snapping Turtle on an ongoing basis; and e) consideration of road impacts and the use of eco-passages will be essential if these species are to be sustained in the urban landscape. There is also concern that irrespective of the quality of a future NHS, construction activities may eliminate these species from the landscape before they have the opportunity to become resident within the future NHS.

Shortly after Dougan & Associates' discussion with Conservation Halton (*i.e.* March 2009), the Ministry of Natural Resources released its decision with respect to the conservation status of Western Chorus Frog. MNR determined that the eastern population of Western Chorus Frog is

"Not at Risk" in Ontario. Since there are no federally owned lands within the SUS area, specific protections would only be required if the habitats that support this species are identified as "Significant Wildlife Habitat" under the PPS (2014).. No thresholds specific to Halton Region have been developed to date that would determine which sites merit designation.

According to available literature, Western Chorus Frog can be found breeding in a variety of open wetland habitats including roadside ditches, marshes, flooded fields, pastures, temporary ponds and pools, open canopy ponds, rain flooded and damp meadows, temporary ponds in floodplains, forest edges, bottomland swamps, bog ponds, and glacial kettle ponds (COSEWIC 2008; Harding 1997; Kramer 1973; MacCulloch 2002; NatureServe 2009; Whitaker 1971; Whiting 2004), provided they are adjacent to suitable non-breeding habitat. The tadpoles are most abundant in ponds from 11 to 22 centimetres deep, but can occur in depths up to 40 cm (COSEWIC 2008 b). In general, the breeding habitat for Western Chorus Frog is with at least 10 cm of water, and with no fish (MacCulloch 2002; NatureServe 2009).

Summer foraging and overwintering habitat consist mostly of woodlands and shrubby areas adjacent to the edges of the breeding areas where there is leaf litter and loose shallow soil (COSEWIC 2008b, MacCulloch 2002). They can also be found in flooded areas, such as saturated soil in shrubby habitats (COSEWIC 2008b). It has been shown that the nature of the habitat found within 500 m of the breeding habitat has the most influence on the abundance of this species, and that terrestrial habitats utilized by Chorus Frogs in the summer, fall and winter are more important and specific in nature than the breeding habitats (Houlahan and Findlay 2003). Adults will hibernate usually within 200 m of their breeding sites, while juvenals will disperse anywhere from 50 to 200 m from their natal ponds (Harding 1997; Kramer 1973, 1974; NatureServe 2009).

In order to clarify the range of habitat types and conditions where Chorus Frogs have been reported, seven known Chorus Frog sites in the Boyne Survey area were assessed during the summer and fall of 2009 to further document the habitats. Data included dominant vegetation forms and species, water depth, substrate characterization, canopy cover, adjacent land uses and cover types, and distance from overwintering habitat. The frogs were determined to be breeding in a variety of wetland habitats, in sites that had at least one pond or marsh community with water greater than 11 cm deep. This is consistent with what has been reported in the literature. Although it is difficult to pinpoint the degree to which habitats are specifically used for breeding versus summer foraging and overwintering, and there is likely overlap, we now have sufficient information regarding the known Chorus Frog sites in the Boyne Survey/Phase 3 area to inform strategies to address this species of concern within the Natural Heritage System. Due to the potential for disturbance or removal of the habitats, Dougan and Associates will not provide site specific mapping and analysis within this report.

Snapping Turtle

Snapping Turtle (*Chelydra serpentina*) was listed as Special Concern federally in 2008, and was assigned the same status in Ontario shortly thereafter. Although recorded on only one site in Boyne, it is a relatively common species likely to show up in ponds and floodplains. Its life history (late maturity, great longevity, low recruitment, lack of density-dependent responses), and its dependence on long warm summers to complete incubation successfully, make it unusually susceptible to anthropogenic threats (COSEWIC 2008c). Road kill is of particular

concern as this species is slow-moving, and attracted to gravel roadsides for nesting. Nest predation by dogs, racoons and skunks is also a significant stressor. Measures to ensure safe passage under roads, to provide naturalized ponds for feeding and cover, and habitat enhancements with gravel banks or islands for nesting, are relatively simple and could be effective in retaining this species in the landscape.

Eastern Wood-Pewee

In November, 2012 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Eastern Wood-Pewee (*Contopus virens*) be designated “Special Concern” in Canada (COSEWIC, 2012). However, it has yet to be added to Schedule 1 of the Species at Risk Act. In Ontario, the Committee on the Status of Species at Risk in Ontario (COSSARO) reviewed its provincial conservation status in January 2013. Subsequently on June 27, 2014, it was designated “Special Concern” and added to the Species at Risk in Ontario List.

Although this species is a common and widespread songbird in eastern North America’s forest, and it appears to be resilient to a variety of habitat changes, it is (like most other long-distance migrants that specialize on a diet of flying insects) experiencing persistent declines over the past 40 years both in Canada and the United States. The causes of the decline are not understood, but might be linked to habitat loss or degradation on its wintering grounds in South America or changes in availability of insect prey.

Until the reasons for its decline are better understood, conservation efforts in the Milton study areas should ensure suitable breeding habitats are protected wherever they occur.

Barn Swallow

In May, 2011 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Barn Swallow (*Hirundo rustica*) be designated “Threatened” in Canada (COSEWIC, 2011). However, it has yet to be added to the Species at Risk Act. Barn Swallow was subsequently designated “Threatened” and added to the Species at Risk in Ontario (SARO) List on January 14, 2012.

Although this is one of the world’s most widespread and common landbird species, it, like many other species of birds that specialize on a diet of flying insects, has experienced very large declines over the past 20 to 30 years (COSEWIC, 2011). The magnitude and geographic extent of the decline has been cause for great conservation concern. Although it is acknowledged that there have been losses in the number of artificial nest sites (e.g., open barns) and in the amount of foraging habitat in open agricultural areas, the causes of the recent population decline are not well understood. Despite this, the best measures to try and ensure the species continues to be a resident in the three survey areas likely depends on providing artificial nest structures for the species, especially in areas adjacent to streams/ponds, wetlands and open fields within the proposed natural heritage system.

Wood Thrush

In November, 2012 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Wood Thrush (*Hylocichla mustelina*) be designated "Threatened" in Canada (COSEWIC, 2012). However, it has yet to be added to Schedule 1 of the Species at Risk Act. According to COSEWIC (2012): "this forest-nesting species has shown significant long and short-term declines in population abundance. The species is threatened by habitat loss on its wintering grounds and habitat fragmentation and degradation on its breeding grounds. It also suffers from high rates of nest predation and cowbird parasitism associated with habitat fragmentation on the breeding grounds." Common Grackles, Blue Jays and American Crows are significant nest predators. It is also known to be sensitive to development, avoiding woodlots surrounded by housing (Friesen *et al*., 1995).

The Ontario conservation status of Wood Thrush was reviewed in January 2013 by the Committee on the Status of Species at Risk in Ontario (COSSARO). Despite the fact that the Breeding Bird Survey data for Ontario indicated a significant annual population increase of 4.4% from 1981 to 2005, likely due to tripling of woodland cover south of the Canadian Shield since the 1920s, and the fact that it appears to be less impacted by cowbird parasitism in Ontario than elsewhere (Friesen, 2007), it was designated "Special Concern" and added to the Species at Risk in Ontario List on June 27, 2014.

Given the fact that the biggest threat to the species in Ontario is habitat fragmentation and degradation, preservation efforts within the study areas should focus on protecting and enhancing (*i.e.* enlarging) the woodlands fragments where the species has been documented breeding as well as other suitably-sized woodland fragments where they could nest in the future. This could be accomplished by reducing the amount of edge habitat relative to the core by allowing small gaps to naturalize. Preservation efforts will also be dependent on ensuring future buffers are wide enough to negate the associated negative impacts of adjacent developments, especially residential developments.

Grasshopper Sparrow

The Grasshopper Sparrow is a small, inconspicuous songbird with a high-pitched, insect-like song that prefers drier, sparsely vegetated grasslands, particularly rough or unimproved pastures at least 30 ha in size, where it forages almost exclusively on the ground. It also occasionally also inhabits hayfields (Vickery 1996; Earley, 2007). Although Grasshopper Sparrow prefers large tracts of open habitat at least 30 ha in size, they are sometimes documented from natural clearings only a few hectares in size (Vickery, 1996). Its occurrence in a relatively small verge of a mowed driving range (no longer in operation as of 2015) in Boyne does not constitute a viable habitat for the species.

According to the Committee on the Status of Species at Risk in Ontario, Grasshopper Sparrows have suffered continual annual population declines of 1.5% since the 1970s or a 46% decline over 40 years, and a non-significant decline of 13% in the 10 year period from 2002 to 2012 (COSSARO, 2014). Greatest threats appear to be habitat loss, fragmentation and degradation from intensification of agricultural land use practices, including conversion of pastures and other

grassy habitats to row crops. Mowing of hayfields earlier in the season has also likely resulted in much higher rates of mortality (Vickery 1996; Earley, 2007; COSSARO, 2014).

As this species is dependent on large open grassland habitats, the best opportunities to retain this species in and adjacent to the study area in the long term should be focussed on creating/restoring the habitat within the major utility and rail corridors, as well as the major valleylands of Sixteen Mile Creek. Situating complementary land-uses adjacent to these areas can also help enhance overall suitability. Although habitat preferences vary slightly between species, managing habitat for Grasshopper Sparrow will also help support populations of Bobolink and Eastern Meadowlark.

Bobolink

In April, 2010 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Bobolink (*Dolichonyx oryzivorus*) be designated "Threatened" in Canada (COSEWIC, 2010). However, it has yet to be added to the Species at Risk Act. Bobolink was subsequently designated "Threatened" and added to the Species at Risk in Ontario (SARO) List on September 29, 2010. Since Bobolink is regarded as an area-sensitive open-country breeding bird species, it is vulnerable to the same impacts as other area-sensitive open country species (*i.e.* habitat loss and habitat fragmentation). According to COSEWIC, the species is threatened by incidental mortality from agricultural operations, habitat loss and fragmentation, pesticide exposure and bird control at wintering roosts (it feeds on some seed crops) (COSEWIC 2010). Although the MNR SWH Technical Guide (2000) indicates that open country habitats of at least 50 ha are recommended to retain the open country species guild, Bobolinks are known to nest in habitat patches as small as 3 ha in size (OMNR, 2011).

Because Bobolinks are reliant on grassy field cover such as that provided by hay crops (especially those in Timothy or Timothy/clover mixes – OMNR, 2011), they are most likely to persist in active agricultural areas where these crops are regularly cultivated and where their breeding period is not disturbed by early harvesting of hay. Habitat management within the major corridors of Sixteen Mile Creek (Main and East/Middle Branches), major utility and rail corridors, and habitat restoration and site-specific complementary land-uses developed in conjunction with these areas, may be potential measures to retain this species in the vicinity of the study areas for the long term.

Eastern Meadowlark

In May, 2011 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Eastern Meadowlark (*Sturnella magna*) be designated "Threatened" in Canada (COSEWIC, 2011). However, it has yet to be added to the Species at Risk Act. Eastern Meadowlark was subsequently designated "Threatened" and added to the Species at Risk in Ontario (SARO) List on January 14, 2012. Like Bobolink, Eastern Meadowlark is regarded as an area-sensitive open-country breeding bird species and is equally vulnerable to habitat loss and habitat fragmentation.

Similar to Bobolink, habitat management within the major corridors of Sixteen Mile Creek (Main and East/Middle Branches), major utility and rail corridors, and habitat restoration and site-

specific complementary land-uses developed in conjunction with these areas, offer the best opportunities to retain this species in the vicinity of the study areas for the long term. With that in mind, it does prefer slightly different habitat characteristics than the Bobolink. Although it prefers native grasslands, in Ontario this species will nest in pastures and agricultural fields, especially those in alfalfa and hay. It also uses old fields and meadows, often over-grown with shrubs, and prefers dry habitat to wet, and tall grass to short. Occasionally, it will use other areas such as golf courses or sand dunes (Leckie, 2007). Research in other areas in eastern North America (e.g. Ohio, Illinois, Wisconsin) has shown the following tendencies for the species with regards to habitat preference (from Hull, 2002; NPWRC, 2006):

- the species is a habitat generalist, being absent only from those open habitats with little vegetative cover (e.g. rowcrops);
- they are most abundant in dry habitats with short to intermediate height vegetation;
- they are most abundant in open habitats with higher percent litter cover and density of prostrate residual vegetation (e.g. dead grass stems);
- highest densities of breeding birds are found in dry, uncut grasslands, pastures and hayfields;
- in hayfields, nesting densities were highest in red clover and mixed grass, and lowest in alfalfa; they are found in areas with some low woody vegetation, but avoid areas of dense shrubs or trees; their nests are generally in cover from 25 to 50 cm tall;
- although no shrubs or trees are found near their nest sites, their territories are often close to fences or woodlots, primarily for use as singing perches;
- they are generally found in suitable habitat greater than 10 ha in size, but can utilize smaller patches (territory size average 2.3 ha, but can be as small as 1 ha);
- their probability of occurrence exceeded 50% only on grasslands greater than 5 ha, and they regularly avoided suitable habitat of less than 5 ha.

Significant Valleylands

The Region of Halton has not adopted its own criteria for Significant Valleylands, as defined in the PPS (2014). The Natural Heritage Reference Manual, 2nd Ed. (2010) provides recommended criteria related to landform functions and attributes, ecological features, and restored ecological functions.

In general, watercourses in the study areas are not within well-defined valleys except for the Main and Middle Branches of Sixteen Mile Creek, and along the portion of the Centre Tributary of Sixteen Mile Creek, downstream of Fifth Line. These features support surface water functions including water and sediment conveyance, and localized groundwater discharge is associated with a tributary (BP-1-X) feeding into the Middle Branch, north of Derry Road. The three watercourses also contain the most intact, diverse and contiguous natural and cultural vegetation features within or adjacent to the three study areas, as well as some areas of intensive agricultural disturbance. As discussed in Section 3.6.4, and Section 4, the Main and Middle/East Branches also meet criteria for Significant Wildlife Habitat (Category - Animal Movement Corridors). All three features have opportunities for restoration of riparian vegetation. In the context of the SUS study area, the Main Branch and the centre Tributary are identified as areas for restoration and enhancement, through corridor reinforcement (Centre Tributary) and valley habitat restoration (Main Branch). The Middle Branch is technically outside the SUS study

area but obvious restoration opportunities (floodplain wetlands, forest rehabilitation etc.) were noted during our field reconnaissance.

3.6.5 Assessment

Terrestrial

The survey results, and analysis completed to date, indicate that the Derry Green, Boyne Survey and lands west of Tremaine Road landscapes are highly fragmented, with minimal forest and wetland cover that is well below identified optimal thresholds, with the most extensive vegetation resources concentrated in the existing major valleylands of the Main and Middle Branches of Sixteen Mile Creek, and in the Greenbelt / Niagara Escarpment lands to the east and west.

Provincial and Regional policy changes since the original subwatershed studies will require a modified approach to assemble a natural heritage system for these fragmented landscapes. This process will be heavily reliant on strategic integration of stream systems and terrestrial features which meet Significant Woodland or wetland criteria. The adoption of wider riparian corridors and restoration initiatives will undoubtedly produce a more connected system and a ‘net gain’ in natural cover. The functioning of this proposed system under urban conditions will require adoption of management strategies in the accompanying FSEMS for each area, with impact assessments at the SIS stage. The outcomes of the previous developments (Phase 1, Milton North and Northwest) provide some insights on the approaches that have worked and those that have not been implemented effectively. These are discussed in Section 5.

4. UPDATED INTEGRATED CONSTRAINTS AND OPPORTUNITIES ASSESSMENT

4.1 Terrestrial Resources

Section 3.6 summarizes the known terrestrial resources within the detailed Subwatershed Update Study areas based on background data and field studies conducted in 2007 to 2008, plus supplementary investigations in 2009 to 2011. Resources that form the fundamental 'significant' features and attributes within the study areas have been identified, including Significant Woodlands, ESA's, wetlands, and sites known to support plant and wildlife species of concern. These are summarized on Appendix 'H' Figure T5. In addition, potential Significant Wildlife Habitats have been reviewed using the MNR Significant Wildlife Habitat Technical Guide (MNR 2000) in conjunction with the expertise of the team wildlife ecologists on the interpretation of these guidelines.

As part of the multidisciplinary team, the ecologists have ranked watercourses in the study areas according to their current functional roles in linking significant features both within and beyond the study areas. Watercourses with high terrestrial constraints link core significant features within and beyond the study areas. Medium terrestrial constraint watercourses intersect lower level features, while low terrestrial constraint watercourses currently do not provide more than local scale habitat opportunities.

The current extent of habitat and linkages in all of the detailed study areas is moderately to highly constrained by an intensive history of fragmentation under agricultural uses. While in general this has resulted in reduction of habitat for many biota to critical levels, some biota which are somewhat adapted to agricultural land uses, such as open country birds, have benefited from the existing land uses.

The previous subwatershed studies (i.e. Sixteen Mile Creek Subwatersheds 2 & 7 Study; Indian Creek Subwatershed Study) contained NHS opportunity figures which addressed each of the current study areas; these are included as Figures 5.1.1, 5.1.2, 5.1.3, and 5.1.4, and are located in Section 5.1.

The following is a brief summary of existing resources in each study area that offer key features to become future core habitats, and major linkages and other opportunities. Significant features are summarized in Figure T5.

***Derry Green**:*

- Core areas:
  - Three Significant Woodland complexes, associated with watercourses, form core features.
  - Some smaller Significant Woodlands are heavily degraded by past agricultural uses; one woodland was subjected to partial clearing during the period of this study.
  - Small riverine wetlands associated with features on the BP-2 and Centre tributaries have been identified as a locally significant wetland complex in the current study

- Corridors and Linkages
  - The Middle Branch of Sixteen Mile Creek, the Centre Tributary, and habitats within the extensive (128 ha) lands of the hydro corridor located north of Derry Road, frame the majority of the Derry Green study area on three sides. These offer significant opportunities to build a natural heritage system based on the primary corridor connections, supplemented with secondary linkages that are stream-based.
  - Greenbelt extends to 6th Line in some areas along east study area boundary.
  - Secondary linkages, which exist along watercourses with limited riparian cover, connect a series of forest, meadow and marsh habitats.
  - The Union Gas corridor provides an opportunity to reinforce east-west connectivity because it passes in close proximity to two of the core features, is connected to the East/Middle Branch major corridor (and Greenbelt), crosses tributary BP-2, and also is in proximity to a portion of the Centre Tributary corridor.
  - The hydro corridor provides a connected landscape in relatively stable cover, including active agricultural fields, extensive successional meadows and thickets, small wetlands, and upland forest. This is linked to the major corridor of the East/Middle Branches, and the Greenbelt.
- Significant Wildlife / Significant Wildlife Habitat
  - Barn Swallow and Eastern Meadowlark (provincially Threatened 'open country' birds) were documented in Derry Green; consultation with OMNRF regarding strategies and potential permitting may be warranted if breeding habitat is impacted.
  - Specialized Habitat for Wildlife, i.e. foraging habitat presence of abundant mast is present in two of the core woodlots.
  - Although Snapping Turtle was observed, no consolidated habitats that meet its overall needs for foraging and nesting were observed (may be present within ESA) and SWH cannot be assigned.
  - The unbuilt lands in the hydro corridor (representing over 50 ha) qualify as Significant Wildlife Habitat based on the cover afforded to open country area-sensitive bird species, overall size of available habitats, and connectivity to the East/Middle Branch corridor.
  - The largest woodland fragment present qualifies as Significant Wildlife Habitat by supporting Eastern Wood-Pewee and Wood Thrush, two forest breeding bird species designated Special Concern in Ontario.
  - One additional woodlot qualifies as SWH due to presence of Eastern Wood-Pewee.
  - The East/Middle Branches qualify as SWH by providing habitat for Species of Concern, and as Animal Movement Corridor under the OMNR SWH guidelines.
- Enhancement Opportunities
  - Degraded primary and secondary watercourse corridors offer major opportunities for enhancement
  - Restoration and stewardship/management of portions of hydro corridor offer unique opportunities for diverse bird habitat
  - Restoration opportunities exist along the Middle Branch (incl. Greenbelt)
- Comments:
  - Isolated specialized habitats support amphibians located outside of key natural features

- Features and linkages, when enhanced and buffered, would likely meet the current criteria for Sustainable Halton, including upland forest, meadow and wetland components.
- Greenbelt has specific buffer requirements

Boyne Survey

- Core areas:
  - Natural cover outside of the Main Branch valley of Sixteen Mile Creek is very limited both in extent and in terms of available linkages.
  - Five small woodlots that qualify as Significant Woodlands were identified; the ESA also contains forested features that constitute Significant Woodland.
  - Two individual wetlands, and a complex comprised of two small wetlands, have been evaluated as locally significant in the study area; the complex could potentially be added to the Indian Creek PSW Complex, which is located in the Greenbelt.
  - The data records for two wetland evaluations in the Boyne Survey study area (ref. Figure T5 in Appendix 'H') were submitted to MNR in November of 2011, but the Town has received no comments at date of publication. The first evaluation (SMC-1) contains one Swamp Maple Mineral Deciduous Swamp (polygon 124) located along the corridor of the Centre Tributary of Sixteen Mile Creek. The evaluation scoring indicated that the wetland is locally significant. The second evaluation includes several wetland pockets (polygons 216a, 216b, 216c, 216d, 216h, 216i, 216j, 216k, 225a, 225c, 227b, 229a, 229b) located within 750 m of the Indian Creek PSW Complex. The draft data record indicates that either as part of the existing PSW Complex or as a stand-alone evaluation, this complex could be considered provincially significant; however the final assignment of status has not been released by MNR (October 2011 staked wetland mapping yet to be confirmed by MNR).
- Corridors and Linkages
  - There are limited connections to features located beyond the study area, apart from the Main Branch and Centre Tributaries, which afford significant linkage opportunities.
  - Other linkage opportunities are confined to watercourse connections (largely poorly defined due to flat topography);
  - The CP railway corridor provides topographic form and traverses wetlands and watercourses in the study area and southward.
  - Workable east-west linkage opportunities are very limited and hypothetical rather than feature based due to existing and future road crossings.
- Significant Wildlife / Significant Wildlife Habitat
  - Bobolink, Barn Swallow, and Eastern Meadowlark (provincially Threatened 'open country' birds) are present in Boyne; this requires consultation with OMNRF regarding strategies and potential permitting.
  - Specialized Habitat for Wildlife, i.e. foraging habitat presence of abundant mast is present in the ESA and in smaller Significant Woodlands.
  - Although Snapping Turtle was observed, no consolidated habitats that meet its overall needs for foraging and nesting were observed (may be present within ESA).
  - Western Chorus Frog breeding evidence was observed in several features; two sites provide potential summer habitat in the immediate vicinity and warrant further study;

frog populations are apparently small and not currently supported by linkages to other habitats.
  - Three small woodlots qualify as SWH by the presence of Eastern Wood-Pewee, a forest breeding bird species; all three woodlots are included in the NHS.
  - The Main Branch would qualify as supporting habitat for Species of Concern, and as an Animal Movement Corridor under the MNR SWH guidelines; it is also potentially a deer wintering area.
- Enhancement Opportunities
  - The enhancement and extension of the Sixteen Mile Creek ESA represents a significant opportunity to enhance core habitat functions, and the diversity of cover.
  - Degraded primary and secondary watercourse corridors offer major opportunities for enhancement
  - Smaller features warrant consideration for enhancement and improved habitat linkage

- Comments:
  - There are opportunities for specialized habitat restoration within the Main Branch valley north, east and west of the existing ESA; this would be compatible with the NAI (2006) recommendation to extend the ESA northward.
  - The integration of Western Chorus Frog breeding habitats, which are generally small, isolated features, will be a significant challenge, and other options such as habitat creation and species rescue will need to be explored.
  - While Sustainable Halton does not apply to the Boyne lands, features and linkages, when enhanced and buffered, would in most cases meet key criteria for Sustainable Halton, including upland forest, meadow and wetland components.
  - Isolated specialized habitats support amphibians located outside of key natural features
  - Developments within 120 m of Greenbelt (located immediately south of Britannia Rd.) have specific natural heritage evaluation and buffer requirements

4.2 Watercourses

Each of the watercourses within the Derry Green and Boyne Survey areas has been assessed on the basis of the various environmental factors and considerations. A fisheries high constraint relates to perennial watercourses that support good quality habitat utilized by fish, whereas a medium constraint has been assigned to watercourse reaches without perennial flow that support seasonal or permanent habitats utilized by fish, or have the potential to do so. A low fisheries constraint is assigned to watercourses that are not considered fish habitat, or have little potential to contribute to fish habitat based on the flow regime identified. Terrestrial constraints relate to the presence in the watercourse riparian zone of core features, such as woodlots and wetlands, or secondary features that do not qualify as core. Morphological constraints relate to the drainage density, erosion susceptibility, and/or stability of the channel form (aggradation/degradation). Flooding constraints are high if the reach has a registered floodplain associated with it, and the conveyance capacity cannot be replicated artificially through the construction of a vegetated corridor and watercourse designed using Natural Channel Design principles.

