Peel2041
Regional Official Plan Review

Peel Synthesis Report

Appendices
(Part B)

November 2019

Toronto and Region Conservation Authority

Credit Valley Conservation
inspired by nature

Lake Simcoe Region conservation authority

Conservation Halton

Nottawasaga Valley Conservation Authority

Prepared for:

Region of Peel
working with you

This technical summary report (including any attachments) has been prepared using information current to the report date. It provides an assessment of provincial policy conformity requirements, recognizing that Provincial plans and policies were under review and are potentially subject to change. The proposed direction contained in this technical summary report will be reviewed to ensure that any implementing amendments to the Regional Official Plan will conform or be consistent with the most recent in-effect provincial policy statement, plans and legislation. Additional changes will not be made to the contents of this technical summary report.

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List of Acronyms & Abbreviations

AOC	AREA OF CONCERN
BMP	BEST MANAGEMENT PRACTICES
BUI	BENEFICIAL USE IMPAIRMENT
CA	CONSERVATION AUTHORITY
CTC	CREDIT VALLEY – TORONTO AND REGION – CENTRAL LAKE ONTARIO
CVC	CREDIT VALLEY CONSERVATION
DFO	DEPARTMENT OF FISHERIES AND OCEANS
EA	ENVIRONMENTAL ASSESSMENT
ELC	ECOLOGICAL LAND CLASSIFICATION
ERSG	ECOLOGICAL RESTORATION STRATEGY AND GUIDELINES
GTA	GREATER TORONTO AREA
GTAA	GREATER TORONTO AIRPORTS AUTHORITY
HVA	HIGHLY VULNERABLE AQUIFER
IWMP	INTEGRATED WATERSHED MONITORING PROGRAM
LID	LOW IMPACT DEVELOPMENT
LIDAR	LIGHT DETECTION AND RANGING
LOISS	LAKE ONTARIO INTEGRATED SHORELINE STRATEGY
LSRCA	LAKE SIMCOE REGION CONSERVATION AUTHORITY
MCR	MUNICIPAL COMPREHENSIVE REVIEW
MECP	MINISTRY OF THE ENVIRONMENT, CONSERVATION, AND PARKS (FORMERLY MOECC, MOE)
MNRF	MINISTRY OF NATURAL RESOURCES AND FORESTRY (FORMERLY MNR)
NGO	NON-GOVERNMENTAL ORGANIZATION
NHS	NATURAL HERITAGE SYSTEM
NVCA	NOTTAWASAGA VALLEY CONSERVATION AUTHORITY
PCCP	PEEL CLIMATE CHANGE PARTNERSHIP
PPS	PROVINCIAL POLICY STATEMENT
PTTW	PERMIT TO TAKE WATER
PWQMN	PROVINCIAL WATER QUALITY MONITORING NETWORK
RAP	REMEDIAL ACTION PLAN
ROPA	REGIONAL OFFICIAL PLAN AMENDMENT
RWMP	REGIONAL WATERSHED MONITORING PROGRAM
SGBLS	SOUTH GEORGIAN BAY - LAKE SIMCOE
SGRA	SIGNIFICANT GROUNDWATER RECHARGE AREAS
SPP	SOURCE PROTECTION PLAN
SWM	STORMWATER MANAGEMENT

TSS	TOTAL SUSPENDED SOLIDS
TNHSS	TERRESTRIAL NATURAL HERITAGE SYSTEM STRATEGY
TRCA	TORONTO AND REGION CONSERVATION AUTHORITY
WHPA	WELLHEAD PROTECTION AREA

A. Watershed and Subwatershed Planning and Related Studies

This section summarizes each of the conservation authorities' existing watershed and subwatershed studies, reports, and other associated studies that are relevant to Peel Region's jurisdiction, their dates, and intended purpose(s).

A.1 Credit Valley Conservation Authority

- Credit River Water Management Strategy Update (Credit Valley Conservation [CVC] 2006)
- Credit River Watershed Plan (CVC 1984)

The first watershed plan for the Credit River watershed was completed in 1984 (CVC 1984). Currently, the *Credit River Water Management Strategy Update* (CVC 2006), in conjunction with the Natural Heritage System Strategy (CVC 2015b) and other documents, guides CVC's programs. The update builds on the original Credit River Management Strategy that was completed in the early 1990s. A new holistic watershed plan was initiated, with approval from CVC's Board of Directors, in 2017.

Credit River Water Management Strategy

The *Credit River Water Management Strategy Update* (CVC 2006) is a plan of action to ensure "abundant, clean, and safe water for environmentally, socially, and economically healthy communities". The strategy intends to protect and restore the natural features and functions of the watershed and inform decisions on growth and change how we plan our communities and deal with stormwater.

Objectives of the strategy are:

- to maintain or restore the natural hydrological cycle, natural stream processes, flow, and sediment transport to reduce erosion and flooding risks
- to maintain groundwater and baseflow levels to sustain watershed functions and human uses
- to maintain or enhance water and sediment quality for ecological integrity, drinking water, body contact recreation, and aesthetics
- to protect or restore ecosystem integrity, plant and animal species, community diversity and productivity through an integrated network of natural areas, habitats, and linkages

The plan also promotes the social benefits of a healthy watershed ecosystem and environmental stewardship through communications and education programs. It also emphasizes that partnerships with municipalities are key to ensuring policies incorporate an integrated watershed ecosystems approach, but also engagement with provincial agencies, non-government organizations (NGOs), other stakeholders, and the public.

Possible future land use scenarios (Existing Conditions: 15% urban (2002), Scenario 1: 20% urban as per Official Plan, Scenario 2: 25% urban, Scenario 3: 55% urban full buildout) were assessed and predicted a range of future conditions from degradation to improvement. Management scenarios that were considered included: *Do Nothing* [using no stormwater management (SWM)], *Business as Usual*

(current SWM practices), *Technology and Economy Driven* (overcoming technical and economic barriers that limit SWM) and *Ecotopia* (using greater consideration of environment in land use planning). It was also predicted that climate change would cause deterioration of watershed conditions without action and that there are limits to growth if we are to realize watershed goals. It should be noted that this was a qualitative exercise that did not involve modelling or analysis of risks and vulnerabilities from future climate projections. See Appendix D for climate change studies that have been completed to date.

Recommendations include: stream restoration in urban areas and more aggressive SWM, including areas where land use is not changing. Best management practices (BMPs) include: low impact development (LID) techniques, such as infiltration at source, where possible. Additional rural measures include conservation tillage, tile outlet controls, nutrient management, septic system repair/replacement, natural area buffers, reforestation, and wetland restoration.

Credit Valley Conservation Watershed Plan: 100 Years of Conservation 1954 to 2054 (in progress)

An updated watershed plan for the Credit River watershed is currently underway. The new plan will build upon the original watershed plan, *CVC's Strategic Plan* (CVC 2014), and the *Natural Heritage System Strategy* (CVC 2015b). The objective of the new watershed plan is to celebrate and document the past, recognize trends, and identify drivers of change. Lessons learned from past failures and successes and applied to the future is the first step in adopting an adaptive management approach. The initial phase of documenting our history has been drafted and the second phase is underway that summarizes present watershed conditions and trends, as documented by our watershed monitoring program since 1999. The updated watershed plan is expected to be completed in 2021.

Present programs, strategies, plans, and guidelines have been summarized in a relational framework and assessed for their effectiveness and identified gaps will be addressed in the third phase of the development of the plan. Future modelling will include updates to watercourse attributes derived from new tools, such as Light Detection and Ranging (LiDAR), an integrated ground and surface water model, and updated water budget. Future land use and climate change scenarios will be analyzed to predict effects on water and natural heritage systems. Other drivers, such as projected trends in invasive species and recreational demands will be qualitatively discussed. Management options (e.g. urban growth and agricultural BMPs) will be assessed and recommendations will be made for programs at CVC and key stakeholders, such as our municipal partners. There will also be a review of subwatershed plans completed to date to inform the watershed plan and to explore different options for updating subwatershed plans in the future.

Subwatershed Studies

CVC's jurisdiction is shown in Figure A.1. The jurisdiction includes tributaries of the Credit River, five main river reaches, and tributaries draining directly into Lake Ontario. Only subwatersheds 10 and 11 (Black and Silver Creeks) are entirely outside the Region of Peel. Nevertheless, they do drain into Peel Region and thus affect the water resources of the Region and are included in this report. In fact, these two tributaries (Black and Silver Creeks), along with Orangeville, were identified as the most stressed systems by Source Water Protection studies that required Tier 3 studies. All three subwatersheds also

have wastewater treatment facilities discharging into them. A detailed summary is provided for Fletchers Creek only, as it is the only subwatershed to be reviewed part of the municipal comprehensive review (MCR) process required by the Province to support expanded settlement areas in the Region.

Table A.1 provides a summary of information related to subwatershed studies completed in the Credit River watershed. These studies can range widely in terms of meeting criteria or equivalency to the modern standards of a subwatershed study and may be scoped in terms of spatial boundaries, disciplinary content, and integration and completed phases. Spatial scoping is often driven by areas to be developed or areas serviced by infrastructure in the case of settlement and servicing plans. Some studies may be focused on issues, such as erosion or other restoration needs and be detailed for some disciplines and deficient for others.