Table 4.2.1: Watercourse Constraint Rankings for Derry Green					
Watercourse ID	**Fisheries/ Water Quality**	**Terrestrial Resources**	**Stream Morphology**	**Flooding/ Conveyance**	**Net Rating**
Tributary BP-1A					
BP-1-A	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
BP-1-A-1	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
BP-1-A-2	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM
BP-1-A-3	LOW	LOW	LOW	LOW	LOW
BP-1-A-4	LOW	LOW	LOW	LOW	LOW
BP-1-A-5	LOW	LOW	LOW	LOW	LOW
BP-1-G	LOW	MEDIUM	LOW	LOW	LOW
BP-1-H	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-H-1	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-H-2	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-H-3	LOW	LOW	LOW	LOW	LOW
BP-1-H-4	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-H-5	LOW	LOW	LOW	LOW	LOW
BP-1-I	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-I-1	LOW	LOW	LOW	LOW	LOW
BP-1-L	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-L-1	LOW	LOW	LOW	LOW	LOW
BP-1-L-2	LOW	LOW	LOW	LOW	LOW
BP-1-N	LOW	HIGH	LOW	LOW	MEDIUM
BP-1-O	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
BP-1-O-1	LOW	LOW	LOW	MEDIUM	LOW
BP-1-O-2	LOW	MEDIUM	LOW	LOW	LOW
BP-1-O-3	LOW	LOW	LOW	MEDIUM	LOW
BP-1-O-4	LOW	LOW	LOW	LOW	LOW
BP-1-W	LOW	LOW	LOW	MEDIUM	LOW
BP-1-W-1	LOW	LOW	LOW	LOW	LOW
BP-1-W-2	LOW	LOW	LOW	LOW	LOW
BP-1-Y	LOW	MEDIUM	LOW	LOW	LOW
Tributary BP-1-B					
BP-1-B	HIGH	HIGH	MEDIUM	MEDIUM	HIGH[2.]
BP-1-B-1	LOW	HIGH	MEDIUM	MEDIUM	MEDIUM/HIGH[1.]
BP-1-C-1	HIGH	LOW	MEDIUM	MEDIUM	HIGH[1. 2.]
BP-1-C-2	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH[1. 2.]
BP-1-C-3	HIGH	LOW	LOW	MEDIUM	HIGH[2.]
BP-1-C-4	LOW	LOW	LOW	LOW	LOW
BP-1-C-5	LOW	LOW	LOW	MEDIUM	LOW
BP-1-D	LOW	MEDIUM	LOW	MEDIUM	LOW
BP-1-D-1	LOW	LOW	LOW	LOW	LOW
BP-1-F	LOW	LOW	LOW	MEDIUM	LOW
BP-1-V	LOW	LOW	LOW	MEDIUM	LOW
BP-1-V-1	LOW	LOW	LOW	LOW	LOW
Tributary BP-1-M					
BP-1-M	HIGH	MEDIUM	LOW	MEDIUM	HIGH
BP-1-M-1	MEDIUM	LOW	LOW	MEDIUM	MEDIUM
BP-1-M-2	LOW	LOW	LOW	LOW	LOW
Tributary BP-1-X					
BP-1-X	HIGH	MEDIUM	LOW	MEDIUM	HIGH
BP-1-X-1	LOW	LOW	LOW	LOW	LOW
Tributary BP-2					
BP-2-A	HIGH	HIGH	MEDIUM	MEDIUM	HIGH[2.]
BP-2-B	MEDIUM	HIGH	LOW	LOW	MEDIUM
BP-2-B-1	MEDIUM	HIGH	LOW	LOW	HIGH[1.]
BP-2-C	HIGH	HIGH	MEDIUM	LOW	HIGH

Table 4.2.1: Watercourse Constraint Rankings for Derry Green					
Watercourse ID	**Fisheries/ Water Quality**	**Terrestrial Resources**	**Stream Morphology**	**Flooding/ Conveyance**	**Net Rating**
Tributary BP-3					
BP-3-A	LOW	MEDIUM	LOW	LOW	LOW
Tributary BP-5					
BP-5-A	HIGH	HIGH	MEDIUM	MEDIUM	HIGH
BP-5-B	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH
BP-5-C	LOW	MEDIUM	MEDIUM	LOW	MEDIUM
BP-5-D	LOW	LOW	LOW	LOW	LOW
BP-5-E	LOW	LOW	LOW	LOW	LOW
Outside Area					
7-II	HIGH	HIGH	HIGH	HIGH	HIGH
7-III	HIGH	HIGH	HIGH	HIGH	HIGH
7-IV-C	HIGH	HIGH	HIGH	HIGH	HIGH
BP-3-B	HIGH	HIGH	MEDIUM	HIGH	HIGH[2.]
BP-3-C	HIGH	HIGH	MEDIUM	HIGH	HIGH[2.]
BP-3-C1	HIGH	HIGH	MEDIUM	HIGH	HIGH

1. Reaches within woodlots are designated as a High Constraint by virtue of their location within a High Constraint Terrestrial feature.
2. Reaches represent High Constraint with Rehabilitation Potential.

Table 4.2.2: Watercourse Constraint Rankings for Boyne Survey					
Watercourse ID	**Fisheries/ Water Quality**	**Terrestrial Resources**	**Stream Morphology**	**Flooding/ Conveyance**	**Net Rating**
Tributary 1-NE-2A					
I-NE-2A	MEDIUM	HIGH	LOW	LOW	MEDIUM
I-NE-2A-1	MEDIUM	HIGH	LOW	LOW	MEDIUM
I-NE-2A-2	LOW	LOW	LOW	LOW	LOW
I-NE-2A-3	MEDIUM	HIGH	LOW	LOW	MEDIUM
I-NE-2A-4	LOW	HIGH	LOW	LOW	LOW/HIGH[3.]
I-NE-2A-5	LOW	LOW	LOW	LOW	LOW
I-NE-2A-6	LOW	LOW	LOW	LOW	LOW
I-NE-2A-7	LOW	LOW	LOW	LOW	LOW
Tributary 1-NE-1B					
I-NE-1B-1	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM
I-NE-1B-2	LOW	LOW	LOW	LOW	LOW
Tributary SWS-4A					
SWS-4-A	LOW	LOW	LOW	LOW	LOW
Tributary SWS-1					
SWS-1-A	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM
SWS-1-A-2	LOW	LOW	LOW	MEDIUM	LOW
SWS-1-B	LOW	LOW	LOW	LOW	LOW
Tributary SWS-2					
SWS-2-A	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
SWS-2-A-1	LOW	HIGH	LOW	LOW	LOW/HIGH[3.]
SWS-2-B	LOW	LOW	LOW	LOW	LOW
SWS-2-C	LOW	LOW	LOW	MEDIUM	LOW
2-II					
2-II	HIGH	HIGH	HIGH	HIGH	HIGH
SWS-5-A	MEDIUM	HIGH	MEDIUM	LOW	HIGH[3.]
SWS-5-B	LOW	MEDIUM	LOW	LOW	LOW
SE-5-A	MEDIUM[5.]/LOW	HIGH	LOW	LOW	HIGH[3.]/LOW
Tributary SWS-3					
SWS-3-A	LOW	LOW	LOW	LOW	LOW

Table 4.2.2: Watercourse Constraint Rankings for Boyne Survey					
Watercourse ID	**Fisheries/ Water Quality**	**Terrestrial Resources**	**Stream Morphology**	**Flooding/ Conveyance**	**Net Rating**
Tributary SE-2					
SE-2-A	LOW	LOW	LOW	LOW	LOW
SE-2-B	LOW	LOW	LOW	LOW	LOW
SE-2-D-1	LOW	LOW	LOW	LOW	LOW[2.]
SE-2-D-2	LOW	LOW	LOW	LOW	LOW
Tributary SE-3					
SE-3-A	LOW	MEDIUM	LOW	LOW	LOW
SE-3-B	MEDIUM	HIGH	LOW	HIGH[1.]	MEDIUM[1.]
SE-3-B-1	LOW	LOW	LOW	MEDIUM	LOW
SE-3-C	LOW	LOW	LOW	LOW	LOW
SE-3-G	MEDIUM	MEDIUM	LOW	LOW	MEDIUM
Tributary SE-4					
SE-4-A	LOW	LOW	LOW	LOW	LOW
BP-4-C					
BP-4-C	HIGH	HIGH	MEDIUM	MEDIUM	HIGH[4.]

1. Note: "High" ranking for flooding /conveyance reflects requirement for offsite risk management due to presence of downstream Flood Damage Centre, which is satisfied by the stormwater management flood control strategy and requirements provided in this FSEMS. Net constraint ranking for watercourses within Boyne Survey is "Medium".
2. Drainage Density function of Watercourse SE-2-D-1 is to be replicated as part of development, as outlined in Appendices 'E' and 'J' and supporting direction in this FSEMS. Feature is not required to be maintained as a regulated open watercourse.
3. Reaches within woodlots are designated as a High Constraint by virtue of their location within a High Constraint Terrestrial feature.
4. Reaches represent High Constraint with Rehabilitation Potential
5. Reach designated medium fisheries constraint within Sixteen Mile Creek Valley and low fisheries constraint on tableland.

A high constraint rating indicates that the watercourses must be protected/enhanced, and remain open in their existing form and location (horizontal and vertical). However, if it is determined that enhancement may provide a significant environmental benefit to important habitat or the survival of at-risk species, enhancement may be considered, provided it occurs in a carefully studied, controlled and staged manner. A medium rating indicates that the watercourses must remain open, but may be realigned, subject to their function being retained, and by applying natural channel design principles. A low rating implies that the watercourses may be eliminated, and drainage incorporated into stormwater systems if not required to meet drainage density targets; alternatively, watercourses may remain open and realignments would be acceptable, if it is required to meet drainage density targets, however no riparian corridor or setbacks would be required. Drainage density is a measure of channel length per subcatchment area and is discussed in more detail in Section 7.4.

With respect to watercourses ranked as high or medium terrestrial constraint, these watercourses may be relocated (subject to overall ranking) but the terrestrial linkage functions should be maintained or enhanced.

The net constraint rankings for the watercourses have identified reaches as "High Constraint with Rehabilitation Potential", which are depicted on Drawing 9 and 10 as red dashed streams. These watercourses have been subjected to frequent alteration historically and the permanent flowing condition which is, or has been, observed is attributed to an artificial low flow condition rather than a baseflow condition sustained by natural groundwater discharge. The constraint

ranking attributed to these reaches recognizes that these watercourses may be realigned as part of future development, and that such realignment should necessarily include watercourse enhancements, including maintaining baseflow conditions through the implementation of infiltration BMP's.

5. DEVELOPMENT OF A NATURAL HERITAGE SYSTEM

5.1 Relevant Guiding Legislation, Policy, Documents, and Targets

5.1.1 Provincial and Regional Mandates

The approach to be undertaken for the Subwatershed Update Study, and relevant Functional Stormwater and Environmental Management Strategies for each of the detailed study areas (including the Natural Heritage System), must "be consistent with" the Provincial Policy Statement (2014) which provides clear direction on the adoption of an ecosystem approach, and the protection of resources that have been identified as 'significant': wetlands, habitats of endangered or threatened species, fish habitat, woodlands, valleylands, wildlife habitat, and areas of natural and scientific interest.

Natural heritage systems are currently defined under the Provincial Policy Statement (PPS 2014) as follows:

> *"a system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The Province has a recommended approach for identifying natural heritage systems, but municipal approaches that achieve or exceed the same objective may also be used."*

In March, 2010, the Province released the finalized Second Edition of the Natural Heritage Reference Manual (NHRM), which is intended to guide the implementation of the PPS (2005). The first edition NHRM reflected the focus and wording of the 1997 PPS, which was strengthened significantly in 2005, explicitly recognizing linkages "*between & among natural heritage features & areas, surface water features & ground water features, & hydrological functions*" which are necessary for the ecological and hydrological integrity of watersheds. The 2005 and 2014 PPS also identify watersheds as an "*ecologically meaningful scale for integrated and long-term planning*".

The 2010 NHRM suggests an approach to the identification of Natural Heritage Systems that builds on the 1999 version in referencing the system approach first identified in Riley and Mohr (1994), however there is increased detail and reference to more current scientific information to support the suggested approach. The NHRM updates the treatment of specific PPS-identified categories, including significant habitat of endangered and threatened species [now subject to a strengthened provincial Endangered Species Act (2007)], significant wetlands (now with greater focus on 'linkage' to hydrological regimes, and subject to strengthened protection under updated Conservation Authority Regulations), significant woodlands (now recognized in some upper tier municipal Official Plans and subject to region-specific identification criteria), significant valleylands (now recognized as having cultural heritage value in addition to ecological and

hydrological significance), significant wildlife habitat (planning authorities still encouraged to identify SWH on a comprehensive rather than site-by-site basis), significant areas of natural and scientific interest, and fish habitat.

The 2010 NHRM also provides helpful guidance on development of Natural Heritage Systems in settlement areas, whether in existing built-up areas, or in "*designated growth areas*" as defined in the PPS (2005 and 2014); this has direct application to the future development areas addressed in the Subwatershed Update Study and in the associated secondary planning processes.

The updated NHRM is applied to guide the NHS development for the subject lands.

Greenbelt Plan (2005)

The Greenbelt Act (2005) designated a Greenbelt Plan area containing Protected Countryside, which contains rural lands and a natural heritage system. Although the Greenbelt does not extend into the areas approved for urbanization in the Town of Milton, designated lands are located to the immediate east and west of these lands, as well as along the Main Branch of Sixteen Mile Creek south of Britannia Road. The Protected Countryside of the Greenbelt includes the Sixteen Mile Creek ESA and ANSI immediately downstream of Britannia Road. Section 3.2.5 of the Greenbelt Plan addresses External Connections to the Greenbelt NHS, and NHS Map 4 identifies the Sixteen Mile Creek north of Britannia Road as a "River Valley Connection". Where future development abuts portions of the Greenbelt NHS, the approach to the protection of the natural features and functions will need to conform to the natural heritage policies of the Greenbelt Act, and take direction from the technical guidelines that have been prepared by the Ministry of Natural Resources (OMNR 2013).

The Greenbelt Plan defines '*vegetation protection zone*' as:

> "*A vegetated buffer area surrounding a key natural heritage feature or key hydrologic feature within which only those land uses permitted within the feature itself are permitted. The width of the vegetation protection zone is to be determined when new development or site alteration occurs within 120 metres of a key natural heritage feature or key hydrologic feature, and is to be of sufficient size to protect the feature and its functions from the impacts of the proposed change and associated activities that will occur before, during, and after, construction, and where possible, restore or enhance the feature and/or its function.*"

The Greenbelt Plan requires a minimum 30 m vegetation protection zone for wetlands, seepage areas and springs, fish habitat, permanent and intermittent streams, lakes, and significant woodlands. MNR has prepared draft guidelines in support of the Plan which address Key Natural Heritage features identification criteria, Significant Woodlands Criteria, and Significant Habitats of Endangered, Threatened and Special Concern Species. For details on the application of the Greenbelt Plan, see Section 5.2 in the Derry Green and Boyne FSEMS Technical Appendices.

Conservation Halton Regulations (2006)

This document provides policy direction related to Conservation Halton's review of Permit applications made pursuant to Ontario Regulation 162/06 as well as the review of planning applications circulated to Conservation Halton for review by watershed municipalities, provincial agencies and other organizations. Regulatory policies pertain to wetlands, watercourses, erosion hazards, flooding hazards, shoreline hazards and other areas identified by the Conservation Authorities Act and Ontario Regulation 162/06. Planning policies pertain to all aspects of the Provincial Policy Statement Natural Heritage and Natural Hazards policies as well as some specific policies related to larger planning applications such as golf courses.

Region of Halton Official Plan

The Halton Regional Plan (2006) incorporated key natural features under categories including 'Escarpment Natural Area', 'Environmentally Sensitive Area', and 'Greenlands A and B'. The Region has also approved policies regarding the identification of Significant Woodlands as defined under the PPS. The Town of Milton Official Plan (2001) reflects the Halton Region categories, and identifies Environmental Linkage Areas which are primarily watercourse-based. The Sustainable Halton Plan (approved under ROPA 38 by Regional Council in December 2009) identifies a Regional Natural Heritage System, which supplants the existing Greenlands system for areas outside the current urban boundaries. This is discussed in more detail below, as it has relevance to the development of NHS for the designated urban lands within the Sixteen Mile Creek and Indian Creek subwatersheds.

North Oakville Creeks Subwatershed Study (2006)

Conservation Halton staff have recommended consideration of the NHS methodology utilized in the North Oakville Creeks Subwatershed Study (2006). This was a relatively recent example of a systems-based approach undertaken under the updated Provincial Policy Statement (2005). The North Oakville systems approach as described in the North Oakville Creeks Subwatershed Study Management Report (TSH et al., 2006) identified core areas which consist of relatively large, compositionally diverse habitat features, readily linked to other features, containing significant features and attributes, and overall watershed functionality with respect to hydrological processes. The core areas are woodlands and/or wetlands that may be associated with semi-natural successional features. Primary and secondary linkages were defined, with primary linkages serving to connect the major core features with primarily forested linkages of 100m width, and secondary linkages of more variable habitats and widths, determined by stream corridors and floodlines. Potential linkages could take advantages of smaller features and hedgerows as well as stream corridors.

The SUS study team recognizes that there are key differences between the North Oakville landscape, and the portions of the Peel Plan that contain the study areas within the Town of Milton. Key differences include the number of large habitats in the North Oakville Study Area, substantially greater existing natural cover (2 to 7% in Milton, vs 16% in North Oakville), and the presence of more varied physiographic conditions (i.e. Trafalgar Moraine). Notably, the North Oakville study rationalized the removal of some features including Significant Woodlands. We have considered the North Oakville approaches, in the light of comparing approaches to the

original Subwatershed Study Areas 2 & 7 approach, Indian Creek Subwatershed approach, and other contemporary examples of NHS planning underway in the Peel Plain. As discussed earlier in this section, the second edition of the Natural Heritage Reference Manual (OMNR 2010) recognizes that "*every natural heritage system will be different*".

Sustainable Halton Plan

The Sustainable Halton Plan is a growth management planning project initiated in May 2006, intended to promote the concept of sustainable development, which is defined in the 2004 Policy 25 of the Regional Official Plan as "*meeting the needs of the present without compromising the ability of future generations to meet their own need*". The policy also states that "*planning decisions in Halton will be made based on a proper balance among the following factors: protecting the natural environment, enhancing its economic competitiveness, and fostering a healthy, equitable society*". The overall goal is to enhance the quality of life for all people of Halton. The Growth Management Strategy and the supporting resource management strategies that make up the Sustainable Halton Plan were completed in 2009, and adopted under ROPA 38.

Documents in support of the Sustainable Halton were first circulated by the Region of Halton in June 2008. This phase identified an evaluation framework to assess growth options. The Framework Theme Area relevant to natural heritage, "Protect What is Valuable", identified the following principles (RMOH, 2008):

1.1 Protect a resilient and self-sustaining Natural Heritage System (NHS) integrating an 'ecosystem-based' approach that encompasses a connected system of cores of sufficient size to maintain or improve biological diversity and ecological function.

a. *Identify and protect core natural areas.*
b. *Identify and protect centres of regional biodiversity of sufficient area to allow the permanent protection of regional biodiversity.*
c. *Identify and protect centres of regional biodiversity that represent the two main landscapes in Halton "above" and "below" the escarpment.*
d. *Provide ecologically functional connections between Halton's NHS and the greater landscape in which the Region is situated.*
e. *Protect existing designated natural heritage.*

Enhance the NHS to strengthen habitat areas and reduce the impact of new development.

a. *Promote existing natural heritage features within a connected system of cores, linkages and watercourses.*
b. *Promote existing natural heritage features within a connected system of cores, linkages and watercourses (evaluated by different measures than in 1.2.a).*
c. *Provide alternate connections among natural heritage features.*

The Phase III NHS report (April 2009) entitled *Natural Heritage System Definition & Implementation - Sustainable Halton Report 3.02,* summarized the system standards recommended.

Feature size thresholds used to guide the development of the Sustainable Halton NHS considered the following minimum core areas as defined by Environment Canada (2004):

- ***Core Area Woodlands***: 20 ha
- ***Core Area Wetlands***: 10 ha for marsh/thicket and 20 ha for treed swamp
- ***Core Area Open Habitat***: 15 ha
- ***Centres for Biodiversity***: 200 ha

Linkage corridors in the Sustainable Halton NHS meet the following guidelines:

- ***Regional Linkage***: 300 to 400 m width
- ***Local Linkage***: 60 to 100 m width

The Sustainable Halton NHS includes the following minimum buffers intended to protect natural heritage features as follows:

- ***Woodland Buffer***: 30 m
- ***Wetland Buffer***: 30 m

The Sustainable Halton NHS also proposes buffers along watercourses based on the following criteria:

- all watercourses located within the Regulatory Floodline have a 30 m buffer on both sides
- watercourses located outside the Regulatory Floodline that are determined to provide an important ecological linkage function have a 30 m buffer on both sides

The Sustainable Halton NHS document does not apply directly to the detailed study areas for the Subwatershed Update Study. Most lands were included within the current urban boundaries of the Region in the Halton Urban Structure Plan, a previous growth management study. Sustainable Halton provides guidance on the principles currently considered important for natural heritage system planning in the Region of Halton. It represents a 'high level' systems approach; detailed NHS planning studies for new development such as those within Derry Green, Boyne Survey, and lands west of Tremaine Road will be informed by elements of the Sustainable Halton NHS, but will rely upon accepted principles of natural heritage planning more fully informed by detailed site specific data collection and analysis.

Targets

The development of guideline targets for optimal levels of natural cover has been the subject of study by federal and provincial agencies for more than a decade. In 2004 a document entitled "*A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern*" was released jointly by Environment Canada, the Ontario Ministry of Natural Resources, and the Ontario Ministry of Environment. An updated Third Edition was released in 2013. This document included guidelines for the establishment of forest and wetland targets in watersheds and subwatersheds. These included the identification of the following watershed-based targets:

- Ten percent of a watershed, and six percent of any subwatershed should be comprised of wetlands
- The Critical Function Zone (*i.e.* core wetland) and Protection Zone (i.e. buffer) of a wetland should be naturally vegetated
- 75% of stream length should be naturally vegetated
- Streams should have a minimum 30 m wide naturally vegetated lands area on both sides, greater depending on site specific conditions
- a minimum forest cover target of 30% is desirable for watersheds
- Forest patches should be circular or square in shape
- Forest patches should be within two kilometres of one another
- At least 10% of watersheds should consist of forest cover with more than 100 m from the forest edge; 5% of the watershed should have forest cover with more than 200 m from the forest edge
- Watershed forest cover should be representative of the full diversity of forest types found at that latitude
- Corridors designed to facilitate species movement should be a minimum of 50 to 100 m wide
- Seventy-five percent of stream length should be naturally vegetated
- streams should have a 30 m wide, naturally vegetated buffer on both sides
- Less than 10 percent of an urbanized watershed should be impervious

The past application of these guidelines to highly fragmented landscapes in southern Ontario, which have been under intensive use for agriculture for more than a century, has been challenging, and jurisdictions (such as TRCA with its Terrestrial Natural Heritage System Strategy) have generally applied these targets outside of urbanizing areas. The need to balance other planning objectives (such as those under the Province's Places to Grow Plan) has resulted in these compromises. In this regard, the Second Edition of the Natural Heritage Reference Manual (OMNR 2010) advises (ref. Section 3.4.6.2):

> *"Every natural heritage system, however, will be different. There is no minimum size for a system or minimum percentage of a planning area or its natural features that must be included in the system. Therefore, the extent of the natural heritage systems identified in the noted examples represents what was appropriate and achievable in those situations."*

Therefore, while the Environment Canada guidelines represent useful considerations in defining watershed priorities for natural heritage protection, their application in designated growth areas that are already highly fragmented may not be feasible except where opportunities exist to integrate highly functional lands within identified development areas.

In the case of the Derry Green, Boyne and lands west of Tremaine Road that are the focus for NHS development in this Subwatershed Update Study, existing limitations of the landscape (e.g. 3% to 7% existing natural cover) must be recognized, while approaches for habitat enhancement and diversification are identified, based on opportunities to protect and link viable natural features, as well as reinforcement of the NHS with complementary existing and future land uses that support important ecological functions. Based on contemporary subwatershed experience in similar landscapes of the Peel Plain and South Slope Physiographic Regions, it is

anticipated that that the future NHS will achieve substantial increases in natural cover within the Derry Green and Boyne study areas.

The lands west of Tremaine Road (3% existing natural cover) pose special challenges due to the relative lack of stream cover and the concentration of existing features in the Greenbelt located west of the study area, with some localized extensions of these features into the immediate vicinity of the study area. This is being examined in a separate ongoing Secondary Planning process for this area (i.e. Milton Education Village).

5.2 Relevant Experience with NHS Recommendations from Previous Subwatershed Documents

The Natural Heritage System recommended for the Sixteen Mile Creek Watershed Plan (1996) proposed the following as core natural areas: ESA's, ANSI's, significant fish & wildlife habitat, significant wetlands & open water bodies, habitat for species at risk, and significant woodlots. Connecting natural corridors were identified as linear natural features such as streams, floodplains, steep slopes, valleys, contiguous narrow woodlands and wetlands that connect two or more core areas. Habitat nodes were identified as natural areas contiguous with or within 30 m of a core area or natural corridor. Secondary natural areas, secondary connecting linkages, and potential connecting linkages were identified in the Watershed Plan to supplement the primary system.

The 1996 Watershed Plan indicated relatively limited Natural Heritage System opportunities within Subwatersheds 2 & 7 due to a lack of habitat cover and very limited vegetated riparian cover. Major core areas comprised by the Escarpment are located at the west to north-west margins of Subwatershed 2; natural corridors and core areas comprised by the main branches of Sixteen Mile Creek occur in each subwatershed. The tableland areas were not considered to offer any significant system components based on available information at the time that the Watershed Plan was prepared. This was in part the rationale for the assignment of future urban growth to these "low constraint" areas in the Halton Urban Structure Plan.

The Sixteen Mile Creek Areas 2 & 7 Study (2000) was prepared under the guidance of the 1997 Provincial Policy Statement, and determined relative constraint levels of existing terrestrial features, and integrated input of all key disciplines (terrestrial, water resources, groundwater, stream morphology and aquatic resources) to identify opportunities and strategies for improved linkages, promoting 'net gain' of natural cover and linkage primarily through the protection of medium to high constraint features, and through natural channel restoration as part of future development. The success of this approach is evaluated below to guide the Subwatershed Update Study.

Figure 5.2.1 summarizes the NHS opportunities that were identified in the Subwatersheds 2 & 7 Study (2000) for the Derry Green / Business Park 2 lands, Figures 5.2.2 and 5.2.3 reflect comparable information and analysis for the portion of the Boyne Survey / Phase 3 lands, located within the Sixteen Mile Creek watershed. Figure 5.2.4 identifies the proposed NHS for the Indian Creek Subwatershed (Philips Engineering Ltd., 2004) including the Boyne Survey lands within the Indian Creek subwatershed, and the lands west of Tremaine Road.

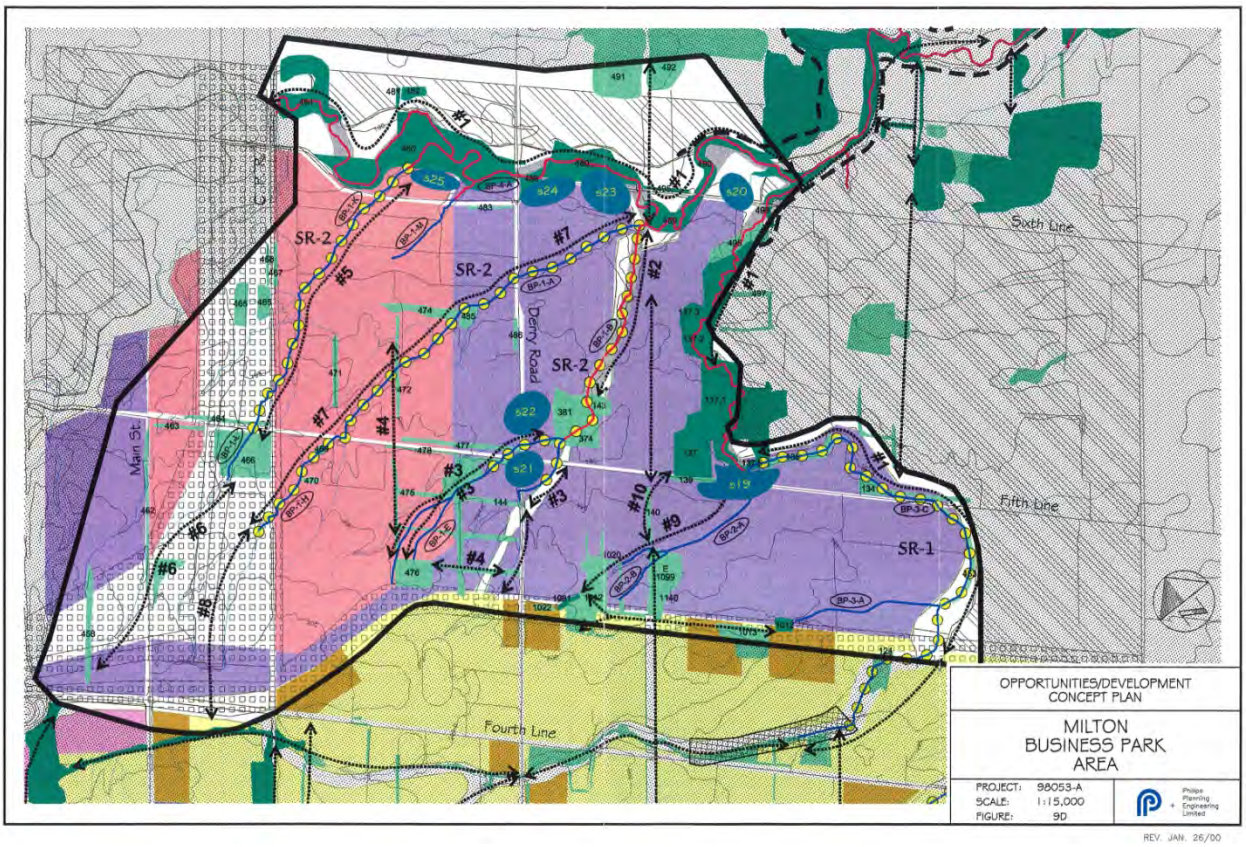

Figure 5.2.1 Derry Green Area NHS Opportunities (Philips Engineering Ltd. 2000)

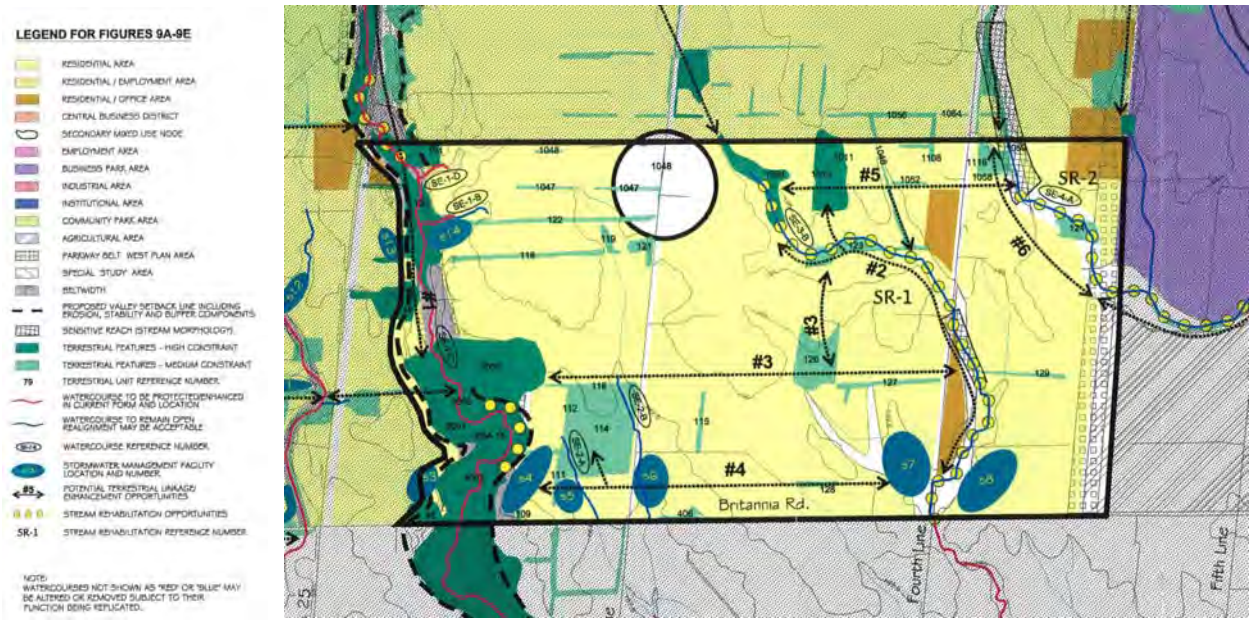

Figure 5.2.2 Boyne Survey Area NHS Opportunities (Philips Engineering Ltd. 2000)

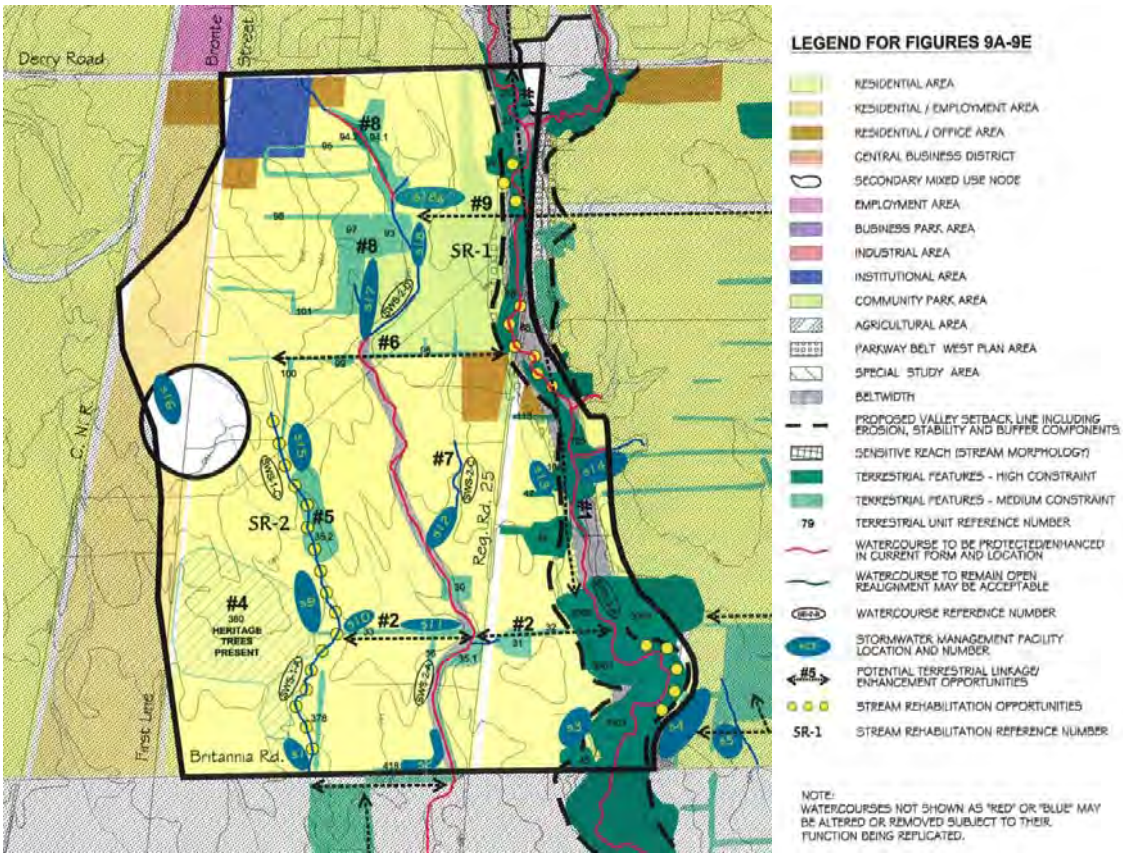

Figure 5.2.3 Boyne Survey Area NHS Opportunities (Philips Engineering Ltd. 2000)

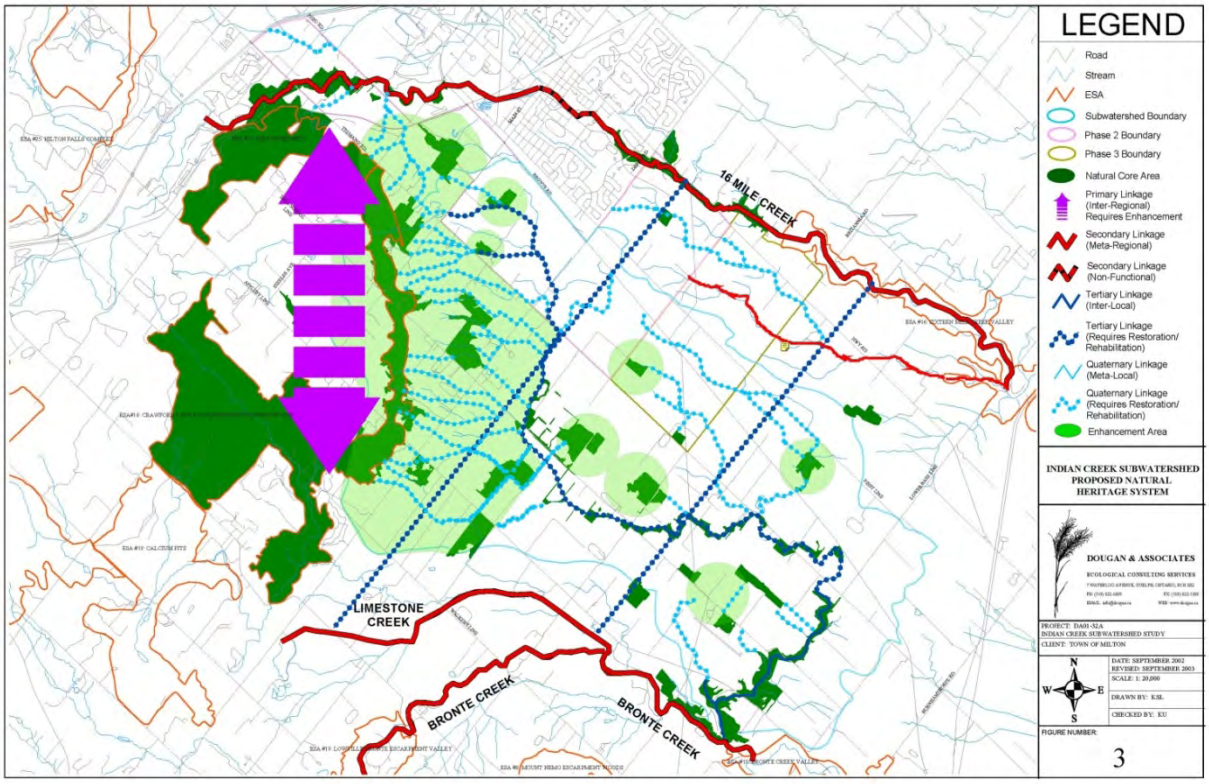

Figure 5.2.4 Indian Creek Subwatershed Proposed Natural Heritage System (Philips Engineering Ltd. 2004)

The Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2003) identified a Proposed Natural Heritage System for the entire subwatershed area. The Milton Indian Creek Phase 2 lands were determined to have similar limitations of cover and linkage that was the case on the Phase 1 (Bristol Survey) lands. An intensified 'net gain' strategy was recommended which was focused on enhancement of the high constraint features associated with valleylands, as well as wider riparian corridors, to provide a more substantial and connected system of stream-linked habitats. However, the application of the recommended NHS was not carried forward through the Subwatershed Impact Studies (SIS). This matter has been discussed with Town and Conservation Halton staff during the present study, to ascertain how future implementation recommendations can have a higher certainty of implementation when the current Subwatershed Update Study is implemented. Proposed changes to Town policies for the processing of Draft Plans and SIS are one of the outcomes.

The terrestrial study team met with staff of the Town of Milton and Conservation Halton in November 2008 to discuss the outcomes from the Phase 1 (Bristol) NHS implementation in Subwatersheds 2 & 7, and the Phase 2 (Sherwood) implementation in the Indian Creek Subwatershed. The following is based on relevant comments that were received from Conservation Halton.

In Phase 1 (Bristol Survey), the NHS consisted of watercourses / valleylands plus a limited number of tableland woodlots. There was extensive creek realignment and in general the enhancements worked well, although landscaping was considered sparse in many locations. The NHS included 7.5 m lot line setbacks along tributaries, and 15 m lot line setbacks along the Main Branch of 16 Mile Creek. Net gain was focused exclusively on the creek channel works. There were no buffers implemented around woodlots, (despite recommendations contained in the Subwatersheds 2 & 7 Study for 5 and 10 m buffers from valleylands and woodlots), which has led to residential encroachment impacts as well as requirements for grading and catchbasin placement within features. Inconsistencies in the application of SIS have been problematic, leading to gaps in meeting requirements and follow-through on implementation.

In Phase 2 (Sherwood Survey), the NHS consisted of watercourses/ valleylands plus tableland woodlots. Although the Indian Creek Subwatershed Study recommended 25 m buffers around high constraint features as a mechanism to achieve 'net gain', the Town subsequently reduced the standard to 10 m, which prevented 'net gain' when coupled with the loss of lower constraint features. The creek realignments worked well and landscaping was more intensive given application of the Conservation Halton landscaping guidelines which were applied with coordination from the Town's Community Services Department. As in Phase 1, the NHS included 7.5 m lot line setbacks along tributaries, and 15 m lot line setbacks along the Main Branch of 16 Mile Creek. Net gain in Phase 2 was very difficult to implement as it was not explicit as to how the protection or removal of lower constraint features was to be factored in after the buffers were reduced by the Town. However, the reduced 10 m buffers resulted in fewer disturbances to features than was the case in Phase 1. There was confusion regarding interpretation of the intended vision and implementation of the Union Gas Pipeline as an east-west corridor.

These outcomes helped to frame many of Conservation Halton's requests related to the Terms of Reference for the SUS. They have requested that the NHS be clearly defined and not subject to alteration at the SIS level of study. There was concern from Town Planning staff as well as from CH staff that the SIS requirements be more clearly related to the required NHS. Additional comments on the SIS process are discussed elsewhere in this report, and in the FSEMS documents.

The current subwatershed level Natural Heritage System is shown in Appendix 'H' Figure T6; this was compiled from mapping of the current detailed study areas during the Subwatershed Update Study, from mapping in the 2000 Area 2 & 7 Study, the 2004 Indian Creek Subwatershed Study, from a review of the Phase 1 (Bristol Survey) as-built conditions, and from Conservation Halton's ELC mapping. Note that the Sherwood Survey Phase 2 lands are still under development. This database is available to provide updated information on individual development areas.

5.3 Natural Heritage System Development Approach

The purpose of this section is to describe the general process for NHS identification that will be applied in the areas which were identified for urbanization in the HUSP (1996) process (i.e. the Derry Green/Phase 2 Business Park lands, Boyne Survey / Phase 3 lands, and for the lands west of Tremaine Road). The NHS which are developed in these areas should encompass the existing features and functions present in the study areas, with reinforcement to ensure their continued presence and function, and where feasible, their restoration and enhancement. Further, this system needs to integrate with the Natural Heritage Systems within adjoining developed areas, and the regional scale system.

The SUS has encompassed the following process in preparation for the development of preliminary Natural Heritage Systems for the detailed study areas that are currently subject to secondary planning:

1) Review of 2000 and 2002 subwatershed study data & findings;

2) Review of Phase 1 (Bristol) and 2 (Sherwood) NHS outcomes with Town and Conservation Halton staff, and updating of Sixteen Mile Creek Subwatersheds 2 & 7 NHS mapping (ref. Section 5.2);

3) Updating of Goals and Objectives based on current policies, guidelines & legislation (ref. Section 2.2; repeated below for convenience);

4) Comprehensive updated field investigations (2007 to 2008) based on Terms of Reference agreed to by the Town of Milton, Conservation Halton, and Region of Halton, encompassing Ecological Land Classification to the most detailed level, as well as seasonal inventories of flora and wildlife; additional study of key biota including species at risk;

5) Wetland evaluations conducted in accordance with the Ontario Wetland Evaluation System (1993) methodology;

6) Analysis of terrestrial resources in terms of the PPS (2014) policies regarding habitat of endangered and threatened species, significant wetlands, significant woodlands, significant valleylands, significant wildlife habitat, significant areas of natural and scientific interest;

7) Identification of features and functions to be protected based on PPS (2014);

8) Identification of other features that provide linkages or otherwise support habitat functions; these may include hedgerows in key locations, cultural units that do not qualify as Significant Woodlands but are strategically located, etc.;

9) Consideration of utility and rail corridors; these offer naturalized connections. Rail corridors offer habitat connectivity through the urban area, and topographic diversity that provides shelter and cover for many wildlife species. They may require noise and safety buffers. Pipeline corridors are typically maintained in the urban landscape and kept in grassy cover, however they may be planted along the edges and in some cases have hedgerows. hydro corridors offer linkage opportunities between major systems;

10) Integration, within the Functional Stormwater and Environmental Management Strategy (FSEMS) of studies by other disciplines including hydrogeology, hydrology and hydraulics, stream morphology and aquatic biology, including ranking of watercourses based application of criteria:

- Terrestrial Significance of Watercourses
  - High – linking core 'significant' natural features
  - Medium – linking secondary features
  - Low – not providing linkages between terrestrial habitats

- Fisheries Significance of Watercourses
  - High
  - Medium

- Stream Morphologic Constraints of Watercourses
  - Meander belt width
  - Sensitive points of gradient control

- Stream Hydrology and Hydraulics
  - Regulated Floodplains (existing and proposed)
  - Channel, bridge and culvert sizing for conveyance and wildlife passage

- Net Ratings - Watercourses Protection Hierarchy
  - Protect/enhance in-situ
  - Maintain as open; realignment possible
  - Alter or remove as necessary; subject to function replication

- Definition of minimum planning corridors by reach, including Regulation buffers.

11) Terrestrial Unit Enhancement
    - Linkages/corridors - locations, specifications and implementation details
    - Habitat restoration/enhancement/consolidation measures
    - Invasive species management
    - Integration of other discipline mitigation measures (e.g. swale compensation, channel relocations to reinforce terrestrial functions of natural features)

12) Avoidance of impacts to these features potentially caused by development on "adjacent lands" (120 m from significant features) through identification of buffers, setbacks and complementary uses.