Figure A.1: Subwatershed Delineation for the CVC Jurisdiction

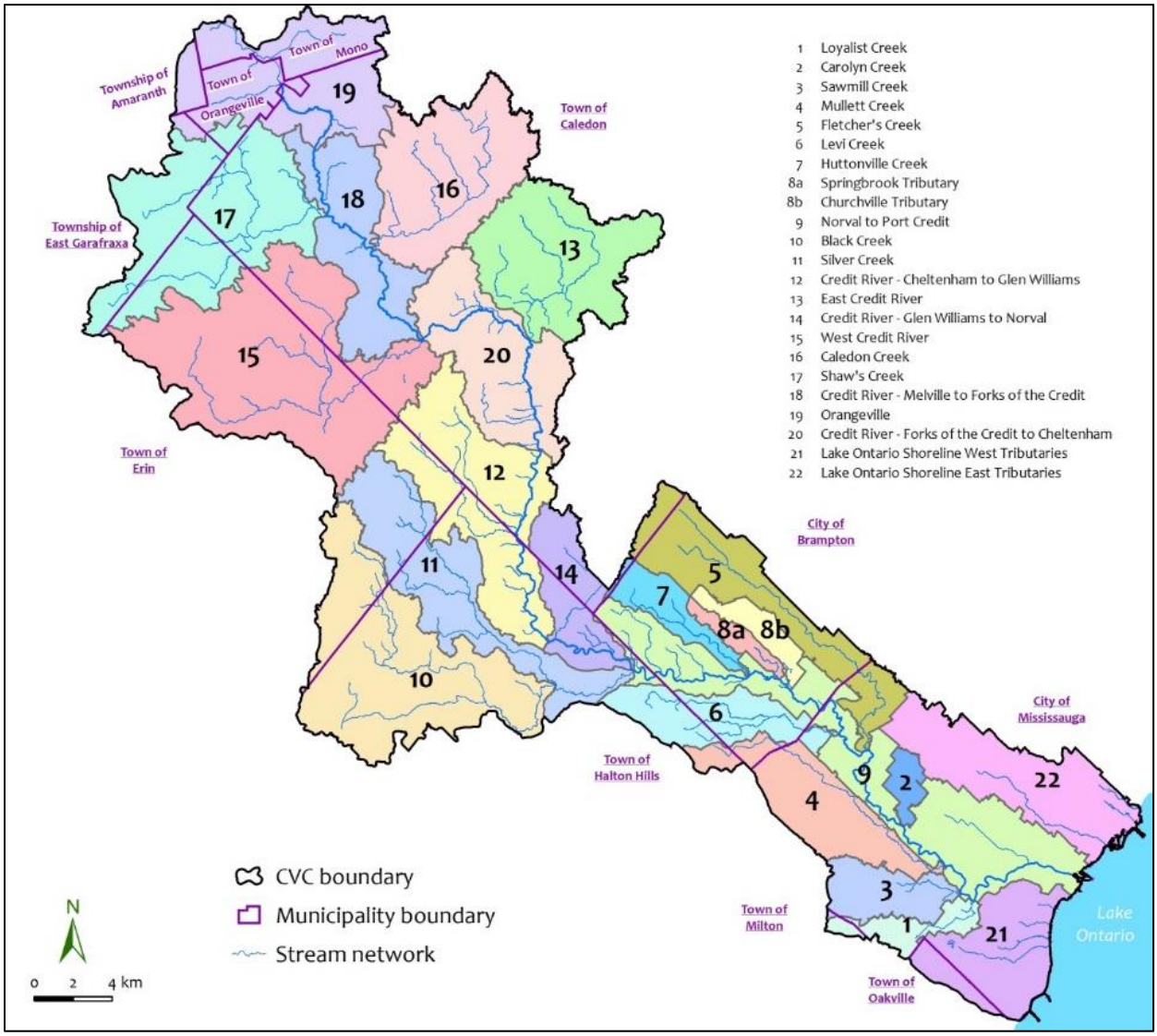


Table A.1: List of Subwatershed Studies Available for the CVC Jurisdiction

#	Subwatershed Name	Document Name	Comments (If applicable)
1.	Loyalist	Loyalist Creek Watershed Study (1980)	Outdated
2.	Carolyn	Master Drainage Study for Carolyn Creek (1987)	Outdated
3.	Sawmill	Sawmill Creek Subwatershed Study Update (2000)	Outdated
4.	Mullet	1) Mullet Creek Rehabilitation Study (2001) 2) Gateway West Subwatershed Study Update (1999)	Gateway study was geographically scoped.
5.	Fletchers, Huttonville	1) Fletcher's Creek Restoration Study (2012) 2) North West Brampton Subwatershed Study (2011) 3) Fletcher's Creek Subwatershed Study (1996)	The North West Brampton study was led by the City of Brampton. The City of Brampton commissioned the Fletcher's Creek Restoration Study to offset phosphorous contributions.
6.	Levi	Gateway West Subwatershed study (1999)	See comment in row 4.
7.	Huttonville	1) Credit River Subwatershed Study (2004) 2) North West Brampton Subwatershed Study (2011) 3) Heritage Heights Community Subwatershed Study (2012)	Heritage Heights study has only completed Phase 1 to date (Phase 1 consists of watershed characterization).
8a)	Springbrook	1) Credit River Subwatershed Study (2004) 2) Heritage Heights Community Subwatershed Study (2012)	See comment in row 7.
8b)	Churchville	1) Credit River Subwatershed Study (2004) 2) Heritage Heights Community Subwatershed Study (2012) 3) Churchville Subwatershed Study (1998)	N/A