13) Consideration of Proposed Land Uses
    - Secondary plan options, preferred option and policies
    - Integration (conceptual level) of complementary land uses in vicinity of NHS
    - Urban design standards for "green infrastructure", trail links

14) Direction for site specific studies (SIS) where additional opportunities and constraints may be identified that will help to further refine the future Natural Heritage System and supportive land uses. These include:
    - Valley and Hazard Land Setbacks
        - Geotechnical setback criteria based on site-specific studies
        - Refined regional floodlines and potential erosion sites

    - Stormwater management facilities (SWM) footprints and design:
        - SWM facilities are functionally important in terms of their placement and design because i) they are fundamental linkage elements between landscape hydrological functions with the receiving watercourses and their corridors; ii) they occupy a significant area of the built landscape (typically >5%); and iii) it is well documented that they are functionally important to, and regularly utilized as habitats by upland, wetland and aquatic biota.
        - May be placed strategically to add strong nodality to stream corridors. However, according to their performance objectives, they pose a significant risk of exposing biota to contaminants. They are currently designed to be regularly monitored and managed in the built landscape, and assuming that due diligence is respected in this maintenance, could provide net functional benefits to the ecosystem.
        - SWM facilities are not included in the protected NHS.
        - Guidance provided in FSEMS on optional facilities locations, diversion opportunities, retrofit areas and naturalization criteria, specialized water supplies for habitat elements (e.g. Foundation Drain Collectors, Low Impact Development, roof water diversion/dedication)

    - Swale compensation and Low Impact Development (LID BMP's) are relatively new opportunities as features that do not qualify for dedicated corridors or blocks in the landscape, but are potentially valuable adjuncts within channel or feature buffers, stormwater facility blocks, or integrated with existing or new terrestrial linkages. They may be utilized to support the maintenance of hydrologic regimes of palustrine wetlands.

Updated NHS Goals and Objectives for the Subwatershed Update Study Areas (repeated from Section 2.2)

The following updated objectives and targets build upon those previously defined for the Natural Heritage System and terrestrial resources in the Indian Creek/Sixteen Mile Creek - Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2004). They have been updated based on the current study approach, available Natural Heritage System policies, and further refined based on comments received from Conservation Halton staff.

i) Identify and classify natural/semi-natural terrestrial features and assess their significance according to their conformity with significance categories established by the Province, Region and Conservation Authority, based on criteria regarding size, biophysical attributes and ecological functions for the purposes of developing a sustainable natural heritage system for the urban and rural portions of the watershed.

ii) Given the depleted, degraded and fragmented state of existing terrestrial resources in the subwatershed study area, the key objective of the subwatershed plan is to achieve a 'net gain' in terms of the extent of natural terrestrial habitat and associated functions and linkages. The goal is a well-linked system within the urban setting which promotes the maintenance and enhancement of key subwatershed resources.

iii) All identified 'Significant' terrestrial features should be protected and enhanced within a recommended Natural Heritage System, to be defined as part of the Secondary Plan processes.

iv) The Subwatershed Update Study and Functional Stormwater and Environmental Management Strategy (FSEMS) will define standards for protection and linkage of these resources. These protection and enhancement requirements will be integrated into detailed Subwatershed Impact Studies (SIS).

v) Other terrestrial features not meeting policy-based significance criteria should be integrated into a linked system which optimizes their integrity and functions within the future urban landscape. The system can be further enhanced with habitat restoration, and integration of protected natural areas with land uses that support the functionality of natural features (such as parkland, golf courses, school campuses and other uses that can incorporate naturalized elements).

vi) All identified linkage features in the subwatershed study area represent constraints to future land uses and are to be protected and enhanced. Within the Milton Business Park / Derry Green and Phase 3 / Boyne Survey urban expansion areas, some linkage features may be modified, and their relocation and enhancement should place a high priority on natural heritage system objectives wherever feasible and practical in an urbanizing landscape.

vii) The functioning components of linkages should be protected and enhanced. Terrestrial linkage features can be used to accommodate trail systems.

viii) Stormwater management facilities should be integrated outside the NHS but due to their related hydrologic functionality, contribute complementary landscape connectivity functions and naturalized cover that is routinely used by wildlife.

ix) The SIS for each detailed study area will refine desirable riparian corridors and other linkage features following an integrated multi-disciplinary assessment. This will include recommended corridor dimensions as well as structural components to be considered at subsequent planning and design stages. The identified terrestrial system should also accommodate existing and new wetland and pond features that can support identified species of concern in the urban setting.

With respect to Objective (ix), Sections *5.2*of the Derry Green and Boyne FSEMS address enhanced wildlife crossings. Target species and habitats are also addressed in the Derry Green FSEMS and in the Boyne FSEMS).

5.4 Defining Natural Corridors and Linkages, Buffers, and Road Crossing Standards

Urban cover, people and traffic in settlement areas alter landscape functions from the existing agricultural matrix, exposing natural features and areas, and linkages between and among them to more stressors. This makes it important to organize and link lands within a natural heritage system with explicit spatial or functional protection to help maintain its long-term ecological function and biodiversity. These take the form of corridors, linkages and buffers.

The value of corridors has been asserted and debated in landscape ecology literature for more than 20 years; a consensus has been reiterated consistently that corridors, when connecting remnant habitats set into a relatively hostile landscape matrix, are a net benefit to most biota. In an urbanized setting, naturalized corridors provide many additional benefits for runoff management, scale-effective servicing, and human access to recreation, living and work centres. The valued role of riparian corridors in the current secondary planning areas is indisputable. However, as discussed below, certain disbenefits or conflicts should be recognized associated with corridors.

The key tests for the adequacy of corridors are as follows:

a) do they adequately address regulatory, conveyance, fluvial morphology and runoff management needs;
b) will they adequately address species migration/habitat access needs in an urban context;
c) do they offer opportunities for functional space (i.e. spatially and operationally) to provide riparian habitats of sufficient size and diversity to sustain quality cover and species (plant communities and wildlife); and
d) do they provide adequate connections to address the broader regional linkage system.

With respect to a), these are addressed by other disciplines.

With respect to b) species movement, continuous riparian cover of minimum width would be a distinct improvement over current conditions where riparian corridors are limited by agricultural encroachment; however the conversion from an agricultural to urban dominated landscape

matrix will expose these corridors to significant stressors. There is evidence that adding natural corridors into a landscape that is already operating in 'sink' mode for many biota, may exacerbate the 'sink' condition, spreading the limited biota even more thinly through the expanded system (Hilty et. al., 2006). There is also evidence that focused expansion and diversification of core natural features will have more benefits for conservative biota on a comparative area basis, than the creation of wider corridors that attempt to promote species residency crossing a 'hostile' landscape matrix (Falcy and Estades, 2006; Simberloff and Cox, 1987, Simberloff et. al., 1992). Core enlargement may have disproportionately greater benefits relative to corridor establishment or enlargement (Matter 1997; Connor et. al., 2000).

The inclusion of pedestrian trails adds to urban stressor effects both in corridors and within natural features. The regular presence of domestic dogs, whether on- or off-leash, has been demonstrated to alter wildlife usage of habitats. Changes to wildlife behaviour (including small to large mammals, and canids such as Red Fox) have been identified extending 50+m beyond trails (Lenth et. al., 2006). It is likely that these effects can be somewhat moderated with better placement of trails away from key sensitive habitats, and through topographic separation of trails from these habitats. Where more extensive trail links are required, wider corridors may be warranted. Conservation Halton permits trails within the 15 m buffers along watercourse corridors. The FSEMS recommendations reflect detailed discussions with the Town, Conservation Halton, the Region of Halton on the placement of trails in corridors, and within buffers to natural features.

A balanced approach is recommended that considers the intended functions and uses of the corridor, and their 'fit' within the NHS, as a means to establish the appropriate width. Based on available literature, corridors of 50-100 m will primarily benefit edge-adapted species. More conservative species may use corridors of this size depending on the habitat structure and proximity of core and nodal features. Critical habitats of conservative species consist of larger natural features, generally associated with the Main and Middle/East Branch of Sixteen Mile Creek, and there would be greater benefit in consolidation of core areas in these areas with adequate ecological buffering, rather than from substantial increases in corridor width along smaller tributaries.

With respect to c) riparian diversity, the existing corridors contain some limited existing riparian and wetland habitat features (including locally significant wetlands and wetland complexes – ref. Section 3.6.4), but there are frequent nodal opportunities where off-line wetlands could be established that would (desirably) not be reliant on urban runoff. The configuration of these areas under the corridor categories in the secondary plans does not provide certainty that necessary adjustments in adjoining land uses can be made to ensure that a diverse range of clean water sources is assured to sustain such features. Some flexibility in the plan would therefore be desirable to ensure a functional as well as a spatial 'fit'.

With respect to d) regional connections, the Derry Green and Boyne lands contain or abut sections of major corridors of the Main and Middle Branch. The watercourses in Derry Green are well connected to this regional system, with supplementary linkage via the Union Gas pipeline corridor, and hydro/rail corridors. Corridor connectivity is more constrained in the Boyne lands and the lands west of Tremaine Road; however the strengthening of the Main Branch and secondary corridors will have immediate benefits to habitat as well as providing the opportunity

for future improvements to linkages extending southward along the tributaries, as Sustainable Halton has identified this area for future growth. All secondary corridors will be widened as part of the secondary plans, typically in the 50 to 95 m range including buffers. In conjunction with core areas, habitat restoration and nodal opportunities in conjunction with stormwater integration, the 'effective' corridor structure will be more robust that that represented simply by the watercourses.

Three realities face the secondary plan areas: i) most of the proposed NHS corridors and linkages are weak or absent today and would realistically begin to function over a period of decades, during which the status of biota may change; ii) the construction of urban development and the NHS itself (i.e. construction of new watercourses, water management facilities, major grading) will surround the existing features and may conflict with some of the NHS objectives during implementation; and iii) road crossings of corridors can be most effectively addressed (i.e. connectivity and cost) where corridors (or linkages) are associated with regulated watercourses. These concerns will need to be addressed through the FSEMS and SIS stages.

East-west NHS connectivity is typically difficult to achieve in southern Ontario, where most watercourses are oriented in a (more or less) north-south orientation. East-west linkages that lack a riparian component are constrained topographically; the creation of safe road crossings for wildlife is less practicable. Utility corridors are occasionally oriented in a favourable direction to permit east-west connections. Derry Green contains two such features (Union Gas pipeline and hydro corridor); Boyne and the lands west of Tremaine Road do not have any opportunities of comparable scale, although the CN rail corridor through Boyne provides local linkage functions. The major hydro corridor in Derry Green is also an area of diverse cover and sustains existing concentrations of open country birds; the land uses in the area are relatively static, and there is good connectivity to the Greenbelt to the east.

Smaller linkages that are not tied to watercourse corridors would be desirable in key areas. These afford the potential to incorporate swale compensation, or to allow trail linkages away from roads. These are recommended to be a minimum of 15 m wide, with landscaped cover.

Conservation Halton Regulations

On April 27, 2006 the Halton Region Conservation Authority Board of Directors approved the document entitled *Policies, Procedures and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document* which establishes the policies made under Ontario Regulation 162/06. The result of this publication was an update to the policies governing apparent and non-apparent river and stream systems as well as shorelines affected by erosion and flooding hazards, wetlands and lands adjacent to these hazards/features. These new policies prohibit development within the following limits, unless otherwise specified in the policy document:

(a) Within 15 m of the stable top of bank of a major valley system and 7.5 m of the stable top of bank of a minor valley system, where a valley is apparent. The valley systems within the Boyne Survey and Derry Green areas are all considered "major valley systems" with respect to setback requirements;
(b) Within 15 m from the greater of the limit of the flood plain or the predicted meander belt width of a watercourse associated with a major valley system and within 7.5 m from the

greater of the limit of the flood plain or the predicted meander belt width of a watercourse associated with a minor valley system, where a valley is not apparent;

(c) Within 120 m of a Provincially Significant Wetland and all wetlands greater than or equal to 2 ha in size;

(d) Within 30 m of wetlands less than 2 ha in size;

(e) Within 5 m of the furthest landward extent of the aggregate of the flooding, erosion and dynamic beach hazards along the Lake Ontario and Hamilton Harbour shorelines; and,

(f) Hazardous lands.

The required buffers for the Derry Green and Boyne Survey Secondary Plan Areas have been established consultatively through the completion of the FSEMS for these areas and are prescribed in the respective Technical Appendices. Additional potential wetlands have been identified by Conservation Halton as part of the mapping update associated with the revised regulation. These wetlands have been screened and evaluated under the Ontario Wetland Evaluation System where criteria for evaluation were met. These are discussed in Section 3.6.4 of this report.

Recommendation for lot line setbacks from hazardlands including wetlands are contained within Section 4.0 of the Conservation Halton Policies, Procedures and Guidelines for the Administration of Ontario Regulation 162/06. The relevant portions of Policies 4.1.3, 4.2.3, 4.3.2 and 4.4.4. The FSEMS reports recommend approaches compliant with these policies.

Buffers

The PPS and other guiding documents identify the consideration of ecological buffers based on needs identified through functional analysis of hydrology and sensitive species or habitats. Commonly prescribed buffers for the protection of Provincially Significant Wetlands are 30 m except where site-specific issues are identified that require greater buffers (occasionally 50 or 100 m). However, sometimes other actions, such as where watercourses are to be relocated adjacent to existing features, provide potential buffer benefits along those edges.

In past subwatershed plans, various buffer approaches have been recommended:

- Buffer determination left to detailed site specific studies such as SIS/EIS;
- Buffers pre-defined in subwatershed studies for features; e.g. North West Brampton: 10 m (woodlands), 20 m (wetlands); North Oakville: 10 m (woodlands), 30 m (PSW's)
- Minimum buffers defined, with refinement required through SIS.EIS;
- EIS trigger threshold distances defined for protection; if development is proposed within the threshold buffer area, an EIS must be conducted to address impacts and mitigation.

Conservation Halton has requested that minimum buffers be assigned in the SUS; recommended buffers for the Derry Green and Boyne Survey NHS are presented in the FSEMS reports. The *Town of Milton Restoration Framework* has been developed for exclusive use within the Sixteen Mile Creek subwatersheds; it contains a restoration rationale and approach for the planting of stream corridors and buffers. The FSEMS reports provide further guidance on the application of this document.

The Greenbelt Plan requires a minimum 30 m vegetation protection zone for wetlands, seepage areas and springs, fish habitat, permanent and intermittent streams, lakes, and significant woodlands. MNR has prepared draft guidelines in support of the Plan which address Key Natural Heritage features identification criteria, Significant Woodlands Criteria, and Significant Habitats of Endangered, Threatened and Special Concern Species. The interfaces of the study areas with the Greenbelt are quite varied, and road infrastructure is in place that will eventually be widened and altered following Environmental Assessments. These are outside of the scope of the SUS but some guidance on Greenbelt interfaces will be provided in the FSEMS (ref. Section *5.2 Buffers* in both the Derry Green and Boyne FSEMS). .

Buffers must be assigned to a defined limit of features; this requires field staking of features, which would normally occur as part of SIS preparation, or sooner where tertiary planning efforts warrant such detailed information. Disturbances (such as clearing) and community succession will affect the extent of features observed at this time. Dougan and Associates recommends that the approximate limits of features indicated in current ELC mapping in the SUS form the benchmark for future comparisons. The intention is that the functional and habitat objectives of the NHS shown on the Secondary Plans are achieved; this may require negotiations with the Town and Conservation Halton regarding site-specific interpretation at the time of field staking.

Road Crossings

Road crossing design for corridors encompasses aquatic biology, stream morphology, hydrology and hydraulic input, in addition to terrestrial matters. The riparian channels will consist of naturalized corridors at least 60 m in width. Culverts or small bridge spans may be required based on floodplain characteristics, to be determined in FSEMS and CFCP standards and through the completion of the SIS and detailed designs. Road widths and profiles will affect the opportunities for enhanced wildlife passage in each crossing location. Provision of wing wall and other elements to direct wildlife passage will be included. Crossings will require terrestrial benches to permit passage under a range of flow conditions.

Improved standards for road crossings of wildlife corridors are now becoming more standardized. In urban and agricultural settings, riparian-based crossings are the most effective from the standpoint of attracting wildlife movements, and managing the crossing from the standpoint of geometrics and cost. There is now a significant body of international research on the design of crossings, and monitoring results (ref. Forman et. al., 2003). Key considerations relate to the need to separate wildlife from human trail systems, targeting of appropriate wildlife species for safe passage, and design considerations to encourage use of passages by target species rather than crossing of the busy road network. The FSEMS provides direction as to the recommended location and design considerations for wildlife passage (ref. Section *5.2.1 Enhanced Wildlife Crossings* of both the Derry Green and Boyne FSEMS). The determination of site specific dimensions for crossing is an SIS requirement.

6. IMPACT ASSESSMENT

The Subwatershed Study process is intended to identify:

(i) Where are important resources?
(ii) How will they be affected by proposed development?
(iii) What should be done to mitigate and/or avoid negative impacts?
(iv) How can these resources be enhanced and/or protected in the most practical and economic way?

As part of this Subwatershed Update Study, the important resources within the Subwatershed have been established as part of the updated study area characterization, which has been developed based upon the baseline assessment, field monitoring, and integrated constraint rankings completed as part of this study. The information provided in Sections 3, 4 and 5 of this report summarize the methods and results of the characterization process, and the subsequent application toward the updated constraint rankings for the Sixteen Mile Creek Areas 2 & 7, specifically within the limits of the Derry Green and Boyne Survey areas.

The January 2000 Subwatershed Planning Study included analyses which assessed the anticipated impacts to the natural resources within the Sixteen Mile Creek Subwatershed Areas 2 & 7, associated with the proposed urban expansion as per the Town of Milton Official Plan. The following section provides a summary of the key findings resulting from those assessments. [NOTE: The local impacts from future development within the limits of the development area, require a detailed level of analysis which is typically initiated in support of the Secondary Planning Process. Such analyses are beyond the scope of the current Subwatershed Update Study, and have rather been completed as part of the Functional Stormwater and Environmental Management Strategy process for Derry Green and Boyne Survey.] Although analyses for water quality impacts are considered beyond the scope of the Subwatershed Update Study, a summary of the findings advanced from the original Subwatershed Planning Study is provided herein for contextual continuity with the baseline inventory provided in Section 3 and the long list of management strategies summarized in Section 7.

6.1 Hydrology

As indicated in the original Sixteen Mile Creek Areas 2 & 7 Subwatershed Planning Study, hydrologic processes are considered central to many of the natural functions and features within the subwatershed. Therefore, maintaining hydrologic function after land use changes is considered important to preserve existing resources. The impact assessment for future land use conditions within the Sixteen Mile Creek Subwatershed Areas 2 & 7 included hydrologic analyses to evaluate the impact of development on baseflow/low flow, peak flow rates and flood potential, and in-stream erosion potential.

The impact assessment of future conditions within the Sixteen Mile Creek Subwatershed evaluated the hydrologic impacts associated with land use conditions as per the Halton Urban Structure Plan (HUSP), in the absence of any stormwater management measures. The analyses have been based upon continuous simulation and frequency analyses for the simulated annual maximum flow rates.

The results of the impact analyses indicated that, under future uncontrolled land use conditions, flow rates within the Sixteen Mile Creek Areas 2 & 7 would increase for all events up to and including the 100 year frequency. The highest relative increases to peak flow rates were anticipated along the watercourses within the development areas themselves, with the highest increases anticipated during the more frequent storm events. Flow rates along the major tributaries of the Sixteen Mile Creek (i.e. the Sixteen Mile Creek Main Branch and the Sixteen Mile Creek East Tributary) were essentially insensitive to the impacts of future development for the less frequent storm events, due to the undeveloped land use conditions which would remain within the headwater subwatersheds of the Sixteen Mile Creek; nevertheless, peak flow rates during the more frequent storm events were shown to increase as a result of future development. Additional analyses indicated that these impacts could be successfully mitigated through the implementation of stormwater quantity control measures within the future development areas.

The results of the continuous simulation were further analyzed as part of the original Subwatershed Planning Study in order to determine the impacts of future development on baseflow conditions along the Sixteen Mile Creek Main Branch and at the outlet of the Sixteen Mile Creek East Tributary. The results of this assessment indicated that, under future land use conditions without stormwater management, baseflows along the Sixteen Mile Creek Main Branch would be anticipated to decrease by 0.6 % and baseflows along the Sixteen Mile Creek East Tributary would be anticipated to decrease by 1.6 %. Analyses for future land use conditions with stormwater management indicated that the implementation of the stormwater management strategy proposed in the Subwatershed Planning Study would effectively mitigate these impacts, and would result in an augmentation of baseflows, and that the duration of baseflow conditions was anticipated to increase by 8.3 % and 5.0 % along the Sixteen Mile Creek Main Branch and the Sixteen Mile Creek Tributary respectively.

Finally, erosion analyses were completed as part of the original Subwatershed Planning Study at three locations within the Sixteen Mile Creek Subwatershed. The results of those analyses indicated that increases in erosion potential would occur under future uncontrolled land use conditions, with maximum increases in erosion exposure of 1200 % occurring along the Sixteen Mile Creek Main Branch (i.e. within Subwatershed Area 2). The results also indicated that the total duration exposure to excess bed and bank shear was approximately 1 to 3 orders of magnitude greater within Subwatershed Area 7 compared to Subwatershed Area 2, likely due to the steeper local channel slope and higher peak flows throughout the Sixteen Mile Creek East Tributary under future uncontrolled land use conditions. The results for future land use conditions with recommended stormwater management indicated that the recommended erosion control storage volumes would not entirely mitigate increased erosion potential within Subwatershed Area 2; however, given that the total duration of erosion producing flows were low, the predicted increases were not considered significant.

As part of the field monitoring for the Subwatershed Update Study, erosion thresholds have been obtained at various locations within the Sixteen Mile Creek Subwatershed Areas 2 & 7, within or downstream of the Derry Green and Boyne Survey Areas. The information collected under this update study has been used in subsequent studies (i.e. the Functional Stormwater and Environmental Management Strategies) in order to quantify the impacts of the proposed

development of the respective areas, based upon the Secondary Plans developed for these areas, as well as to assess the effectiveness of proposed stormwater management strategies in order to mitigate these impacts. Moreover, these analyses will identify the critical erosion site (i.e. the most erosion-prone site) located downstream of the proposed development area; this site will represent the target site for erosion protection within the upstream Secondary Planning area.

6.2 Groundwater

Basic potential impacts related to the groundwater flow system include:

- Groundwater quantity and quality impacts related to changes in the amount and quality of groundwater recharge;
- Subsequent changes to stream baseflow or groundwater levels related to wetlands;
- Short circuiting of local groundwater flow systems through infrastructure;
- Increased groundwater levels due to importation of water and infrastructure leakage.

These impacts were not specifically modeled quantitatively within the scope of this study. It was expected that groundwater monitoring through historical and ongoing development since the previous subwatershed study would provide an indication, through water level and water quality trends, of any measureable impacts from development.

Groundwater monitoring data was basically limited to the one local PGMN well and limited data carried out through the Environmental Monitoring Activities as well as a comparison of recent and historical spot baseflow data. Although the data overall is rather limited it appears that groundwater levels and baseflow have been relatively stable within the seasonal and longer term climatic trends. Notwithstanding this general assessment there is a lack of consistent long term groundwater monitoring data the specifics of which are further discussed in Section 8.

Groundwater modeling and groundwater monitoring within the same hydrogeologic setting (Halton till on the Queenston shale with very low relief) in Northwest Brampton indicates minimal change to the water table. The modeling shows a potential drop of up to 0.3 m given a conservative estimate of decreased recharge. This reduction indicated minor local changes to groundwater discharge within various reaches. In some cases there were increases and in other cases decreases. This assessment did not take into account the importation of water or infrastructure leakage. Monitoring of the local water table did not indicate any downward trends adjacent to areas of development. The potential change in the water table would not impact the local well water quantity.

As discussed in Section 3.2.5 the impact on the local water table and local groundwater flow, as a result of potential, preferential drainage due to infrastructure, would appear to be confined to an area within 30 m or less of the service. This potential reduction is considered minimal but should be taken into account during the more site specific groundwater assessment. Where necessary the preferential pathways can be restricted through site specific trench design.

Groundwater aspects are incorporated into other impact assessments related to stormwater management with a more specific focus on baseflow.

6.3 Surface Water Quality

Mass balance modelling was completed as part of the January 2000 Subwatershed Planning Study in order to assess the potential for changes to annual pollutant deliver to the Sixteen Mile Creek, as a result of future development as per the Town of Milton Official Plan. The analyses evaluated the impacts to contaminant loadings generated in storm runoff, and did not evaluate baseflow pollutant loadings. The primary objectives of the mass balance model assessment were to:

- Characterize and context the relative contribution of various pollutant sources with each watershed,
- Indicate proposed development's relative impacts on annual pollutant loads and effectiveness of mitigation of such development, and
- Provide an estimate of each Subwatershed's pollutant loads in the context of the overall watershed loading.

The results of the mass balance modelling completed for the January 2000 Subwatershed Planning Study indicated that the application of stormwater quality controls to Enhanced (formerly Level 1) standard of treatment for all new development would mitigate increases in TSS and phosphorus, with TSS loadings anticipated to be reduced by 20 % compared to existing levels. The results also indicated that the mass loadings of fecal coliforms, metals, and TKN would all increase by 30 % +/- compared to existing levels with the application of stormwater quality controls for future development areas; nevertheless, the application of stormwater quality control would achieve a reduction in the mass loadings of these contaminants compared to uncontrolled conditions.

6.4 Stream Morphology

A primary and substantive impact from urban development is the change in hydrologic regime. Specifically, as a result of urbanization, a greater volume of flow will be conveyed through the downstream watercourses. The impact from these increased flows can be largely mitigated through integrated stormwater management. Changing land uses, especially to an urban setting, can have several other impacts on watercourses. Basic potential impacts related to stream morphology include the following:

- Loss of sediment supply due to change in land use, stormwater retention and loss of headwater features;
- Planform alteration to facilitate land development;
- Lowering of channels to facilitate grading and drainage of adjacent developed lands; and
- Erosion and planform migration in response to land use, flow regime and watercourse modifications.

A stable channel will be in balance or quasi-equilibrium with the flows and sediment that it conveys. When part of this balance is altered, the channel will adjust. Through urbanization, both flows and sediment are typically altered through stormwater management. Part of the stormwater management control, is the removal of sediment which may impair water quality. This loss of sediment is further exacerbated through the loss of headwater drainage features

which lack form but do offer function through the production and conveyance of sediment and conveyance of flow. While it is not possible to avoid the loss of sediment supply from tableland sources through urbanization, improved awareness and consideration of open conveyance requirements on the landscape should help future management decisions.

Typically, as the demand and value for land grows, particularly adjacent to channels, so does the pressure to acquire and modify the valley system. This frequently occurs through the straightening, relocation and/or lowering of a watercourse to facilitate the development of adjacent lands. Unfortunately, the watercourse in this typical scenario will respond to such modifications through adjustments in the form of erosion and planform migration, resulting in morphologic instability and potential risks to property, infrastructure and public safety. Moreover, lowering of unconfined systems can have potential policy implications if the deepening is sufficient to trigger a re-classification of the system to confined, as these systems require further geotechnical allowances within the overall established corridor.

The inclusion and implementation of stream corridors, based on natural functions to urban development has reduced and controlled many of these negative impacts. The incorporation of the meander belt width into stream corridor dimensions, allows a watercourse sufficient lateral width to permit channel migration without risking damage to surrounding infrastructure and property. For this reason, recommended corridor widths should be maintained regardless of whether a watercourse remains in place or is relocated on the landscape. A more comprehensive stream corridor management approach includes additional allowances to promote aquatic, terrestrial, geotechnical and hydrologic requirements. The requirement for watercourse lowering to facilitate development is a particular consideration within the Boyne Survey lands where the existing topography is minimal and existing watercourse grades are low. As a result, any lowering of the channel will require substantial grading upstream and downstream to achieve an appropriate stream profile. Consequently, impacts associated with implications to corridor requirements and the development potential of downstream lands must be considered in future management decisions.

6.5 Fisheries/Benthics

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 movement and migration. The overall impact on aquatic resources is determined by the cumulative effects of impacts on those factors.

The drainage features within the Phase 3, Business Park 2 areas have been classed according to the *Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines* (ref. CVC and TRCA, March 2009). To preserve the function of drainage features, the guidelines recommend certain management strategies for each stream habitat class.

The classes of headwater drainage features (CVC and TRCA, March 2009) are as follows:

1. *Permanent* - Provides direct habitat onsite (e.g. feeding, breeding, and/or migration) as a result of year round groundwater discharge and/or permanent standing surface water within a storage feature (i.e. ponds, wetlands, refuge pools, etc.). Habitat may be either existing or potential (i.e. isolated by a barrier). Permanent habitat also may include critical fish habitat (i.e. habitat that is limited in supply, essential to the fish life cycle, and generally habitat that is not easily duplicated or created). Hydrogeological studies and/or water balance calculations may be required to confirm groundwater contributions, as appropriate, with regard to the scale of the development application(s).

2. *Seasonal* - Provides limited direct habitat onsite (e.g. feeding, breeding, migration and/or refuge habitat), as a result of seasonally high groundwater discharge or seasonally extended contributions from wetlands or other surface storage areas that support intermittent flow conditions, or rarely ephemeral flow conditions. Occasionally, limited permanent refuge habitat may be identified within seasonal habitat reaches.

3. *Contributing* - Provides indirect (contributing) habitat to downstream reaches – functions generally increase with flow and/or as flows move downstream with increasing length of channel or channel density (e.g. extent of contributing area). There are two types of contributing habitat:
    i) Complex contributing habitat – generally as a result of intermittent (or less commonly ephemeral) surface flows, can have marginal sorting of substrates – generally well vegetated features that influence flow conveyance, attenuation, storage, infiltration, water quality, sediment, food (invertebrates) and organic matter/nutrients (i.e. there are two types of nutrients, e.g. dissolved nutrients, and course/fine matter). Generally, two structural types: a) defined features with natural bank vegetation consisting of forest, scrubland/thicket or meadow (as defined in OSAP or ELC); or b) poorly defined features (swales) typically distinguished by hydrophilic vegetation.
    ii) Simple contributing habitat – generally as a result of ephemeral (or less commonly intermittent) surface flows – generally not well-vegetated features that influence flow conveyance, attenuation, storage, infiltration, water quality and sediment transport. Generally two types: a) defined features characterized by crop cultivation, mowing or no vegetation; or b) poorly defined features (swales) may contain terrestrial vegetation.

4. *Not Fish Habitat* - The pre-screened drainage feature has been field verified to confirm that no features and/or functions associated with headwater drainage features is present – generally characterized by no definition or flow, no groundwater seepage or wetland functions, and evidence of cultivation, furrowing, presence of a seasonal crop, lack of natural vegetation, and fine textured soils (i.e. clay and/or silt).

5. *Recharge Zone* - Coarse-textured soils described as sand and/or gravel have been confirmed through field verification; majority of potential flow will be infiltrated. These features may have ill-defined channels as a relic of past flows; however the key function is groundwater recharge and maintenance of downstream aquatic functions via

groundwater connections to streams. No direct fish habitat or indirect contributions through surface flow conveyance, allochthonous or sediment transport provided.

6.6 Terrestrial

The updated baseline information (Section 3.6) clarified current terrestrial conditions within the three detailed study areas. Features have been mapped according to ELC cover (Appendix 'H' Figure T1, T2, T3), and assigned significance status according to available provincial, regional and municipal policies (ref. Appendix 'H' Figure T5). This has included assignment of Habitat of Threatened and Endangered Species, Significant Woodland status, Significant Wildlife Habitat, and Significant Valleylands. Other wildlife issues have been further researched, and updates have been provided based on the most current COSEWIC and COSSARO status rankings. Individual Species at Risk have been discussed in terms of their status in the study areas, habitat requirements, and potential strategies identified to be examined as part of the NHS development and implementation. Unevaluated wetlands were screened, prioritized, and then four evaluations were completed according the Ontario Wetland Evaluation System (1993).

Watercourses have been rated from a terrestrial significance perspective, and these ratings in combination with those of other disciplines, have prioritized the existing watercourses in terms of whether they will be protected in place, relocated but remaining as open watercourses, or removed, with functions to be replicated by landscape level measures. Opportunities for other linkages, potentially integrated with functional initiatives by other disciplines (e.g. hydrology, groundwater, swale compensation) are being considered for each study area.

Section 4 summarized constraints and opportunities for each study area with respect to the existing terrestrial components as determined from field studies and historical documentation of resources. Cumulative impacts have already occurred within the three detailed study areas, reflecting intensive agricultural and urban fringe uses; these impacts may be further exacerbated if development occurs without appropriate regard for terrestrial resources and functions.

The NHS is a management strategy intended to integrate, protect and enhance existing features and functions that have been assessed and prioritized through the characterization, and to reflect the terrestrial objectives and those of other disciplines, including those on the SUS study team, as well as land use planning. Section 5.1 identifies the relevant guiding documents, objectives and targets related to help define a future natural heritage system. Section 5.2 reviews the experience with NHS implementation in earlier development phases. Section 5.3 presents the detailed NHS Development Approach that is being applied to the subject study areas. Section 5.4 presents a discussion of potential approaches to defining corridors and linkages, buffers, and road crossings, Insights from key literature are included.

Constraints are represented by the areal extent, habitat diversity, sensitive attributes, and associated functions of identified significant features. Constraints are sometimes site-specific (related to intrinsic biological and physical sensitivities) but functional constraints related to the existing or potential role of features with physical landscape functions often extend beyond the features. Due to the nature of terrestrial constraints, and the intention to alter the functionally dominant landscape conditions (i.e. conversion from agricultural to urban), some of which have

a direct bearing on particular biota or their habitats. It is the intent of the subwatershed management strategy (including a future Natural Heritage System) to avoid impacts as a first priority, and to offset the extent and magnitude of impacts associated with urbanization. The recommended NHS subwatershed management strategy is generally summarized in Section 7.6; details on application to each study area are found within the Functional Stormwater and Environmental Management Strategy reports for each area.

Development activities which result in the loss of terrestrial habitats and/or further degradation or impairment of ecological functions within the subwatershed study areas constitute impacts. The future urbanization of the identified expansion areas may result in such impacts. It is possible to avoid or offset many impacts through appropriate mitigation, however the potential to mitigate varies based on the particular sensitivities of the individual features and functions as well as the nature of the impact source (i.e., small scale/large scale; direct/indirect; temporary/permanent, etc.). The greatest change associated with urbanization is the transformation of the landscape matrix into a new regime, affecting water resources, microclimate, ambient noise and light levels, contaminants, and intensified stressors related to human proximity and road density.

The Natural Heritage Reference Manual (OMNR 2010) recognizes that each NHS will be unique; where existing natural cover is already very limited and poorly linked, the NHS will be different than where cover is extensive and already well linked. In areas where the existing system is already depleted, the consideration of basic NHS enhancements, in concert with recognition that creative design standards for development and potential complementary values of land cover, may yield value-added potential to the future NHS.

Potential direct, indirect and cumulative impacts resulting from urbanization may be summarized as follows:

Size, Extent and Linkage of Natural Features

- Loss of remaining natural habitats
- Disruption of terrestrial habitat linkages (including agricultural field roles)
- Removal of surface landscape connections which are already poorly defined

Diversity of Natural Features

- Loss of already limited habitat diversity (wetlands, forest, successional lands)
- Loss of representative habitat features
- Loss of heritage trees and hedgerows
- Loss of small isolated habitat pockets and their biota (e.g. amphibians in farm ponds)
- Displacement of native flora by invasive introduced species

Stresses on Natural Features and Functions

- Increased encroachment of intensive human activities into remnant natural habitats
- Alterations to hydrologic regimes of sensitive features
- Further introduction and spread of invasive and exotic species into remaining natural habitats and creates system elements such as new corridors

- Displacement of rural-adapted wildlife by urban-adapted species due to loss of habitat cover, noise, light, and human proximity effects
- Introduction of domestic pets and encouragement of urban affiliated wildlife which are predatory or inhibit the sustainability of native wildlife diversity
- Microclimate alteration due to urban heat island effects and reduced vegetative cover
- Exposure risk to air and water-borne contaminants
- Conversion of rural hydroperiods to more unpredictable urban hydroperiods, resulting in loss or simplification of plant and animal species

The relevance and extent of potential impacts in each detailed study area will be dependent on the features and functions within the areas, and the management strategies which can feasibly be applied in each area. This is addressed in the FSEMS for each area.

7. SUBWATERSHED MANAGEMENT STRATEGIES

This Subwatershed Update Study has provided the characterization and constraint rankings for the environmental features and systems within the Boyne Survey and Derry Green Secondary Planning Area within the Town of Milton. The detailed Subwatershed management strategies for each area are provided in the Functional Stormwater and Environmental Management Strategies for each Secondary Planning Area, and which have been prepared as Technical Appendices to this Subwatershed Update Study.

It is recognized that there tend to be two levels of management opportunities associated with the Subwatershed resources: those which apply to the whole of the subwatershed study area, and those which relate to a specific location or environmental unit. The level of detail associated with the management strategies for a specific development area is directly related to the level of detail associated with the planning and design of the respective study area. Specifically, Secondary Plan areas provide an opportunity to develop management strategies at a higher level of detail than development areas which are represented as broad "block-based" land uses. Nevertheless, the guiding principles and the "long list" of potential techniques and technologies, which are used to develop the preferred management strategy as part of the Secondary Planning Process can be evaluated at the higher level.

In general, Subwatershed management strategies are developed in order to address the constraints associated with each study discipline which has been applied for the characterization of the overall study area (i.e. hydrology, hydrogeology, surface water quality, fluvial geomorphology, fisheries, and terrestrial resources). The detailed Subwatershed management strategies, which are developed as part of the Secondary Planning Process, comprise of the following three elements:

- Watercourse Systems
- Natural Heritage Systems
- Stormwater Management

The scope of the management strategy which is developed as part of the Secondary Planning Process, should consider the following objectives:

a) Any management strategy must embrace the fact that human activities will continue within the Subwatershed and that urbanization within the Official Plan designated areas is imminent.

b) Subwatershed Management Strategies must meet the current Federal Department of Fisheries and Oceans "No Net Loss" policy objectives for fisheries habitat.

c) In terms of impact assessment and alternative strategy evaluation, it is necessary to concurrently address the requirements of the economic, social, and physical (natural) environment.

d) Stormwater Management practices should, to the greatest extent possible, preserve the existing hydrologic regime, including surface and groundwater flows.

e) Land Use, proposed for the urban area, should complement the recharge/discharge characteristics of the subwatersheds, enhance and protect terrestrial resources (including corridors) and stream systems.

f) Natural Heritage provisions of the Provincial Policy Statement and the Region's and Milton's Official Plans, should be implemented in existing and new urban areas. Opportunities for restoration/rehabilitation of degraded resources, including retrofit areas, should be identified.

Natural and constructed features must be considered in order to logically delineate or define development areas as part of any discrete assessments. While these details are beyond the scope of the current Subwatershed Update Study, they are to be taken into consideration in the detailed assessment and development of Subwatershed Management Strategies as part of Functional Stormwater and Environmental Management Strategies.

The following section provides an overview of the general requirements and opportunities for the development of Subwatershed Management Strategies in order to address the requirements of the various components associated with the Subwatershed Characterization. Specific requirements and strategies for the Derry Green and Boyne Survey Secondary Planning Areas are provided in the respective Functional Stormwater and Environmental Management Strategies, which are Technical Appendices to this Subwatershed Update Study.

7.1 Hydrology

Management strategies are to be implemented in order to provide flood protection and erosion controls for future development areas, as well as to maintain baseflows within the receiving watercourses downstream of the future development areas.

7.1.1 Flood Protection

Flood protection measures are required within the receiving watercourses downstream of the future development areas, as well as at key locations within the overall development area (i.e. existing and proposed bridges and culverts, and along receiving watercourses through undeveloped areas under interim conditions within the overall development area). Flood protection of downstream areas may be achieved by any combination of the following general techniques:

- Construction of stormwater management facilities for all new development in order to control post-development flows to pre-development levels.
- Increase capacity of hydraulic structures (i.e. bridges and culverts) as well as watercourses downstream of future development areas.
- Construction of hydraulic structures and watercourse corridors to control post-development flows to pre-development levels for the Regulatory Flood (greater of Regional (Hurricane Hazel) or 100 year storm event).

7.1.2 Erosion Controls

Erosion controls are required to provide erosion protection at key locations downstream of the future development areas. Erosion protection for downstream watercourses may be achieved through any combination of the following techniques:

- Increase extended detention storage and drawdown times within stormwater management facilities.
- Application of Low Impact Development (LID) within existing and/or future development areas in order to reduce runoff volumes and promote infiltration, in combination with increased extended detention storage and drawdown times within the end-of-pipe facilities.
- Implement instream works to stabilize channels against erosion.

7.1.3 Baseflow/Low Flow

Measures are to be implemented for future development areas in order to maintain baseflow/low flow conditions at existing levels within the regulated receiving watercourses. Baseflow/low flow conditions may be maintained or enhanced through any combination of the following techniques:

- Increase extended detention storage and drawdown times within stormwater management facilities.
- Application of Low Impact Development (LID) within existing and/or future development areas in order to reduce surface runoff volumes and promote infiltration.
- Importation of water from offsite and recharge to the groundwater regime. Although this is not necessarily a “technique” it is currently recognized that when water is brought into urban centres (i.e. lake based source) leakage from infrastructure, lawn watering etc. has a strong potential to increase groundwater levels and potentially groundwater discharge.

7.1.4 Criteria for Selection

The foregoing demonstrates that a variety of techniques are available in order to achieve the objectives for managing hydrologic conditions within the Subwatershed following development. The recommended strategy would necessarily require consideration of the spatial extent of application available and required, and would therefore be developed as part of the Functional Stormwater and Environmental Management Strategies developed in support of the Secondary Planning Process for the development areas. The following would necessarily need to be considered in the development of a preferred management strategy:

- Size of contributing drainage area available for end-of-pipe stormwater management facilities.
- Environmental constraints (i.e. watercourses and natural heritage systems) and associated rankings.
- Length of reach affected by development.
- Physical constraints (i.e. steep valley walls, absence of drainage features, presence of downstream structures, extent of floodplain, soil conditions).
- Timing constraints associated with off-site works (i.e. timing of development contingent upon completion of off-site works).
- Opportunities to reduce overall operations and maintenance requirements by implementing a single system to achieve all of the above objectives, as well as

stormwater quality control (i.e. construction of end-of-pipe wet ponds, wetlands, or hybrid facilities).

Depending upon other constraints related to proposed development (i.e. grading, servicing, etc.), the stormwater management plan may require the diversion of runoff from the pre-developed drainage system for certain events. This approach was previously applied for the Milton Phase 1 Area and has been identified as a preferred alternative for portions of the Boyne Survey lands (ref. FSEMS). Current practice by Conservation Halton seeks to avoid drainage area diversions wherever possible; consequently, the need or requirement for diversions must be demonstrated to the Authority's satisfaction, and it must also be demonstrated that environmental criteria related to the maintenance of downstream systems and features can be satisfied under the proposed diversion scenario.

7.2 Groundwater

It is generally proposed that groundwater management strategies address the potential reduction in groundwater recharge as a result of an increase in less permeable surface. This is commonly carried out through the implementation of various storm water management practices which promote infiltration. These practices continue to be recommended for the Derry Green area particularly where shallow overburden or more permeable lenses of sand and gravel occur. As usual, the quality of infiltrating water should be such that there is minimal impact to the local groundwater flow system.

Subcatchment areas where the reaches demonstrate perennial flow should focus on maintaining the local groundwater level. This relates to maintaining recharge as described above as well the potential for changing the very local shallow groundwater flow paths and water table due to the installation of various subsurface infrastructures.

7.3 Surface Water Quality

An Enhanced (formerly Level 1) standard of stormwater quality control is required for all future development within the Sixteen Mile Creek Watershed. Stormwater quality controls may be achieved by any of the following techniques:

- Construction of end-of-pipe facilities.
- Application of vegetative techniques on-site.
- Cash-in-lieu for the construction of off-site facilities.
- Application of LID/BMP's to reduce surface runoff and promote infiltration, in combination with the construction of a permanent pool and extended detention storage component within the end-of-pipe facility in order to improve stormwater quality.

The application of LID/BMP's in combination with the application of permanent pool and extended detention storage to provide stormwater quality control within the end-of-pipe stormwater management facility would be anticipated to improve upon the quality of storm runoff beyond current Provincial standards. The recommended strategy would necessarily require consideration of the spatial extent of application available and required, and would therefore be developed as part of the Functional Stormwater and Environmental Management Strategies

developed in support of the Secondary Planning Process for the development areas. Nevertheless, the following would necessarily need to be considered in the development of a preferred management strategy:

- Size of contributing drainage area available for end-of-pipe stormwater management facilities.
- Environmental constraints (i.e. watercourses and natural heritage systems) and associated rankings.
- Length of reach affected by development.
- Physical constraints (i.e. steep valley walls, absence of drainage features, presence of downstream structures, extent of floodplain, soil conditions).
- Timing constraints associated with off-site works (i.e. timing of development contingent upon completion of off-site works).
- Opportunities to reduce overall operations and maintenance requirements by implementing a single system to achieve both stormwater quality and quantity (i.e. flood protection and erosion protection) controls.

7.4 Stream Morphology

7.4.1 Geomorphic Constraint Ranking

The following general management recommendations are presented for each geomorphic constraint ranking as identified in **Section 3.4.5**:

1. High Geomorphic Classification: These corridors contain a defined channel with a well-developed channel morphology (i.e., riffle-pool) and/or a well-defined valley. These corridors offer both form and function and have been identified as 'no touch' reaches that must be maintained undisturbed in their present condition. They have been deemed high-quality systems that could not be re-located and replicated in a post-development scenario.

2. Medium Geomorphic Classification: These reaches may or may not have a well-defined morphology (form) but do maintain geomorphic function and have potential for rehabilitation. In many cases, these reaches are presently exhibiting evidence of geomorphic instability or environmental degradation due to historic modifications and land use practices. Management options for these reaches include the following:
   a) Do nothing: leave the corridors in their present condition and develop outside of their boundaries.
   b) Enhance existing conditions: maintain the present location of the corridor but enhance the existing conditions (e.g. bank stabilization, re-establish a meandering planform, connect channel to functioning floodplain).
   c) Re-locate and enhance existing conditions: many of the reaches within the study area have undergone extensive straightening and modification for agricultural drainage purposes. As such, they are not as sensitive to re-location and would benefit from enhancements such as the re-establishment of a meandering planform with functioning floodplain and development of a riffle-pool morphology. In the event that these reaches are re-located, the corridor width associated with each reach must, at a minimum, be maintained.

3. Low Geomorphic Classification: these reaches consist of ephemeral headwater systems that lack defined bed and banks (form) but do perform a geomorphic function through the conveyance of flow and sediment. Management options for these reaches include the following:
   a) Do nothing: leave the drainage feature intact and develop the surrounding lands, with a minimal buffer (i.e., a corridor width is not prescribed for these systems).
   b) Combination of stormwater management and open conveyance techniques: the function of headwater streams can be mimicked through the combined implementation of stormwater management techniques with sufficient maintenance of open conveyance systems such as backyard swales to meet drainage density targets. A corridor width is not prescribed for these systems.
   c) Open conveyance techniques: the function of the ephemeral swales is replicated entirely through a system of open conveyance techniques (e.g. backyard swales). A corridor width is not prescribed for these systems.