#	Subwatershed Name	Document Name	Comments (If applicable)
9.	Norval to Port Credit (Main Credit)	Credit River Adaptive Management Strategy: Development of a Rehabilitation Plan, City of Mississauga (2005)	Scoped primarily to Mississauga reach
10.	Black Creek	1) Black Creek Subwatershed Study (2018) 2) Tier 3 Water Budget Study (2015)	N/A
11.	Silver Creek	1) Silver Creek Subwatershed Study (2003) 2) Tier 3 Water Budget Study (2015)	N/A
12.	Cheltenham to Glen Williams (Main Credit)	Glen Williams Integrated Planning Project - Scoped Subwatershed Plan (2003)	Geographically scoped to Glen Williams
13.	East Credit	East Credit Subwatershed Study (2007)	N/A
14.	Glen Williams to Norval (Main Credit)	N/A	No study completed to date.
15.	West Credit	1) Erin Wastewater Treatment Plant Environmental Assessment (2017) 2) Erin Servicing and Settlement Master Plan (2014) 3) West Credit Subwatershed Plan (1998)	The Master Plan is geographically focused on the Town of Erin.
16.	Caledon Creek	Caledon Creek and Credit River Subwatershed Study (2003)	N/A
17.	Shaws Creek	1) Shaws Creek Subwatershed Study (2018) 2) Alton Village Study (2008)	The Alton Village study is geographically focused and based on wastewater servicing.
18.	Melville to Forks (Main Credit)	Caledon Creek and Credit River Subwatershed Study (2003)	N/A
19.	Headwaters/ Orangeville	1) Headwaters Subwatershed Plan Update (2018)	N/A

#	Subwatershed Name	Document Name	Comments (If applicable)
		2) Tier 3 Water Budget Studies (2015) 3) Headwaters Subwatershed Plan (1997)	
20.	Forks to Cheltenham (Main Credit)	Cheltenham Village Water and Wastewater Servicing Class Environmental Assessment (2005)	N/A
21. **22.**	Lake Ontario Shoreline East and West Tributaries	Lake Ontario Integrated Shoreline Study (2018)	N/A

Fletchers Creek Subwatershed Study / North West Brampton Subwatershed Study

The Fletcher's Creek studies [*Fletcher's Creek Subwatershed Study* (Paragon Engineering Ltd 1997), *Environmental Implementation Report for Fletcher's Meadow Secondary Planning Area* (Marshall Macklin Monaghan 1997)] were completed in preparation for urban development but predated both the Provincial Policy Statement (PPS) and Ecological Land Classification (ELC) system. However, these studies provided guidance on linkage functions and feature sensitivity related to the Fletcher's Creek subwatershed. A greenspace hierarchy was identified in the Fletcher's Creek Subwatershed Study related to ecological functions, reflecting stream hydrology, habitat, and linkages. Greenspace system components included natural core areas, regulatory floodplain, valley land corridors, support natural areas, isolated natural areas, and linkage/rehabilitation areas. The environmental implementation report was reliant on the subwatershed study findings with respect to identification of terrestrial features and linkages; although somewhat dated in approach, this analysis can inform the future Natural Heritage System (NHS) in the present study.

The Fletcher's Creek Subwatershed Study Report contained detailed quantitative and qualitative information with respect to channel conditions for the whole of Fletcher's Creek Subwatershed. Specifically, the report characterized the drainage basin through morphometric analysis and hydraulic relations; determined sediment characteristics, identified and assessed erosion along the creek and determined the stability of the channel through identification of threshold indices with respect to the entrainment of bed material. The nearest channel cross-section that was established by the North West Brampton Study Area was located downstream of Highway 7. This cross-section showed susceptibility of movement of bed material at flows below bankfull conditions, indicating instability of the channel in this location. In 1996, there was bank erosion identified north and south of Highway 7 due to lack of vegetation and livestock. Also, this report identified that the headwater area was sensitive to disturbance and more susceptible to erosion.

The *North West Brampton Subwatershed Study* (AMEC 2011) has built upon these previous studies and been scoped for development in parts of Huttonville and Fletcher's Creeks. The subwatershed study has been conducted to assist in the establishment of a land use and associated management system for the Mount Pleasant Community Secondary Planning Area. The subwatershed study was complemented by a landscape scale analysis offering a broader perspective on resource linkages outside of the stormwater standards. The landscape scale analysis was issued in August 2007 to provide an overview summary of landscape level functions and to support the planning for the NHS in North West Brampton. The key GIS map products summarized the regional context of the Mount Pleasant lands, summarized natural area cover, hydrologic functions, and preliminary restoration opportunities to improve hydrologic functions, identified natural areas according to their total functional priority, summarized stream ratings and barriers, and identified existing as well as potential corridors and linkages at the landscape scale analysis scale. GIS summaries are included of original and current natural and urban cover, as well as recent change in cover (1966-1983, 1983-2005). The landscape scale analysis report concluded with preliminary principles and strategies to guide NHS planning in the North West Brampton subwatersheds. These were considered in Phase 2 along with other guiding documents. The Phase 1 Characterization assessed the resources by study discipline (i.e. hydrology/hydraulics, hydrogeology, water quality, stream morphology, aquatic, and terrestrial ecology) to establish a baseline inventory for use in subsequent study phases.

During 2008 and early 2009 extensive discussions took place between stakeholders on the land use and NHS planning being considered for the Mount Pleasant Community. A set of working subwatershed targets was developed for consideration. A land use plan, called the "*Point of Departure Plan*", was prepared by City of Brampton staff for formal impact testing. The purpose of the testing was to determine if the various subwatershed targets could be met with respect to overall environmental goals and objectives. Based on the *Point of Departure Plan* impact assessment results, input was formulated for the subsequent land use plan, termed the Second Generation Plan, in the way of land use changes and modified management directives. The preparation of this Plan was a collaborative effort between the City of Brampton Subwatershed Study Team, CVC, Ontario Ministry of Natural Resources, Department of Fisheries and Oceans (DFO) and the Mount Pleasant Landowners Group. The Plan reflected consultation that refined the key elements of the *Point of Departure Plan* to develop a functional NHS that placed a strong emphasis on the protection of key existing natural features and the creation and / or maintenance of key natural functions and linkages, along with the application of feature specific buffers.

As a requirement of the Mount Pleasant Community Secondary Plan Land Use Plan going forward to Council, the City of Brampton, CVC, Ministry of Natural Resources and Mount Pleasant Landowners Group prepared and agreed upon the "*Implementation Principles for the Mount Pleasant Subwatershed Study,* November 24, 2009" which defines the elements of the proposed NHS plan, as well as the implementation approach. Schedules A, B, and C are to be read in conjunction with the Principles wherein: Schedule A is the proposed Secondary Plan Natural Heritage System (November 24, 2009) which summarizes the proposed NHS graphically, with natural feature annotations; Schedule B consists of vignettes prepared to illustrate the intent of corridor restoration and enhancement of the NHS in key

areas of the East Huttonville Creek system; and Schedule C is the Mount Pleasant Secondary Plan Work Plan and Schedule.

The 'agreed upon elements' of this Plan were tested through impact assessment. Based on the results of this assessment, no significant land use changes were determined (e.g. additional Fletcher's Creek stream corridor and modified stream corridor widths), although further refinement of the management systems was required to improve certain discipline results in comparison to the working targets.

The implementation plan has been prepared to ensure compliance by identifying specific actions in the following areas: planning and policy (e.g. land use designations and form), rehabilitation and retrofit, stewardship, monitoring, and research and development. In addition, the monitoring strategy is to establish requirements from each discipline to evaluate how the respective management solutions are functioning as related to the subwatershed goals, objectives, and targets.

Phase 4 involves the long-term monitoring initiative that evaluates the effectiveness of the finalized management strategies by assessing whether the assumptions are appropriate, and predictions are correct, and determining if parts of the plan and the management strategies should be modified. Phase 4 will not be conducted as part of this study; however, further details will be offered by the development proponents, in consultation with the City of Brampton and CVC.

A.2 Toronto and Region Conservation Authority

There are three TRCA watersheds located in the Region: Humber River, Etobicoke Creek, and Mimico Creek. Watershed plans have been developed for each of these watersheds. However, due to their relatively small size and similar issues, Etobicoke Creek and Mimico Creek watersheds are part of a single watershed plan.