7.4.2 Drainage Density

In order to determine targets for open conveyance within the Derry Green and Boyne Survey lands, drainage densities have been calculated on a subcatchment basis using the subcatchments defined in Drawing 4 (Derry Green) and Drawing 5 (Boyne Survey) lands. The total stream length (km) was measured for each identified subcatchment within the study area utilizing 1:10,000 Ontario Base Maps (OBMs). These stream lengths were then divided by the total subcatchment area (km^2) to provide a drainage density (stream length per unit drainage area). OBMs were used to calculate drainage density because they represent a readily available mapping resource from which to derive stream length information. This allows a standard method for not only calculating drainage densities for a particular study area, but facilitates any comparison with other watersheds. Upon completing the drainage density calculations for the study area, these values and their associated standard deviation were compared to drainage densities previously determined for the headwater portions of the North Oakville Subwatersheds, Sheldon Creek and Sawmill Creek also using 1:10,000 OBMs. These systems share a climate and geology similar to those in Milton and, thus, provided an appropriate reference to ensure that the values being considered for the Derry Green and Boyne Survey lands are appropriate and, upon including these additional values into the overall average drainage density calculation, provided a more robust and representative regional drainage density target.

This regional average drainage density target was developed by averaging the drainage densities for all of the Derry Green, Boyne, North Oakville, Sheldon Creek and Sawmill Creek subwatersheds (based on the 1:10,000 OBMs) and determining the standard deviation for the data set. The actual target for each subcatchment was calculated by taking the drainage density measured from the OBMs and subtracting one standard deviation (derived from the regional average sample population. If, however, this target fell below the average regional drainage density (2.74 km/km^2), minus one standard deviation (1.45), which equals 1.287 km/km^2, then the drainage density target defaulted to the minimum allowable post-development drainage density of 1.287 km/km^2.

In order to evaluate the implications of imposing a drainage density target within the study area, the new drainage density targets were compared on a subcatchment basis to the proposed stream corridor management strategy to determine whether the target was reasonable. Therefore, for each subcatchment, a drainage density was calculated initially based on the combined stream length associated with medium (blue) and high (red) constraint streams because these streams would be protected under post-development conditions. Once this calculation was performed, the subcatchments were categorized by whether they met, exceeded or did not meet the regional target. For those subcatchments that exceeded the target, their 'surplus stream length' was also identified.

Due to the highly undefined nature of the drainage network within the Derry Green and Boyne Survey lands, results of the analysis predicted that upstream subcatchments tended to fall short of achieving regional targets, while downstream subcatchments that captured the main tributaries of Sixteen Mile Creek were able to achieve or exceed regional targets. Recognizing this imbalance, as well as the potential influence of subcatchment scale on the overall results, a sensitivity analysis was undertaken through which upstream catchments were combined with their downstream receiving systems and the resultant drainage density targets assessed.

The findings of the drainage density assessment and sensitivity analysis are presented in Appendix 'F' and summarized in Table 7.4.1. Under the approach adopted for the sensitivity analysis, surplus stream length present in the downstream areas is effectively able to compensate for deficiency in stream length within upstream subcatchments, as reflected in the differences in drainage deficiency when comparing the individual and groups approaches.

Table 7.4.1: Summary of Drainage Density Assessment & Sensitivity Analysis

Study Area	Total Stream length based on 1:10 000 OBM (km)	Stream length based on High and Medium Constraint streams (km)	Drainage deficit – individual subcatchments (km)	Drainage deficit – grouped subcatchments (sensitivity analysis) (km)
Derry Green (Business Park II) – Phase 2 Lands	21.27	12.37	2.26	-0.57
Boyne Survey – Phase 3 Lands	14.63	9.84	0.97	-0.54

Under the grouped subcatchment approach for Derry Green, there is a 0.57 km surplus in stream length above the drainage density target if the proposed management strategy is implemented. However, when analysed on an individual subcatchment basis there is a 2.26 km deficit in stream length. Similarly for Boyne Survey lands, while there is a stream length surplus of 0.54 km under the grouped subcatchment approach, there is a deficit of 0.97km when subcatchments are considered individually. The creation of additional new swales as part of the management strategy, for example within the Natural Heritage System or public lands (parks, schools), would enable this deficit to be addressed and maintain appropriate drainage density.

This drainage density assessment has been be used to develop the Functional Stormwater and Environmental Management Strategy (FSEMS) for both Derry Green and Boyne lands. This helps refine the management strategy for watercourses and test potential land use solutions to

ensure maintenance of channel functions and appropriate length of open channel in the post-development landscape, and incorporate appropriate consideration of headwater drainage features.

7.5 Fisheries/Benthics

The following general management recommendations for each class of watercourse aquatic habitat are presented in the *Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines* (ref. CVC and TRCA, March 2009).

i) ***Protection*** *– Permanent Fish Habitat, Critical Habitat and Species at Risk (SAR)*

Protection 1 – permanent, critical fish habitat or habitat associated with species at risk. Generally associated with permanent groundwater discharge or wetland storage – either habitat and/or flow source characteristics may be difficult to replicate or maintain.

- Preserve the existing drainage feature and groundwater discharge or wetland in-situ, particularly if species at risk are present;
- Maintain external drainage;
- Incorporation of shallow groundwater and base flow protection techniques such as infiltration treatment;
- Use natural channel design techniques or wetland design to restore and enhance existing habitat features, if necessary; realignment not generally permitted;
- Drainage feature must connect to downstream watercourse/habitat;
- Stormwater management (e.g. extended detention outfalls) are to be designed and located to avoid and/or minimize impacts (i.e. sediment, temperature) to fish habitat;
- Examine need to incorporate groundwater flows through infiltration measures (i.e. third pipes, etc.) to ensure no net loss and potential gain.
-

Protection 2 – permanent fish habitat generally with permanent standing surface water associated with a wetland and/or pond flows

- Preference is to maintain existing surface water source;
- Maintain external drainage or if catchment drainage has been previously removed due to diversion of SWM flows, restore lost functions through enhanced lot level controls (i.e. restore original catchment using clean roof drainage) as necessary;
- Replicate on-site surface water sources including wetland creation and incorporating extended detention outlets, if necessary;
- Use natural channel design techniques to replace and enhance existing habitat features only if features are easily replicated;
- Drainage feature must connect to downstream watercourse/habitat;
- Examine need to incorporate groundwater flows through infiltration measures (i.e. third pipes, etc.) to ensure no net loss and potential gain.

ii) ***Conservation*** *– Seasonal Fish Habitat*

Conservation 1 – seasonal fish habitat associated with seasonally high groundwater discharge or seasonally extended contributions from wetlands potential permanent refuge habitat may be provided by a storage feature.

- Maintain existing seasonal groundwater or wetland surface flows,
- If catchment drainage has been previously removed due to diversion of SWM flows, restore lost functions through enhanced lot level controls (i.e. restore original catchment using clean roof drainage), as feasible;
- Replicate on-site seasonal groundwater or surface flows using infiltration measures and/or wetland creation, if necessary;
- Maintain external flows,
- Use natural channel design techniques to replace existing habitat features to maintain overall fish productivity of the reach;
- Drainage feature must connect to downstream habitat.

Conservation 2 – seasonal fish habitat associated with intermittent surface flows.

- Replicate on-site surface flows;
- Maintain external flows; or if catchment drainage has been removed restore lost functions through enhanced lot level controls, as feasible;
- Use natural channel design techniques to replace existing habitat features to maintain overall fish productivity of the reach;
- Drainage feature must connect to downstream habitat.

iii) ***Mitigation*** *– Contributing Fish Habitat*

Mitigation 1 – Complex contributing fish habitat: flows conveyed through natural vegetation communities that support complex, contributing fish habitat i.e. influences water quality, sediment, organic matter, food and nutrients to the downstream habitat.

- Replicate functions through enhanced lot level conveyance measures, such as well-vegetated swales (herbaceous, shrub and tree material) to mimic online wet vegetation pockets, or replicate through constructed wetland features;
- Replicate on-site flow and outlet flows at the top end of system to maintain feature functions. If catchment drainage has been previously removed due to diversion of SWM flows, restore lost functions through enhanced lot level controls (i.e. restore original catchment using clean roof drainage);
- Feature form and flow that connects directly to downstream fish habitat (i.e. direct connection to other drainage features/watercourse or wetlands);

Mitigation 2 – Simple contributing fish habitat: flows that support simple contributing fish habitat, i.e. influences flow conveyance, attenuation and storage to downstream reaches.

- Replicate functions by lot level conveyance measures (e.g. vegetated swales) connected to the natural heritage system, as feasible and/or Low Impact Development (LID) stormwater options (refer to TRCA's Water Management Guidelines for details);
- Replicate on-site flows and outlet flows at the top end of vegetated swales, bioswales, etc. to maintain feature functions.

iv) ***No Management Recommendation Required****– Not Fish Habitat*

The pre-screened drainage feature has been field verified to confirm that no feature and/or functions associated with headwater drainage features are present – generally characterized by evidence of cultivation, furrowing, presence of a seasonal crop, and lack of natural vegetation.

v) ***Recharge Protection – Recharge Zone*** **-** No direct habitat or indirect habitat providing surface flow, sediment transport, or allochthonous contribution to downstream fish habitat.

Maintain overall water balance by providing mitigation measures to infiltrate clean stormwater, unless the area qualifies as a Significant Recharge Area under the Source Water Protection Act. These areas will be subject to specific policies under their respective legislation.

Watercourses classed as "Permanent" will fall under the "Protection 1" management recommendations, while the subset of Permanent watercourses classed as "Permanent with rehabilitation potential" will fall under the "Protection 2" management recommendations. All watercourses within the Business Park 2 and Phase 3 lands that are classed as "Seasonal" fall under the "Conservation 2" management recommendations, as no watercourses requiring "Conservation 1" recommendations were identified. Watercourses classed as "Complex Contributing" fall under the "Mitigation 1" management recommendations, and those classed as "Simple Contributing" fall under "Mitigation 2".

In addition to the above general management recommendations, site-specific recommendations will be developed where opportunities exist for habitat restoration or enhancement. These will primarily target rehabilitation opportunities, where feasible, such as:

- restoration of natural channel form;
- the reinstatement of original catchment area boundaries;
- establishment of low flow refugia (usually associated with infrastructure such as culverts);
- removal of barriers to fish migration;
- Enhanced/Level 1 SWM controls for SWM facilities;
- daylighting of piped watercourses;
- provision of contributions to baseflow.

7.6 Terrestrial

7.6.1 Natural Heritage Systems as a Key Management Strategy

The Natural Heritage System is a key management strategy that integrates existing terrestrial resources and landscape functions with related management strategies for surface and groundwater, stream morphology, and aquatic resources. It therefore merges the present rural system conditions with other management, targeting a future system that will be in an urban context. It is of necessity tied to strategies around parks, trails and neighbourhood character that are not clearly integrated at this stage of planning. Therefore the recommended NHS represents a target system that will be subject to further refinement as other details of development are refined.

Section 5.1 summarizes the guiding legislation, policy, other documents and targets that define the mandate for NHS development. Section 5.2 reviewed the experience with past NHS in the Town of Milton, and also presented the NHS opportunities concepts contained in those documents for the current detailed study areas that are the focus of this SUS. Several points need to be recognized based on that review:

a) there have been changes to the landscapes and the knowledge base since the previous studies were completed, including loss of some features, expansion of others, shifts in agricultural practices, discovery of previously undocumented biota, changes to the composition of biota, and changes to the status of key biota;

b) the earlier subwatershed documents identified 'high-level' opportunities (ref. Section 5.1) for linkages and integration which did not reflect the practicalities of details such as road networks and servicing requirements; these must be given formal consideration to ensure that the NHS and development areas are practical and efficient;

c) the guiding legislation, policies and targets have undergone a major evolution since the previous studies were completed; while the general approach to NHS identification has not changed substantially, the focus on particular details, and greater attention to functional linkages, has altered the balance and emphasis;

d) the outcomes of previous NHS initiatives, in Milton and elsewhere, have a strong bearing on the current concerns of the Town, Region and Conservation Halton.

On the latter point, it should be emphasized that while a subwatershed study provides direction and recommendations, the outcome on the landscape reflects the rigour with which it is implemented. Comments on the outcomes of the previous studies clearly indicate that some standards were altered or not applied as per the subwatershed studies.

Section 5.3 provided a detailed outline of the NHS development approach that is being applied on this project. This included the updating of goals and objectives, as first summarized in Section 2.2. The NHS identification process has taken the lead in the determination of the key features and functions that are desirable to retain and enhance within an urbanized landscape. The Secondary Plan processes have been moving forward concurrently, however this has reinforced the ability to review, discuss and adjust the plans to the benefit of both the natural and future built environments, by ensuring adequate balance and 'fit'. This integrated process is fully consistent with guidance documents under the PPS with respect to the NHS approach for designated growth areas. In both processes there is a logical growth of information and integration as the subwatershed information is brought into focus with inter-disciplinary input, and as technical issues in the land use planning identify options or potential conflicts that need informed feedback from the SUS study team. See Section *4.3 Natural Heritage Strategy* of both the Derry Green and Boyne FSEMS for the rationale for the detailed development of the NHS and its application as a management strategy.

7.6.2 Recommended Natural Heritage Systems

The recommended NHS for Derry Green and Boyne Survey are shown on Figures NHS-1 and NHS-2 respectively. The full technical information for each NHS is presented in the FSEMS document for each area, which is provided in a separate Technical Appendix to the SUS. Table 7.6.1 provides a summary of key status information related to provincial policies, and treatment of significant features for each of the plans. This information is based on the recommended Secondary Plans; modifications to the development areas and NHS are subject to consideration in the SIS and will affect the final disposition of spatial cover and connections within the NHS.

The recommended NHS provide for the integration of all features identified as significant in the characterization and functional analysis reported in Section 3.6. The creek corridors are supplemented by the major corridors of the Main and Middle Branches of Sixteen Mile Creek, which are generally over 200 m in width. Restoration areas are identified in key locations in each NHS. In Derry Green these are focused on strengthening and restoring key core habitats south of Derry Road. In the Boyne Survey, major restoration is proposed north of the existing ESA, and the immediate east and west of the ESA. There areas will include restoration of wetland, forest and meadow conditions to offset the loss of agricultural cover, and to create refugia for species such as Western Chorus Frog Snapping Turtle, Eastern Meadowlark, Barn Swallow and (potentially) Bobolink, Other restoration sites in Boyne are intended to reinforce the larger woodland and wetland features outside the Main Branch valley.

The hydro corridor in Derry Green has been identified as Significant Wildlife Habitat (ref. Section 3.6.4). This represents a large area (>100 ha) with diverse cover ranging from active agricultural fields, to meadow, thickets, marsh and forest. It is connected to the Greenbelt along the Middle Branch. Due to its presence on OPG lands it has been mapped as Existing NHS Supporting Use. The Union Gas corridor also offers open country habitat which intersects with features, channels and the Greenbelt.

The major focus of the FSEMS is to provide the technical basis for the implementation of the NHS. This includes prescriptions for the treatment of channels, linkages and features, including consideration of invasive species (ref. Section *5.2.3* in both the Derry Green and Boyne FSEMS for details). It also addresses phasing to ensure that the NHS can be developed while retaining current biota and functions through the development process. The FSEMS includes the *Town of Milton Restoration Framework*, to guide habitat restoration and buffer approaches within the Secondary Plan areas.

Table 7.6.1: Summary of Recommended Natural Heritage Systems (Derry Green and Boyne Survey)								
Study Area	**Key Approaches**	**Habitat of Endangered &Threatened Species**	**Significant Wetlands**	**Significant Woodlands**	**Significant Valleylands**	**Significant Wildlife Habitat**	**Significant Areas of Natural and Scientific Interest**	**Fish Habitat**
Derry Green	NHS includes woodlots, wetlands, valleylands, and regulated stream corridors (with associated habitat restoration works). Other areas with natural heritage functions include Union Gas corridor, CN rail corridor, and public/leased OPG lands Corridor Widths include 10 + 15 m buffers Buffers: See FSEMS for details. Habitat Restoration: Recommended NHS includes restoration of woodlots, wetlands and meadows.	Habitat of provincially Endangered or Threatened species is potentially present; to be confirmed with MNRF	Locally significant wetlands protected or otherwise integrated within recommended NHS	Significant Woodlands present; all retained within recommended NHS	Significant Valleylands present within or immediately adjacent to study area (East/Middle Branch and portion of Centre Tributary of 16 Mile Creek)	Significant Wildlife Habitat present; protected within recommended NHS or located on public lands.	No Significant Areas of Natural and Scientific Interest present within study area or within 120 m of study area	Intermittent and permanent fish habitat is present; protected within recommended NHS; net gain in permanent habitat is expected
Boyne Survey	Corridor Widths include 10 + 15 m buffers 16 Mile Creek Valley Corridor Width average including NHS supporting uses and buffers: 250 m Outside the Sixteen Mile Creek Valley, three existing wetlands will be protected and new wetlands created in the proposed NHS. Buffers: See FSEMS for details Habitat Restoration: Recommended NHS includes restoration in 16 Mile Creek Valley/ESA, and creek blocks, wetlands and woodlots elsewhere in Boyne.	Habitat of provincially Endangered or Threatened species is potentially present; to be confirmed with MNRF	Provincially Significant Wetlands potentially present; locally significant wetlands protected or otherwise integrated within recommended NHS	Significant Woodlands present; all retained within recommended NHS	Significant Valleyland present within and immediately downstream of study area (Main Branch of 16 Mile Creek); to be protected and restored	Significant Wildlife Habitat present; protected within recommended NHS.	No Significant Areas of Natural and Scientific Interest within study area; Regional and Candidate Provincial Sixteen Mile Creek Valley Life Science ANSI located >120 m downstream	Intermittent and permanent fish habitat present; protected within recommended NHS; net gain in permanent habitat is expected

8. IMPLEMENTATION PLAN

The implementation plan provided in the January 2000 Subwatershed Planning Study was developed to specifically address the requirements of the Phase 1 Area. Nevertheless, the Subwatershed Planning Study provided an overview of guiding principles which should be applied in the development of implementation plans in support of the Secondary Planning Process for future development areas. Subsequent to the January 2000 Subwatershed Planning Study, these principles have been applied for the Highway 401/Industrial Business Park Functional Stormwater and Environmental Management Strategy (Philips Engineering Ltd., July 2000) as well as the Indian Creek/Sixteen Mile Creek Sherwood Survey Subwatershed Management Study (Philips Engineering Ltd., 2004). These guiding principles have been refined as part of the Subwatershed Update Study, based upon comments provided by the Steering Committee. Implementation plans are to be prepared for the Secondary Planning Areas as outlined in the Functional Stormwater and Environmental Management Strategies, and refined as required as part of the subsequent Subwatershed Impact Studies.

In general, implementation plans are required to provide specifics associated with the implementation of the overall requirements of the Subwatershed Plan:

(i) Phasing
(ii) Financing/Cost Sharing
(iii) Operations and Maintenance
(iv) Monitoring and Adaptive Management
(v) Terms of Reference for Future Studies
(vi) Fisheries Compensation Plans
(vii) Watershed Plan Checklist

The following section provides an overview of the principles which are to be applied in the development of the above components of the implementation plans which are to be defined as part of subsequent studies (i.e. FSEMS's).

8.1 Phasing

The purpose of the Phasing Plan is to identify inter-development timing dependencies for construction of stormwater and environmental management infrastructure which would serve to:

- Minimize overall cost.
- Minimize environmental impacts due to repeated construction disturbance.
- Minimize requirements for temporary works.
- Avoid liability associated with impacts of out-of-phase works.

Typically, the sequence for implementing new development is not compatible with the timing and need for major infrastructure projects, particularly for drainage works. The January 2000 Subwatershed Planning Study established the following Subwatershed-wide phasing principles, which have been applied for all developing lands within Milton's Urban Expansion Areas:

i) *Development Phasing by Local Drainage Areas:* There is significant benefit to grouping phases based on/having regard for the ultimate drainage patterns. This may be best identified at the time of Subwatershed Impact Studies.

ii) *All Developments, Regardless of Timing, Require Stormwater Management:* Stormwater management facility construction is to be completed in conjunction with development to meet quality, quantity and extended detention/erosion control objectives.

iii) *Downstream to Upstream Staging Philosophy is Recommended:* For stormwater infrastructure where topography is flat and there is minimal depth for storm servicing, there is an advantage to development proceeding from downstream limit to upstream.

iv) *Geographic Distance from Communal Facilities can Influence Staging and Need for Interim Works:* Where topography is not a significant constraint, the distance to facilities becomes the primary consideration.

v) *Phasing of Communal Infrastructure is Possible:* Communal stormwater management facilities can be constructed in phases.

vi) *Conveyance Systems Need to be Designed to Ultimate Capacity:* Trunk storm sewers should be constructed to ultimate capacity.

8.2 Financing/Cost Sharing

The purpose of the financing/cost sharing plan is to:

- Identify and evaluate alternative models for financing and cost sharing for capital and program works.
- Evaluate and select methods of cost apportionment for capital and program works.

The preferred solution would outline the approach to be applied for the financing and cost sharing of:

i) flood control works (watercourse and culvert improvements, stormwater management storage facilities),

ii) erosion control (extended detention in stormwater management facilities and watercourse improvements),

iii) water quality (extended detention stormwater management facilities),

iv) servicing (watercourse lowering), and

v) system/subwatershed management guidelines.

Of the foregoing, it is inferred that the system/subwatershed management guidelines will apply to all development proponents in a uniform, unbiased manner. The remaining works all relate to

specific undertakings which will be required prior to, or in conjunction with, development of the respective development area. As such, the following philosophy, originally advanced as part of the January 2000 Subwatershed Planning Study, has been established as a basis for cost-sharing formulation:

> *Where stormwater works are recommended which can be considered to benefit multiple property owners (i.e. communal), the lands within the benefitting area will be responsible in proportion to total impervious coverage. All other works which would be of benefit to the local landowner, would be wholly attributable to that landowner.*

The January 2000 Subwatershed Planning Study identified various legislative vehicles to implement the specific Subwatershed Management Strategy for development areas. Depending upon the will of the potentially affected landowners, as well as Municipal Council, there may be a preference toward one particular legislative vehicle. While the selection of the preferred approach is considered beyond the scope of any Subwatershed or Secondary Planning Study, it is nevertheless recognized that a landowner financial agreement is required by the Town.

8.3 Operations and Maintenance Plan

The purpose of the Operations and Maintenance Plan is to develop a plan for effective and efficient operation and maintenance of all infrastructure and environmental systems recommended through the Subwatershed Management Plan. The Subwatershed Management Strategy for each development area provides recommendations for various component elements of the Municipal infrastructure, which, once constructed, will need to be operated and maintained by the Municipality in order to preserve its intended function. Specific infrastructure components requiring operation and maintenance include:

- Stormwater management facilities
- Trunk storm sewers
- Open watercourse systems
- Hydraulic structures (culverts and bridges)
- Natural Heritage Systems

The specific maintenance requirements of each component element depend upon the type of infrastructure constructed; these details are beyond the scope of the current Subwatershed Update Study, and are to be established as part of future FSEMS's and SIS's to be completed in support of the Secondary Planning processes for the development areas.

8.4 Monitoring and Adaptive Management Plan

The purposes of monitoring plans and adaptive management plans, respectively, are to:

- Develop mechanisms through which the performance of the Subwatershed Management Plan recommendations may be evaluated with respect to overall subwatershed and watershed goals, and

- Develop mechanisms to adjust and/or optimize the Subwatershed Management Plan and associated recommendations, based on results of monitoring and future advances in resource management.

- Holistically and comprehensively assess the full study area, accounting for cumulative effects associated with the proposed development.

The monitoring plans are currently integrated with the Conceptual Fisheries Compensation Plan as part of the Fisheries Act authorization for the project, and is subject to approval by the approval agencies. These details are developed as part of the FSEMS studies in support of the Secondary Planning Studies for the development areas, which have been prepared, under separate cover, as technical appendices to the Subwatershed Update Study. Nevertheless, it should be recognized that the monitoring and adaptive management plans are required to evaluate the natural heritage systems, fisheries, hydrogeology, stormwater management, and fluvial geomorphologic components of the Subwatershed Management Strategy developed for the respective drainage area.