- *Humber River Watershed Plan: Pathways to a Healthy Humber* (TRCA 2008a)
- *Humber River Watershed Plan Implementation Guide* (TRCA 2008b)
- *Legacy: A Strategy for a Healthy Humber* (TRCA 1997)
- *Etobicoke and Mimico Creeks Watersheds Technical Update Report* (TRCA 2010)
- *Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watershed Report Card* (TRCA 2006b)
- *Greening Our Watersheds: Revitalization Strategies for Etobicoke and Mimico Creeks* (TRCA 2002)

Humber River Watershed

Building off of Legacy: A Strategy for a Healthy Humber which was published in 1997, an update to the Humber watershed plan called *Humber River Watershed Plan: Pathways to a Healthy Humber* was completed in 2008. The 2008 watershed plan addressed data gaps identified in the previous 1997 plan, with respect to the groundwater system, water budget, water use, and inclusion of findings from the Terrestrial Natural Heritage System Strategy (TNHSS) (TRCA 2007).

The impetus for the most recent version of the watershed plan was to inform and guide municipalities as they undertook their growth planning exercises in response to the provincial Growth Plan policies that were established in 2006. In addition, the *Oak Ridges Moraine Conservation Plan* required municipalities to incorporate the objectives and requirements of watershed plans into their Official Plans, and the *Clean Water Act* (2006) called for watershed-based planning to protect sources of drinking water. Information from this watershed plan was intended to be used as input into these municipal planning efforts. Other uses included providing strategic recommendations regarding high priority remedial actions to assist in de-listing impaired beneficial uses in the Toronto Area of Concern of Lake Ontario, such as priority areas for improvement of SWM controls and aquatic habitat restoration.

Scenario modelling was undertaken as part of this 2008 watershed plan update, and a full build out scenario was analyzed that considered the effects of development up to the boundaries of the Greenbelt Plan protected areas. Scenario modelling also included two climate change scenarios of the day (CGCM2 Scenario A21 and HadCM3 AOECM; A1F1) using the "delta or climate change factor" approach for the year 2080. In addition, this information complemented the City of Toronto's *Wet Weather Flow Management Master Plan* (2003) by identifying stormwater impacts associated with potential future upstream development and stormwater retrofit needs.

The *Humber River Watershed Plan Implementation Guide* (TRCA 2008b) is intended to facilitate implementation of the recommendations contained in the *Humber River Watershed Plan* (TRCA 2008a). This implementation guide outlines a ten-year work plan for numerous recommendations grouped according to implementation mechanisms: policy; regeneration; land securement; stewardship and education; operations and maintenance; enforcement; and monitoring.

Etobicoke Creek & Mimico Creek Watersheds

In 2010, TRCA completed a report called *Etobicoke and Mimico Creeks Watersheds Technical Update Report*, to update technical information from the *Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watershed Report Card* (TRCA 2006b) and *Greening Our Watersheds: Revitalization Strategies for Etobicoke and Mimico Creeks* (TRCA 2002). The purpose of this technical update was to develop an improved understanding of the watersheds and update the strategic management recommendations and implementation priorities, based on analysis of new technical information. The technical update consolidates and integrates updated information relating to groundwater quantity and quality, surface water quantity and quality, fluvial geomorphology, terrestrial NHS, and the aquatic system.

The information in the Technical Update Report was intended to support municipal partners in land use and infrastructure planning in conformity with the provincial Growth Plan (2006). Additionally, the *Greenbelt Plan* (2005) identifies where urbanization should not occur to protect the agricultural land base and ecological features and functions within the landscape, which includes the Etobicoke Creek Headwaters subwatershed.

The Technical Update Report outlined five strategic management directions for existing and future land uses:

1) Expand and enhance natural cover and habitat connectivity
2) Restore a more natural water balance through enhanced SWM controls
3) Foster stewardship and sustainable behaviour
4) Manage rebounding groundwater levels (particularly in the vicinity of former Brampton Esker aggregate pits)
5) Advance the science and practice of watershed management

Part of the policy recommendations arising from these strategic management directions included the suggestion that master environmental servicing plans, done on a subwatershed scale, be required for major urban development, redevelopment, or regeneration, and major infrastructure projects.

The Technical Update Report mentions the potential impacts of climate change as previously discussed in *Turning Over a New Leaf.* In recognition of what can be done at the local scale to mitigate and adapt to climate change, the Region of Peel developed a Climate Change Strategy in 2010. The Technical Update Report acknowledges that further investigations are needed into the impacts of climate change on these watersheds.

Subwatershed Studies

- *Etobicoke Creek Headwaters Subwatershed Study Synthesis Report* (TRCA 2008c)
- *Centreville Creek Subwatershed Study Synthesis Report* (TRCA 2008d)

Humber River – Centreville Creek Subwatershed

To help evaluate the Region of Peel and the Town of Caledon evaluate the servicing options for new developments in Caledon East, TRCA undertook a subwatershed study for Centreville Creek. The study was initiated to collect, integrate and summarize information on baseline conditions in the subwatershed. It also provided an opportunity to examine local watershed management issues and opportunities and formulate recommendations for local actions that would contribute to achieving the objectives of the Humber River watershed strategy (TRCA 1997). The *Centreville Creek Subwatershed Study Synthesis Report* (TRCA 2008d) summarizes, integrates, and documents the findings and recommendations from work on the subwatershed planning study conducted. While the Centreville Creek Subwatershed Study Synthesis Report was finalized in 2008, the information on baseline subwatershed conditions represents what was available between January 2003 and December 2004.