The collection of field data from similar sites over an extended period of time can provide great insight on channel processes and function. This monitoring can also yield information regarding the response of a channel to changes in upstream land use. Typically, these responses take the form of planform adjustment, bank erosion, changes in cross-sectional area and changes in substrate composition. These adjustments can, in turn, affect aquatic habitat and water quality.

Future work from a geomorphic perspective should consist of two components: long-term monitoring of existing control stations and additional geomorphic field work to confirm appropriate and relevant erosion thresholds on a more site-specific basis for proposed development. Long-term monitoring would entail the repetition of baseline efforts undertaken through this study, whereby control cross-sections, substrate composition and erosion pins would be re-measured on an annual basis at a similar time of year and documented through photographic record. A qualified fluvial geomorphologist must be retained in order to interpret the findings and assess whether substantial change has occurred and to recommend any potential mitigative efforts. Additional detailed geomorphic field work would remain consistent with efforts documented through this study (10 cross-sections, substrate composition, bank properties and longitudinal survey) at the most sensitive downstream reach to be impacted by proposed land use modifications in order to establish the governing threshold for that drainage system.

Further details are provided in Section 7.5.2 and Appendix ‘H’ of the FSEMS’s for the Derry Green and Boyne Survey Secondary Planning Areas.

Groundwater Monitoring

Throughout the course of the Subwatershed Update Study, it has been recognized that groundwater monitoring previously recommended as part of the January 2000 Subwatershed Planning Study and advanced as part of the SIS’s completed for the various development areas, has not been implemented accordingly. During the course of the Subwatershed Update

Study, the absence of this information has been identified as a significant data gap, despite the current significance ascribed to maintaining groundwater resources.

Site specific groundwater studies are recommended to be implemented in order to confirm the more local hydrogeologic setting and its functional relationship to the other ecosystem components. Generic guidelines for these studies can be found in Appendix 'D' of this document. These studies should incorporate the site specific data into the more regional characterization to assess potential impacts and mitigation. It is critical that a representative number of monitoring wells and baseflow measurement locations (i.e. where baseflow exists and is functionally important) be carried forward to assess the potential impacts on the local groundwater quantity and quality, compare it to natural trends and assess the performance of any mitigative practices.

The groundwater monitoring program is designed to consider the potential impacts from a reduction in groundwater recharge and the potential for degraded stormwater infiltrating into the groundwater system.

As major developments proceed, shallow piezometers would normally be installed to confirm the water table. A number of piezometers should remain in each major development area. These piezometers should be cased and locked for security. Water levels and water chemistry should monitored at least on a two to five year schedule depending on the local hydrogeologic sensitivity and the ongoing trends. The schedule is also dependent to a large degree on the pace of development. Chemical analysis should include inorganic parameters, nitrogen species, and metals. Water level trends correlated to rainfall are necessary to assess changes on the recharge resulting from development.

Spot baseflow measurements will give an indication of changes in groundwater discharge to the local watercourses and long with water levels provide data to assess changes in recharge. Groundwater discharge areas within the streams can vary over time due to the stream dynamics. It is important to correlate the spot baseflow measurements with the continuous stream flow measurements. It is recommended that water quality and temperature measurements be taken at a number of spot baseflow locations. The spot baseflow measurements are to be taken during periods when only groundwater is expected to be providing flow to the stream such as in between rainfall events, or subsequent to spring runoff.

Table 8.5.1: Sixteen Mile Creek Subwatershed Update Study Summary of Management Recommendations				
Discipline	**#**	**Report Recommendation**	**Source**	**SIS and/or Program Follow-up Action Requirement**
Hydrology/Hydraulics	HH1	Implement Low Impact Development Best Management Practices (LID BMPs)	Boyne FSEMS Section 5.1	SIS and Functional Stormwater Management Plans to assess feasibility and identify opportunities for infiltration BMP's
	HH2	Implement flood control (storage and discharge) within stormwater management facilities.	Boyne FSEMS Section 5.1 Table 5.1.2	SIS to define stormwater management facility details based on refined drainage areas and levels of impervious coverage and determine total flood control volumes and discharge rates using unitary rates provided.
	HH3	Implement Regional Storm flood storage (off-line or on-line in constructed corridors) to Pre-development Peak flow targets	Boyne FSEMS Section 4.2.5 Table 4.2.21	SIS hydraulic model to confirm Regional Storm flood storage; control structures by location and size; where control is a proposed roadway embankment detailed design requirements to be cited to ensure roadway meets warrants for functional stability.
	HH4	Implement erosion control within stormwater management facilities as per the storage and discharge rates.	Boyne FSEMS Section 5.1 Table 5.1.2	SIS to define stormwater management facility details based on refined drainage areas and levels of impervious coverage and determine total erosion control volumes and discharge rates using unitary rates provided in the subwatershed study.
	HH5	Provide surface water quality treatment via a combination of LID BMPs and stormwater management facilities.	Boyne FSEMS Section 4.2.1	SIS to define stormwater management facility details based on refined drainage areas and levels of impervious coverage and determine permanent pool sizing for water quality protection. Extended detention volumes and discharge rates to be determined using unitary rates.
	HH6	Apply thermal impact mitigation measures in stormwater management facilities to reduce thermal loading	Boyne FSEMS Section 4.2.1	SIS and detailed design to assess thermal impact mitigation measures..
	HH7	Develop monitoring plans and environmental management plans that address: • Stormwater management hydraulic functionality • Water Quality • Sediment quality and quantity	Boyne FSEMS Appendix H	SIS and detailed design to develop monitoring plans and environmental management plans, in consultation with Town and Conservation Halton.
Stream Morphology	SM1	Manage stream reaches as per watercourse management strategies.	Boyne FSEMS Section 4.4.2	SIS to demonstrate accordance with stream management approach.
	SM2	Create new swales to maintain drainage density targets	Boyne FSEMS Section 5.1	SIS to refine the location of new swale lengths, including opportunities for new swales as per the watercourse management strategy.
	SM3	Design new channels for medium watercourses using natural channel design principles.	Boyne FSEMS Section 4.4.1	SIS to identify reaches to be designed using natural channel design principles. Detailed design to be accompanied by Natural Channel Design Brief.
Terrestrial NHS	T1	Address feature-specific restoration and enhancement opportunities identified in Implementation Principles, using FSEMS for guidance on technical standards	Boyne FSEMS Section 5.2 Tables 5.2.1 and 5.2.2 Section 5.2	SIS and detailed development plans to address identified opportunities.
	T2	Update baseline inventories, identify previously undocumented biota and habitats, identify any changes in significant status, and refine recommended management practices for defined areas of the NHS, as appropriate and in accordance with the Implementation Principles and FSEMS.	Boyne FSEMS Sect. 5.2Appendix F	SIS and monitoring program must reflect the most current information and practices for management of features and biota.
	T3	Identify presence and status of invasive species and contemporary solutions in management plans for individual natural features.	Boyne FSEMS Section 5.2	SIS to identify invasive species status and specific need for management strategies; detailed design to address detailed management requirements.
	T4	Qualify occurrence and status of potential and confirmed species at risk and species of conservation concern.	Boyne FSEMS Section 5.2 Appendix F	SIS to undertake focused field studies, as necessary. Detailed design to consider identified species, and their specific needs in accordance with direction from MNR, ESA Regulations, and available Recovery Strategies (i.e. ESA permits, provision for habitat compensation, habitat structures and safe road crossings etc.).
	T5	Apply recommended NHS corridors	Boyne FSEMS Appendix I	SIS to confirm NHS corridors implemented as per Implementation Principles and accompanying Schedules.
	T6	Locate pedestrian trails within the NHS corridor buffers in accordance with the Secondary Plan and Implementation Principles.	Boyne FSEMS Appendix I	SIS to confirm pedestrian trails implemented as per Secondary Plan policies, Implementation Principles and accompanying Schedules.
	T7	NHS corridors to include habitat enhancement components: floodplain and off-line wetlands, measures to support target biota and species at risk; native plantings and created habitats in conformity with the FSEMS targets, Implementation Principles and Planting Guidelines, other habitat enhancements, monitoring and management.	Boyne FSEMS Section 5.2	SIS to provide strategy for establishment of natural cover in corridors, buffers and restoration areas; detailed design to specify implementation methods and materials.

Table 8.5.1: Sixteen Mile Creek Subwatershed Update Study Summary of Management Recommendations

Discipline	#	Report Recommendation	Source	SIS and/or Program Follow-up Action Requirement
	T8	Size and design road crossings to provide safe passage for small to medium sized wildlife species, e.g. terrestrial benches, provision of plantings, wing walls or other measures to direct wildlife, and buffering between pedestrian uses and wildlife movement zones.	Boyne FSEMS Section 5.2	SIS to provide general dimensioning and integration measures for all crossings, for integration into detailed design.
	T9	Naturalized elements for stormwater management (e.g. infiltration trenches, bioswales, etc.) may be integrated within corridor and feature buffers.	Boyne FSEMS Section 5.2	SIS to provide strategies and specifications to be included in detailed design, to protect the ecological functions of the natural features. Placement of stormwater management infrastructure within NHS corridor or feature buffers is subject to the approval of the Town of Milton and Conservation Halton
	T10	Plan feature buffer grading and drainage to address water balance (e.g. area, depth and hydroperiod longevity) to protect and enhance habitat for amphibians and other sensitive ecosystem components that are reliant on vernal systems.	Boyne FSEMS Section 5.2	SIS to include feature-based monitoring data, water balance analysis, strategies and specifications, to be included in detailed design.
	T11	Adaptive management of natural features should be planned within a risk management framework that assesses potential outcome scenarios, and responses.	Boyne FSEMS Section 6.5.2	SIS to outline local scale monitoring program to identify adaptive management plan requirements and opportunities.
	T12	Phasing of NHS implementation to ensure that resources remain functional throughout the development process.	Boyne FSEMS Sections 5.2, 6.1	SIS to outline strategy for NHS implementation in accordance with recommended practices provided in the report.
Fisheries	F1	Watercourse management should ensure an overall net gain of fish habitat.	Boyne FSEMS Section 4.4.1	To be addressed by CFCP and SIS
	F2	Provide Monitoring Plan for Fish and Fish Habitat that addresses principles of using standard protocols; sampling to allow a statistical analysis of the data collected; and use of reference data.	Boyne FSEMS Section 6.5.2	General requirements for monitoring are provided in Appendix H of the FSEMS. The detailed monitoring program is to be further developed during the preparation of the SIS.
Groundwater	G1	Implement LID infiltration BMP's to manage groundwater recharge.	Boyne FSEMS Section 6.5.1	SIS to identify opportunities to maintain groundwater recharge through the implementation of LID infiltration BMP's. LID infiltration BMP's to be specifically sited and designed at detailed design stage and discussed in the Functional Stormwater Management Plan
	G2	Undertake site specific hydrogeologic investigations, as necessary, to refine the local, shallow hydrostratigraphy and related groundwater flow to confirm that the installation of infrastructure (including servicing, SWM measures, channel realignment works, foundations etc.) will not intercept critical groundwater flow which may discharge to local receptors.	Boyne FSEMS Section 6.5.2	Groundwater monitoring to be implemented as part of SIS and conducted through detailed design stage.
	G3	Basic groundwater quality management should be considered which would include: • Spills management plan • Location consideration for underground storage tanks and mandatory groundwater quality monitoring associated with underground storage tanks, • The appropriate abandonment of unused water wells and maintenance of existing water wells • Effectively manage road de-icing and locations of snow dumps, • Keep an ongoing contaminant threats inventory, • Minimize application of lawn chemicals	Boyne FSEMS Section 6.5.2	Management plan to be coordinated between Town, Landowners, Region, Conservation Halton, and MOE.
		The more detailed site specific SIS characterization will direct the number and specific locations of monitoring sites but the following should be considered: • A spatially representative number of water table monitors should be retained to assess any potential change to the water table and larger scale groundwater flow direction, • A number of multilevel piezometers should be included to assess vertical gradient trends, • Spot baseflow measurements should continue, • Spatial discretization to represent functional linkages and potential hydrostratigraphic variation, • Seasonal measurements are recommended with selected sites considered for the installation of data loggers to monitor shorter term trends, • Annual water quality monitoring of selected well and spot baseflow sites, • Pre-development monitoring of spot baseflow and groundwater levels for a minimum of two years, • Need for coincident background natural water level trends in a similar local physiographic setting in the absence of development, • Need for local climate data, and • Post-development monitoring. Continued efforts should be made in obtaining and assessing historical and ongoing monitoring data from developed sites in a similar physiography.	Boyne FSEMS Appendix H	Town, Landowners, Region and Conservation Halton to refine long-term groundwater monitoring program requirements.

8.5 Future Study Requirements

Future developments of lands within the Sixteen Mile Creek Watershed will need to address the directives provided in the higher level planning documents. Moreover, more locally based and higher resolution studies will be required in order to support local development initiatives; these studies will require an enhanced level of detail at a commensurate with the level of detail associated with the site-specific analyses. The Subwatershed Update Study recommendations and future study requirements are summarized in Table 8.5.1. Further details regarding the future study requirements are provided below, in the corresponding sequence for submission:

- Functional Stormwater and Environmental Management Strategies (ref. Appendix)
- Subwatershed Impact Studies and Environmental Impact Studies/Assessments
- Functional Servicing Reports
- Stormwater Management Plan (Functional Design)
- Stormwater Management Plan (Detailed Design)
- Natural Channel Design Briefs (Detailed Design)

8.5.1 Functional Stormwater and Environmental Management Strategies

As indicated previously within this study, Functional Stormwater and Environmental Management Strategies are implemented in support of the Secondary Planning of development areas within the Town of Milton. These studies are intended to build upon the baseline information and constraint mapping provided within the current document, and to provide detailed recommendations for the systems required to manage the environmental systems within the development areas, in accordance with current Federal, Provincial, Regional, and Municipal policies, legislation, and guidelines. Specific recommendations provided within these studies include:

- Detailed impact assessment of proposed development
- Stormwater management requirements
- Watercourse and hydraulic structure (i.e. bridges and culverts) requirements
- Natural heritage system for development area
- Conceptual Fisheries Compensation Plan objectives
- Development areas to be assessed collectively under specific Subwatershed Impact Studies
- Requirements for holistic and local monitoring programs

The NHS Approach to be applied under each FSEMS for each of the detailed SIS Study Areas will include the following:

- Consider regional scale NHS goals and objectives (Greenbelt, Niagara Escarpment Plan, Sustainable Halton)
- Protect and enhance existing Significant features, including habitats of species of concern.
- Integrate multi-disciplinary ratings of streams to prioritize key corridors and potential linkages based on water features; identify other linkage opportunities where watercourses cannot provide adequate linkages.

- Drainage density assessment and application of compensation within the NHS where feasible
- Identify features and areas to restore and diversify to achieve long-term functional viability
- Apply buffers to significant features and corridors to maintain integrity and species diversity; set minimum buffer standards in FSEMS
- Integrate with infrastructure elements (SWM areas, wildlife eco-passages, bridges and culverts, road crossings) and complementary land uses (Parks, school campuses, other institutional uses, golf courses,)
- Provide implementation and management guidance
- Develop and apply Adaptive Management Plan

The *Functional Stormwater and Environmental Management Strategy for Derry Green Secondary Plan Area* and the *Functional Stormwater and Environmental Management Strategy for Boyne Survey Secondary Plan Area* have been prepared under separate cover as technical appendices to this document.

8.5.2 Subwatershed Impact Studies

Subwatershed Impact Studies represent an intermediate level of study, which is required in areas where multiple land ownership within the subwatershed occurs; the limits of these areas are defined during the Secondary Planning process, and are to be advanced as part of the Functional Stormwater and Environmental Management Strategy. This level of study would focus on integrating the servicing, stormwater, and environmental management of adjacent development to a greater level of detail than is normally achieved through the Subwatershed Plan; the detailed site specific work may identify additional features/functions which were not captured as part of the Subwatershed Study, which should be evaluated using the same criteria as established in the Subwatershed Study. The detailed Terms of Reference for the Subwatershed Impact Studies are provided in the respective FSEMS's for the Derry Green and Boyne Survey Secondary Planning Areas. The objectives of this level of study are to:

- Update the characterization of features that are recommended to be integrated in the NHS.
- Refine the natural heritage and natural hazard limits reflecting the NHS objectives and other intentions of the subwatershed study (i.e. final staking of Natural Heritage System features and buffers, calculation of riparian storage volumes, etc.)
- Refine the local hydrogeologic characterisation as defined in Section 8.4 (Groundwater Monitoring) above
- Confirm watercourse constraint ranking
- Determine preferred servicing plan
- Determine road layout
- Develop and define integration of stormwater management facilities
- Determine opportunities to integrate recreation opportunities with stormwater management
- Define phasing in areas of multiple ownership
- Validate fisheries mitigation and compensation

- Define cost sharing for monitoring programs
- Refine meander belt width delineation, including examination of historic aerial photography of the reaches (according to the methodology outlined in Parish Geomorphic, 2004) and reach-by-reach consideration of appropriate erosion setbacks.
- Develop further characterization of groundwater resources associated protection measures, and mitigation techniques
- Identify special treatments and stormwater management practices which are to be implemented within hydrogeologic areas of higher recharge potential.
- Verify that the water balance would be maintained through the proposed development and stormwater management plan; including the water balances of wetlands and other habitats that are being protected within the NHS
- Determine detailed road alignment and configuration of watercourse and valley crossings
- Identification and field staking of significant NHS features in consultation with Town and Conservation Halton
- Prescribe site specific standards and preliminary design for landscaping, implementation and management of corridors, wetland creation areas, buffers, and restoration areas per the FSEMS.
- Develop strategies to enable construction phasing while allowing rescue of biota from small isolated habitats, and maintenance of the NHS resources and functioning through the construction period.
- Provide mitigation measures for protection of groundwater resources.
- Develop use of LID measures.
- Determine detailed road alignment and configuration of watercourse and valley crossings
- Preliminary analysis of stream corridor dimensions required to maintain pre-development riparian strategy.

Tertiary plans represent an important component to the SIS process, with respect to features and systems which cross SIS boundaries (i.e. NHS protection, road alignments). As such, the SIS should be developed in support of Tertiary Plans rather than draft plans, in order to provide guidance with respect to the constraints and opportunities associated with connecting features and systems to adjacent SIS areas. In accordance with Town of Milton and Conservation Halton Requirements, SIS's are to be completed and approved in advance of the preparation of draft plans.

The SIS level of study would focus on integrating servicing and stormwater management of adjacent development to a greater level of detail than is normally achieved through the Subwatershed Plan or Functional Plans for Secondary Plans. While the SIS process has facilitated the development of the stormwater and watercourse management systems (and by extension the aquatic habitat management systems) for the various site plans, the requirements for the Natural Heritage Systems for the various site plans have been identified as a significant gap in the historically applied SIS process. Specific issues identified in the SIS process to-date include:

- Requirements to provide a 'net gain' in natural cover and functions have often not been advanced in the SIS.
- Buffer and setback requirements have deviated from the recommendations in the governing Subwatershed Study, as well as from Conservation Halton requirements.
- Woodlot buffers have often not been consistently established as specified.

The following recommendations have been advanced in order to avoid future repetition of these issues:

- Assessment of 'net gain' is at the scale of the Secondary Plan; each SIS area must contribute to the overall 'net gain' based on an NHS approach that is consistent with the Secondary Plan. Any modifications must comply with SP policies and be acceptable to the Town and Conservation Halton.
- If the landowners dispute/appeal the NHS in the Subwatershed Study/Secondary Plan, it must be clear that they need to provide an alternative that is acceptable to Town and CH on a SWS scale basis, not on an SIS scale basis.
- CH and the Town are to take ownership of implementing the NHS.
- Town Engineering Department will circulate the SIS, require pre-consultation, standards for SIS completeness and timelines/protocol for review.
- A checklist will be developed which the landowner is required to submit with the SIS to demonstrate that they have met/considered all the requirements of the Terms of Reference.
- Community Services will be involved in SIS consultation and review process from the beginning.
- A procedure should be developed in order to ensure that all landowners within the SIS area, including any non-participating landowners, have received a copy and understand the contents (i.e. the proponent should be required to hold a public information session with the other landowners to answer any questions and a formal written sign-off should be required).

Similarly, the format of the SIS should be established in order to clearly demonstrate that the study requirements have been satisfied. The suggested format for the SIS would be as follows:

- All of the SIS recommendations should be listed at the end of the report for ease of reference
- Digital copies of the report, drawings, field notes, ELC data, etc. should be provided to the reviewers
- An appendix should be included with all previous correspondence
- A comprehensive response letter to comments should be provided

In addition, further discussion is required between Town and Conservation Halton staff in order to establish the criteria upon which an SIS would be considered final.

Ultimately, the decision as to whether a Subwatershed Impact Study is warranted for a specific development application would be determined through consultation between the various development proponents, the Town of Milton, and would depend on:

- level of planning information completed in the Secondary Plan process such as road layout, facility locations, and municipal servicing concept
- number of development proposals/proponents involved in the study area and opportunity to integrate facilities and phase developments
- the prior completion of an SIS which includes the subject property

The objectives and criteria outlined herein as well as the Subwatershed Planning Study and Subwatershed Update Study should form the basis for any Subwatershed Impact Study with respect to the Natural Heritage System and its implementation.

8.5.3 Functional Servicing Reports

Functional Servicing Reports are typically prepared as part of the detailed site design process, in order to identify the manner in which water, sanitary, and storm servicing is to be provided for the site. The information provided within these documents generally includes, but is not limited to:

- Location and preliminary sizing of sanitary sewers.
- Location and preliminary sizing of storm sewers.
- Location and preliminary sizing of watermains.
- Preliminary site grading plan.
- Location and preliminary sizing of stormwater management facilities.
- Location and preliminary sizing of hydraulic structures (i.e. bridges and culverts).
- Preliminary channel grading plans and supporting analyses.
- Assessment of riparian storage for existing channel and preliminary channel designs.

Recent practice by Conservation Halton also requires that these studies include an assessment of the impacts of the proposed servicing for the site, specifically related to potential impacts to groundwater systems and recommended mitigation strategies.

8.5.4 Stormwater Management Plans

Requirements for Stormwater Management Plans are outlined within the March 2003 Stormwater Management Best Management Practices Guidelines. Stormwater Management Plans are prepared in support of individual development applications. The stormwater management plans complement the planning process associated with Draft Plans of Subdivision or individual Site Plans. Stormwater management reporting associated with this planning stage would be the “Functional Design” plan. Subsequently, in support of final subdivision design, a “Detailed Design” plan is prepared.

Functional Design

This level of design typically involves demonstrating the feasibility of providing stormwater management for a particular development. In areas where no Subwatershed Plan has been completed, the Stormwater Management Plan will be required to address additional issues such as environmental baseline conditions and screening of various stormwater management strategies and techniques. For the Derry Green and Boyne Surveys, the intent of the Functional

Design Stormwater Management Plan would focus on demonstrating compatibility and compliance with principles and requirements prescribed in the corresponding Functional Stormwater and Environmental Management Strategies, as well as the specifics emanating from the Subwatershed Impact Study. This includes identifying specific stormwater management infrastructure which is to be implemented for the proposed development (i.e. type of LID BMP's, end-of-pipe facilities, thermal mitigation techniques such as cooling trenches and bottom draws, etc.).

Detailed Design

The detailed design submission is required to demonstrate how the required information, outlined in the Functional Design report, has been integrated as well as addressing details related to minor system design details, landscaping, safety, and maintenance aspects of Stormwater Management Facility design, as well as outlining subsequent specific monitoring requirements.

8.5.5 Natural Channel Design Briefs

Natural Channel Design Briefs are prepared in support of any proposed realignment, alteration, or enhancement to a regulated open watercourse. These reports would provide the following information, specifically related to the detailed design of any proposed realignment, alteration, or enhancement to regulated watercourses.