Recommendations from this subwatershed study are organized according to three general management zones: existing and future urban areas; natural and cultural heritage; and rural and agricultural areas. There are 25 recommendations across these three types of management zones. Specific recommendations to Region of Peel and the Town of Caledon include: improving stormwater management; monitoring of groundwater levels; using more sustainable design principles for new development; and, avoiding and mitigating impacts to the natural and water resource systems.

Etobicoke Creek – Etobicoke Creek Headwaters

The *Etobicoke Creek Headwaters Subwatershed Study Synthesis Report* (TRCA 2008c) summarizes, integrates, and documents the findings and recommendations from subwatershed planning studies. The report describes subwatershed conditions (based on data available between October 2004 and November 2005) regarding land use, groundwater surface water quantity and quality, fluvial geomorphology, terrestrial and aquatic ecosystems and cultural heritage. There are also recommendations for further study.

Recommendations from this subwatershed study are organized according to four general management zones: existing urban areas; future urban growth areas; existing rural and agricultural areas and watershed wide. There are 34 recommendations across these four types of management zones. Specific recommendations to Region of Peel and applicable lower-tier municipalities include: improving stormwater management; avoiding and mitigating impacts to the natural and water resource systems; using more sustainable design principles for new development; and, expanding and improving monitoring programs to understand the impacts of development across the headwaters.

A.3 Conservation Halton

Sixteen Mile Creek Watershed Plan (Halton Region 1996)

The Sixteen Mile Creek Watershed Plan was completed in 1996 in support of the Halton Urban Structure Plan. The project was led by the Region of Halton, with input from Conservation Halton, provincial ministries, and local municipalities. This plan was integrated into the planning process, recognizing the interrelationship of water resources, environmental conservation and urbanization. It was intended to provide a framework for the effective management of watershed and related environmental resources. Given the urbanization of the area, especially below the escarpment, the plan provided a series of recommendations to achieve a sustainable approach.

The plan consisted of 46 recommendations, which combined, represented the watershed management strategy. The plan acknowledged that successful implementation required collaboration and coordination among municipalities and other agencies. It also recognized that the plan was a living document that needed to be updated periodically. Emphasis was placed on the need for appropriate SWM approaches to address potential issues related to growth, such as erosion and sedimentation, increased runoff volumes and creek flows, reduction in base flows, altered water budgets and water quality degradation. The need for a collaborative approach to deal with permits-to-take-water and the associated issues of unreliable summer flows to support farm irrigation, on-line irrigation ponds, and groundwater quality and quantity was also underscored.

The requirement that subwatershed plans, in accordance with the goals and objectives of the Sixteen Mile Creek Watershed Plan, be undertaken prior to development was ensconced in the plan. While the watershed plan was intended to be updated on a regular basis, no comprehensive review or update has been done since it was completed.

Subwatershed Studies

- *North Sixteen District Scoped Subwatershed Study and Ninth Line District Floodplain Mapping, City of Mississauga* (Philips Engineering Ltd. 2014)
- *Ninth Line Lands Scoped Subwatershed Study* (Amec 2015, 2017, and in progress)

North Sixteen District Scoped Subwatershed Study and Ninth Line District Floodplain Mapping, City of Mississauga (Phillips Engineering Ltd. 2014)

The 2004 City of Mississauga study, prepared by a consultant team led by Philips Engineering Limited, provides environmental and SWM recommendations for the development of the North Sixteen District. The approximately 155 ha study area is located within the East Tributary Subwatershed of Sixteen Mile Creek and is bounded by Ninth Line to the west, Tenth Line to the east, Highway 401 to the north and the Canadian Pacific Railway line to the south. The planned land use is predominantly business employment in addition to a large multi-agency municipal facility, hydro corridor lands and regulated watercourse corridors.

The primary purpose of the study is to ensure that North Sixteen District development impacts on flooding, erosion, water quality and NHS features and functions are addressed and mitigated in accordance with provincial, CA and municipal policies and regulations. A secondary purpose of the study involves floodplain delineation for the Ninth Line District which is bounded by Highway 407 to the west, Ninth Line to the east, Highway 401 to the north and Highway 407/Ninth Line interchange to the south.