- Details related to the natural channel design principles applied to the detailed design of the watercourse.
- Fluvial geomorphological analysis of the proposed watercourse design.
- Rationale for selection of plantings within the riparian zone and floodplain.
- Details regarding any enhancements proposed within the adjacent watercourse.
- Detailed hydrologic and hydraulic analyses of proposed watercourse and hydraulic structures to demonstrate impacts to floodplains, and freeboard under proposed conditions, maintenance of riparian storage post-development.
- Detailed assessment of impacts of proposed watercourse to aquatic habitat and fish species.
- Demonstration that the proposed works satisfy the requirements for mitigating impacts to fish habitat are provided in the Conceptual Fisheries Compensation Plan.
- Detailed design drainage for proposed watercourse and corridor.

8.6 Conceptual Fisheries Compensation Plan

The Conceptual Fisheries Compensation Plan forms part of the implementation process for the Secondary Plan areas. Component recommendations of the Compensation Plan may be considered for Development Charges contributions by the developing land base, since the impact being compensated for is caused by the development. It is intended that the Conceptual Fisheries Compensation Plan be used, along with the Functional Stormwater and Environmental Strategy, to support individual development applications for DFO authorization.

The objectives of the CFCP are to:

i) Develop a Conceptual Fisheries Compensation Plan to allow for a holistic assessment and management of cumulative fish habitat impacts, and mitigation of such impacts throughout the development area.

ii) Provide design guidelines and submission requirements for future design and permit submissions/applications to the Regulatory Agencies.

iii) Streamline the review and approval process for applicants and Public agencies.

It should also be re-emphasized that the lowering of streams to facilitate development presents a particular challenge, specifically within the Boyne Survey lands, but also portions of the Derry Green lands as well. Given the minimal existing topography within the study area, any major modifications to stream bed elevations would require substantial grade corrections that could extend beyond the upstream and downstream boundaries of these lands. As such, this issue represents a critical consideration in the implementation of development options.

The Conceptual Fisheries Compensation Plans for the Derry Green and Boyne Survey Secondary Planning Areas have been prepared under separate cover as technical appendices to this document.

9. REFERENCES

Aquafor Beech Limited and C. Portt and Associates, 2005. Environmental audit of channel works. Bristol Survey, Milton. Unpublished report prepared for the Town of Milton. 39 p plus appendices.

Badzinski, D.S., R.W. Archer, S.T.A. Timmermans, K.E. Harrison, and K.E. Jones (revised by M. Doyle). 2008. Assessment of trends in frog and toad populations in Ontario using citizen science monitoring data [electronic resource] / prepared for the Ecological Monitoring and Assessment Network Coordinating Office, Environment Canada.

Bakowsky, W. D. 1996. Natural Heritage Resources of Ontario: Vegetation communities of southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. 21 pp.

Barrett, K. 2010. Conservation Halton Ecologist. Personal communication re: sites for Jefferson Salamander

Beriault, K. 2005. Critical habitat of Jefferson Salamanders in Ontario: An examination through radiotelemetry and ecological surveys. Master of Science Thesis, University of Guelph, Guelph, Ontario

Brooks, A. 1906. Birds of Halton County, Ontario. *Ontario Natural Science Bulletin* **2:** 6-10.

Brummer, C. J. 2004. Process controls on bed-surface grain size and the geomorphic response of low-order mountain channels to landsliding following timber harvest, 25th Anniversary Conference, International Society of Wetland Scientists, Seattle, Washington.

BSC (Bird Studies Canada). 2003. Marsh Monitoring Program - Training Kit and Instructions for Surveying Marsh Birds, Amphibians and their Habitats. 2003 Edition. 40 pages. Published by Birds Studies Canada in cooperation with Environment Canada and the U.S. Environmental Protection Agency. March 2003.

Cadman, M.D., P.I.F. Eagles and F.M. Helleiner (Eds.). 1987. *Atlas of the Breeding Birds of Ontario.* University of Waterloo Press, Waterloo, Ontario. 617pp.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.) 2007. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Catling, P.M. and V. R. Brownell. 2000. *Damselflies and Dragonflies (Odonata) of Ontario: Resource Guide and Annotated List*. ProResources, 2336 Srivens Drive, Metcalfe, Ontario, Canada. 200 pp.

Chapman, L.J., and D.F. Putman. 1984. The Physiography of Southern Ontario. Third Edition. Ontario Ministry of Natural Resources.

Connor, E., A. Courtney, and J. Yoder. 2000. Individuals-area relationships: the relationship between animal population density and area. Ecology 81:734–748.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008a. COSEWIC Species Assessments from the April 2008 COSEWIC meeting (detailed version) http://www.cosewic.gc.ca/rpts/Detailed_Species_Assessments_e.pdf

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008b. COSEWIC assessment and update status report on the Western Chorus Frog *Pseudacris triseriata* Carolinian population and Great Lakes/St. Lawrence – Canadian Shield population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 47 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008c. COSEWIC Assessment Summary for Snapping Turtle. November 2008. Available at: http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/ca_snapping_turtle_0809_e.pdf

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2010. COSEWIC assessment and status report on the Monarch *Danaus plexippus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 43 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2011. COSEWIC Species Assessments (detailed version), May 2011.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2012. COSEWIC Species Assessments (detailed version), November 2012.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2014. Canadian Wildlife Species at Risk. October 2014. Committee on the Status of Endangered Wildlife in Canada. Web site: http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm

COSSARO (Committee on the Status of Species at Risk in Ontario). 2014. Rationale for Conservation Status Classifications of Species in 2014 https://dr6j45jk9xcmk.cloudfront.net/documents/4249/cossaro-report-31-december-2014-en-final.pdf

Coventry, A.F. 1940. Desiccation in Southern Ontario. *Transactions of the Royal Society of Canada*. Vol. 34, p. 15-23

Credit Valley Conservation and Toronto Region Conservation Authority, March 2007. Interim guidelines for the evaluation, classification and management of headwater drainage features.

Crins, 1986. Vascular Plants of the Regional Municipality of Halton. Unpublished list.

Crins, W.J., W.D. McIlween, A.G. Goodban and P.G. O'Hara. 2006. The Vascular Plants of Halton Region, Ontario. pp. 1 – 78. *In*: J.K. Dwyer (Ed.) Halton Natural Areas Inventory 2006. Volume 2 – Species Checklists. 184pp.

Curry, R. 2006. The Herpetofauna of Halton Region, Ontario. pp. 97 – 112. *In*: J.K. Dwyer (Ed.) Halton Natural Areas Inventory 2006. Volume 2 – Species Checklists. 184pp.

Curry, R. 2007. Birds of Hamilton and Surrounding Areas. Robert Curry and the Hamilton Naturalists' Club. 647 pp.

Dobbyn. S. 1998. Ontario Mammal Atlas data records.

Dougan & Associates 2008. Louis St. Laurent Crossing Terrestrial Resources Impact Analysis.

Douglas, M.M. and J.M. Douglas. 2005. Butterflies of the Great Lakes Region. The University of Michigan Press. Ann Arbor, Michigan. 345 pp.

DuBois, B. 2005. Damselflies of the North Woods. North Woods Naturalist Series. Published by Kollath-Stensaas Publishing, Duluth, MN. 131 pp.

Dwyer, J.K. 2006a. Halton Natural Areas Inventory. 2006: Volume 1 Site Summaries

Dwyer, J.K. 2006b. Halton Natural Areas Inventory. 2006: Volume 2 Species Checklists

Dwyer, J.K. , B.K. Axon, P. Attack, and K.A. Barrett. 2006. The Mammals of Halton Region, Ontario. pp. 183 – 184. *In*: J.K. Dwyer (Ed.) Halton Natural Areas Inventory 2006. Volume 2 – Species Checklists. 184pp.

Earley, C. 2007. Grasshopper Sparrow. Pp 550 – 551. In Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Ecoplans Limited. 1996. Compendium to Sixteen Mile Creek Watershed Plan. Prepared for Regional Municipality of Halton.

Falcy, M.R. and C.F. Estades. 2007. Effectiveness of corridors relative to enlargement of habitat patches. Conservation Biology (5): 1341-6.

Forman, R.T. *et. al*. 2003. Road Ecology: Science and Solutions. Island Press, Washington

Friesen, L.E., P.F.J. Eagles, and R.J. Mackay. 1995. Effects of Residential Development on Forest Dwelling Neotropical Migrant Songbirds. Conservation Biology. Vol 9, No. 6. pp 1408 – 1414.

Friesen, L. 2007. Wood Thrush. Pp 440 – 441. In Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005.

Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Geomatics International. 1991. Addendum Report: Environmentally Sensitive Area Study.

Geomatics International. 1993. Environmentally sensitive Areas Study prepared for Regional Municipality of Halton Planning and Development Department.

Glassbeerg, J. 1999. Butterflies through Binoculars. The East. A Field Guide to the Butterflies of Eastern North America. Oxford University Press. New York, N.Y. 242 pp.

Gomi, T., R.C. Sidle and J.S. Richardson. 2002. Understanding processes and downstream linkages of headwater systems. BioScience, 52(10): p. 905-916.

Halton Region, 2006. Halton Region Official Plan**.** 2006.
Available: http://www.halton.ca/ppw/Planning/OP/ROP.htm

Harding, J.M. 1997. Amphibians and Reptiles of the Great Lakes Region. University of Michigan Press. Ann Arbor, Michigan. 378pp.

Hilty, J.A., W.Z. Lidicker Jr., and A.M. Merenlender. 2006. Corridor Ecology: The Science and Practices of Linking Landscapes for Biodiversity Conservation. Island Press, Washington.

Hull, S. D. 2002. Effects of management practices on grassland birds: Eastern Meadowlark. Northern Prairie Wildlife Research Center, Jamestown, ND. 35 pages.

ICOET. 2001-2013. Proceedings of the International Conference on Ecology and Transportation. www.icoet.net/ICOET_2005/05proceedings_directory.asp

Jones, C. 2007. Personal communication with Colin Jones, odonate expert and Project Biologist at NHIC on July 20, 2007 to discuss the status of River Bluet (*Enallagma anna)*.

Jones, C.D., A. Kingsley, P. Burke and M. Holder. 2008. Field Guide to the Dragonflies and Damselflies of Algonquin Provincial Park and the Surrounding Area. The Friends of Algonquin Park. Whitney, Ontario. 263 pp.

Kavanagh and McKay-Kuja, 1992. A Classification of the Natural Communities Occurring in Ontario. Draft. Prepared for Carolinian Canada and Great Lakes Data Center Projects.

Lam, E. 2004. Damselflies of the Northeast. A guide to the species of eastern Canada & the northeastern United States. Published by Biodiversity Books, Forest Hills, New York. 96 pp.

Lamond, W.G. 1998. Site-specific Hamilton Herpetofaunal Atlas database records for Subwatershed Areas 2 & 7. Unpublished and confidential list.

Layberry, R.A., P.W. Hall and J.D. Lafontaine. 1998. The Butterflies of Canada. University of Toronto Press, Toronto. 280pp.

Leckie, S. 2007. Eastern Meadowlark. Pg. 590 – 591, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Ulhig, and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.)

Lee, H.T. 2006. Draft. Treed Ecosystem Classification for Southern Ontario. Reviewers' copy.

Lenth, B., M. Brennan, and R. L. Knight. 2006. The Effects of Dogs on Wildlife Communities. Research report prepared for Boulder County Open Space and Mountain Parks, Boulder, Colorado.

Leopold, L. B. 1994. A View of the River. Harvard University Press, Cambridge, Massachusetts.

LGL Limited, May 28, 2008. Data Transmittal to Jim Dougan, Dougan & Associates, May 28, 2008. Project TA4666. Milton Phase III Land Secondary Plan. Existing Property Conditions Summaries and Figures. Prepared by LGL Limited, 3365 Harvester Road, Burlington, Ontario L7N3N2.

LGL Ltd. 2008a. Milton Phase Three Lands 2007 & 2008 Field Data (copies of field notes provided to Dougan & Associates). May 28, 2008

LGL Ltd. 2008b. Mattamy West Tremaine Natural Heritage Features Fact Sheet. June 2008.

Matter, S. F. 1997. Population density and area: the role of within and between patch processes. Oecologia 110:533-538

McIlveen, W.D. 2006. The Birds of Halton Region, Ontario. pp. 79 – 96. *In*: J.K. Dwyer (Ed.) *Halton Natural Areas Inventory* 2006. Volume 2 – Species Checklists. 184pp.

Mead, K. 2003. Dragonflies of the North Woods. North Woods Naturalist Series. Published by Kollath-Stensaas Publishing, Duluth, MN. 203 pp.

Ministry of Environment, 1999. Ontario Ministry of Environment. Revised Stormwater Management Guidelines Draft Report.

Nelson, J.S. and M.J. Paetz. 1992. The Fishes of Alberta. 2nd edition. The University of Alberta Press, 438 p.

Newmaster, S.G., A. Lehela, P.W.C. Uhlig, S. McMurray and M.J.Oldham. 1998. Ontario Plant List. Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste. Marie, Ontario, Forest Research Information Paper No. 123, 550 pp. + appendices.

NHIC (Natural Heritage Information Centre). 2008. Web-based geographic query of the Natural Areas data and Element Occurrence data. http://nhic.mnr.gov.on.ca/MNR/nhic/queries/geographic.cfm

NHIC (Natural Heritage Information Centre). 2015. NHIC Species Lists. Available at: http://www.mnr.gov.on.ca/en/Business/NHIC/2ColumnSubPage/STDU_138223.html

Nikula, B., J.L. Loose and M.R. Burne. 2003. A Field Guide to the Dragonflies and Damselflies of Massachusetts. Massachusetts Division of Fisheries & Wildlife. Natural Heritage & Endangered Species Program.

North-South Environmental Inc., Dougan and Associates, and Sorensen Gravely Lowes. 2008. Peel-Caledon Significant Woodlands and Significant Wildlife Habitat Study: Draft for Public Comments - October 2008. Ontario: Region of Peel and Town of Caledon.

North-South Environmental Inc., **2009.** Natural Heritage System Definition & Implementation - Sustainable Halton Report 3.02, prepared for the Region of Halton.

NPWRC (Northern Prairie Wildlife Research Center). 2006. Nesting Ecology and Nesting Habitat Requirements of Ohio's Grassland-nesting Birds: A Literature Review Results and Discussion. Available at: http://www.npwrc.usgs.gov/resource/birds/ohionest/elark.htm

OBBA (Ontario Breeding Bird Atlas). 2001. Guide for Participants. Atlas Management Board, Federation of Ontario Naturalists, Don Mills. 34pp.

Oldham, M. J., Bakowsky, W.D. and D.A. Sutherland. 1995. Floristic Quality Assessment System for Southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources.

Oldham, M.J. 1999. Natural Heritage Resources of Ontario: Rare Vascular Plants. Third Edition. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. 53 pages. http://www.mnr.gov.on.ca/MNR/nhic/species/rarevascular.pdf

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2005. Provincial Policy Statement.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2014. Provincial Policy Statement.

OMNR (Ontario Ministry of Natural Resources). 1989. MNR 1:50,000 scale resource mapping: Halton Hills Oakville and Milton, Fish and Wildlife Resources.

OMNR (Ontario Ministry of Natural Resources). 1993. Ontario Wetland Evaluation System Southern Manual covering Hill's Site Regions 6 and 7, 3rd Edition. Revised 1994.

OMNR (Ontario Ministry of Natural Resources). 2000. Significant Wildlife Habitat Technical Guide. 151pp. Appendix C & G.

OMNR (Ontario Ministry of Natural Resources). 2007. Oak Ridges Moraine Conservation Plan: Technical Paper Series, 2 - Significant Wildlife Habitat. 32 pp. http://www.mah.gov.on.ca/Page4808.aspx

OMNR (Ontario Ministry of Natural Resources). 2014. Sixteen Mile Creek Valley Candidate Provincially Significant Area of natural and Scientific Interest. ANSI Summary, Aurora District. May 2014.

OMNR (Ontario Ministry of Natural Resources). 2013. Technical Paper 1: Technical Definitions and Criteria for Key Natural Heritage Features in the Natural Heritage System of the Protected Countryside Area of the of the Greenbelt Plan (2005)

OMNR (Ontario Ministry of Natural Resources). 2010. Natural Heritage Reference Manual. Available at: http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@lueps/documents/document/289522.pdf

OMNR (Ontario Ministry of Natural Resources). 2011. General Habitat Description under the Endangered Species Act, 2007: Dolichonyx oryzivorus (Bobolink). Updated as of 04/19/2011. Ministry of Natural Resources, Policy Division, Species at Risk Branch.

OMNR (Ontario Ministry of Natural Resources). 2012a. Significant Wildlife Habitat Ecoregion 6E Criterion Schedule. 42 pp. Available at: http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTE1ODc5&statusId=MTczNDgy

OMNR (Ontario Ministry of Natural Resources). 2012b. Significant Wildlife Habitat Ecoregion 6E Criterion Schedule. 37 pp. Available at: http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTE1ODc5&statusId=MTczNDgy

OMNRF (Ontario Ministry of Natural Resources and Forestry). 2015. Species at Risk in Ontario List Available at: http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/MNR_SAR_CSSR_SARO_LST_EN.html [accessed April 21, 2015].

Ontario Regulation 162/06. 2006. Policies, Procedures and Guidelines for the Administration of Ontario Regulation 162/06. Conservation Halton.

OOA (Ontario Odonata Atlas). 2005. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. http://www.mnr.gov.on.ca/MNR/nhic/odonates/ohs.html (updated 15-02-2005).

OPIF (Ontario Partners in Flight). 2008. Ontario Landbird Conservation Plan: Lower Great Lakes/St. Lawrence Plain, North American Bird Conservation Region 13. Ontario Ministry of Natural Resources, Bird Studies Canada, Environment Canada. Final Draft, June 2008. Draft February 2006 version available online at: http://www.bsc-eoc.org/PIF/PIFOntario.html

Parish Geomorphic Ltd. 2001. Geomorphological protocols for subwatershed studies. Submitted to: Regional Municipality of Ottawa-Carleton.

Parish Geomorphic Ltd. 2004. Belt Width Delineation Procedures. Submitted to: Toronto and Region Conservation Authority.

Paul, M.J. and J.L. Meyer. 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics, 32: p. 333-365.

Philips Planning and Engineering Limited. 2000. Sixteen Mile Creek Subwatershed Areas 2 & 7 Study. General Report and Appendices.

Philips Engineering Limited. 2003. Indian Creek /Sixteen Mile Creek Sherwood Survey Subwatershed Management Study. Town of Milton. Draft Final Report. 165 pp + appendices.

Philips Engineering Limited. 2005. Environmental Study Report, Regional Road 25, Class Environmental Assessment. Regional Municipality of Halton.

Plourde, S.A., E.L. Szepesi, J.L. Riley, M.J. Oldham and C. Campbell. 1989. Distribution and Status of the Herpetofauna of Central Region, Ontario Ministry of Natural Resources. Parks and Recreational Areas Section, OMNR, Open File Ecological Report SR8903, Central Region, Richmond Hill, Ontario. 27pp.

Rezendes, P. 1999. Tracking and the Art of Seeing (Second Edition). How to Read Animal Tracks and Sign. Firefly Books. Willowdale, Ontario. 336 pp.

Riviere, L. and S. McInnes. 1999. Identifying Woodlands in Halton. Draft Report for Discussion. R.M. Halton Planning and Public Works Department.

RMH (Region Municipality of Halton), 2005. Halton Region Environmental Impact Assessment Guidelines. July 13, 2005. 14pp.

Rothfels, C. 2006. The Dragonflies and Damselflies (Odonata) of Halton Region, Ontario. pp. 135 – 158. *In*: J.K. Dwyer (Ed.) Halton Natural Areas Inventory 2006. Volume 2 – Species Checklists. 184pp.

Rothfels, C. 2007. Personal communication with Carl Rothfels, odonate expert and author of "The Dragonflies and Damselflies of Halton Region, Ontario" on July 20, 2007 to discuss the status of River Bluet (*Enallagma anna)*.

Rowe , J.S. 1972. Forest Regions of Canada. Department of the Environment, Canadian Forest Service. Publication Number 1300, 172 pp + map.

Sandilands, A. 2007. Common Nighthawk. Pg. 308 – 309, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. *Atlas of the Breeding Birds of Ontario, 2001 – 2005*. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Schumm, S.A., 1977. The fluvial system: New York, John Wiley &Sons, 338 p.

Selby, M. J. 1982. Hillslope Materials and Processes. Oxford Univ. Press.

Sierra Club. 2004. Where Rivers are Born:The Scientific Imperative for Defending Small Streams and Wetlands (http://iowa.sierraclub.org/Steve-Sierra%20web%20docs0526/WhereRiversAreBorn.pdf)

Simberloff, D. And J. Cox. 1987. Consequences and costs of conservation corridors. Conservation Biology 1:63-71.

Simberloff, D.J., J.A. Farr, J. Cox and D.W. Mehlam. 1992. Movement corridors: conservation bargains or poor investments. Conservation Biology 6: 493-502.

Snell, E.A. 1987. Wetland Distribution and Conversion in Southern Ontario. Working paper No. 48, Inland waters and Lands Directorate, Environment Canada.

TSH Associates. 2006. *North Oakville Creeks Subwatershed Study.* Submitted to: Town of Oakville.

Toronto Region Conservation Authority. 2007. Terrestrial Natural Heritage System Strategy.

Town of Milton. 2001. Town of Milton Official Plan.
Available: http://www.milton.ca/plandev/officialplan.pdf

Varga, S., D. Leadbetter, J. Webber, J. Kaiser, B. Crins, J. Kamstra, D. Banville, E. Ashley, G. Miller, C. Kingsley, C. Jacobsen, K. Mewa, L. Tebby, E. Mosley, E. Zajc. 2005. Draft. Distribution and Status of the Vascular Plants of the Greater Toronto Area (Draft, Varga et al 2005). Ontario Ministry of Natural Resources. Aurora District. 96 pp.

Vickery, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/239doi:10.2173/bna.239

Whiting, A. 2004. Population ecology of the Western Chorus Frog, *Pseudacris triseriata*. M.Sc. Thesis, McGill University, Montréal, Québec, Canada. 106 pp.

Whiting, P.J., J.F. Stamm, D.F. Moog and R.L. Orndorff. 1999. Sediment-transporting flows in headwater streams. *Geological Society of America Bulletin*; v. 111; no. 3; p. 450-466.

Wolman, M.G., 1954. A method of sampling coarse river-bed material. Transactions of American Geophysical Union. 35: 951-956.

Wormington, A. 2006. The Butterflies of Halton Region, Ontario. pp. 113 – 134. *In*: J.K. Dwyer (Ed.) Halton Natural Areas Inventory 2006. Volume 2 – Species Checklists. 184pp.

Wormington, A. and W.G. Lamond. 2003. The Butterflies of Hamilton, Ontario. pp. 3–1 to 3-30 *In*: J.K. Dwyer (Ed.) *Nature Counts Project: Hamilton Natural Areas Inventory 2003 - Species Checklists.* Hamilton Naturalists' Club, Hamilton, Ontario. 282pp

Zorn, P., V. Blazeski and B. Craig. 2004. Joint EMAN / Parks Canada National Monitoring Protocol for Plethodontid Salamanders. Version 1. July 2004. Prepared for Environment Canada, Burlington ON.

APPENDIX 'A'
CORRESPONDENCE

APPENDIX 'B'
SUBWATERSHED AREAS 2 & 7
MANAGEMENT STRATEGIES

APPENDIX 'C'
HYDROLOGY/HYDRAULICS

APPENDIX 'D'
HYDROGEOLOGY

APPENDIX 'E'
WATER QUALITY

APPENDIX 'F'
STREAM MORPHOLOGY

APPENDIX 'G'
FISHERIES RESOURCES

APPENDIX 'H'
TERRESTRIAL

APPENDIX 'I'
SIS TERMS OF REFERENCE