The report summarizes background information relevant to the East Tributary Subwatershed of Sixteen Mile Creek and identifies development constraints and requirements pertaining to aquatic resources, terrestrial resources, geomorphology, water resources and infrastructure. A management strategy is advanced, based on the background information as well as new field inventory and assessments undertaken for this study. Key activities include; development of preferred stormwater quantity controls, stormwater quality and environmental management for the North Sixteen District and an update to floodplain mapping for the Ninth Line District. Recommendations are to be implemented through planning and development processes and have been adhered to in recent Site Plan and Conservation Halton Permit applications within the study area.

Ninth Line Lands Scoped Subwatershed Study, City of Mississauga (in progress)

The ongoing *Ninth Line Lands Scoped Subwatershed Study* is a City of Mississauga / Region of Peel initiative with a consultant team led by Amec Foster Wheeler (Wood Environment and Infrastructure Solutions).

The Ninth Line Lands were transferred from the Region of Halton / Town of Milton to the Region of Peel / City of Mississauga on January 1, 2010, as part of a restructuring process for municipal boundary realignment. As a result, a planning study was necessary to consider the future of the area including an MCR to determine if there is justification for inclusion of some or all lands within the Region of Peel and City of Mississauga urban settlement boundary.

The Scoped Subwatershed Study is a significant component of the MCR that will define and establish the development constraints and opportunities within the Ninth Line Lands related to terrestrial and aquatic ecology, watercourse system and groundwater resources. Management recommendations and implementation principles will establish a linked and contiguous NHS consisting of a regulated tributary of Sixteen Mile Creek and associated floodplain, wetlands and woodlands in the study area. The study area is approximately 350 hectares at the west limit of the City and is generally bounded by Highway 407 to the west, Ninth Line to the east, Highway 401 to the north and Highway 407/Ninth Line overpass to the south.

The Scoped Subwatershed Study consists of three phases: the study area characterization builds off the City's Natural Areas Survey work in the study area followed by an Impact Assessment / Management Strategy and an Implementation / Monitoring phase. The study is guided by a Technical Steering Committee comprised of representatives from the City of Mississauga, the Region of Peel and Conservation Halton. In addition, representatives from the Ministry of Transportation and the Highway 407 ETR are engaged to coordinate the planning and servicing of the Ninth Line Lands specific to the future of the transitway corridor, which constitutes a significant future land use within the study area.

The Scoped Subwatershed Study will update the floodplain mapping completed as part of the Ninth Line District Floodplain Mapping (2004) and recommend protection of a linked and contiguous NHS including lands subject to flooding and key natural heritage and hydrological features. The inclusion of the Ninth Line Lands in the Regional Urban Boundary implements the Growth Plan population and employment forecasts for the Region for 2031. The more specific local Official Plan amendment will create a new neighbourhood character area for the study area and designate Residential Medium Density, Mixed Use, Business Employment, Public Open Space, Greenlands, Parkway Belt West, Utility and Natural Hazard, and Transitway land uses.

A.4 Nottawasaga Valley Conservation Authority

- *Watershed Plan Strategic Review and Update 1996-2015 (NVCA 2006a)*
- *Nottawasaga Watershed Management Plan 1996-2015 (NVCA 1996)*
- *Integrated Watershed Management Plan: Characterization Report (NVCA 2018)*

The NVCA covers only a very small portion of the Town of Caledon within its jurisdiction (<1% of total area of Peel Region). The majority falls within an area referred to as the "Palgrave Estates Residential Community", all of which is within the Oak Ridges Moraine Conservation Plan Area.

NVCA, in partnership with their watershed municipalities and the counties of Grey, Simcoe and Dufferin, is in the process of developing a new Integrated Watershed Plan for the Nottawasaga Valley. The initial *Nottawasaga Watershed Management Plan* was developed in 1996. Ten years later, a strategic review of the plan was conducted to address issues that had arisen since the plan was completed. NVCA continues to update watercourse and wetland mapping in its portion of Peel Region.

Watershed Plan Strategic Review and Update 1996-2015 (NVCA 2006a)

In 2006, NVCA published their *Watershed Plan Strategic Review and Update 1996-2015* (NVCA 2006a). The strategic review examined *Nottawasaga Watershed Management Plan 1996-2015* (NVCA 1996) strategic directions, issues, recommendations, and assessed the effectiveness of its implementation. The strategic review identified three main issues facing NVCA watersheds: impacts from growth on the natural heritage and aquatic ecosystems, water quality and quantity concerns (including impacts from septic systems, land use practices, water takings and increased flooding), and environmental impacts on water resources from natural resource extractions (aggregates, peat and water bottling).

The evaluation also included a review of new and emerging watershed issues (i.e. issues that had arisen since the 1996 plan was completed). The protection of groundwater was identified as a priority. The review provided 20 recommendations for how to achieve goals and objectives for the watershed, mainly directed at NVCA programs and services. One of the recommendations is for NVCA to provide municipalities with technical and planning assistance to incorporate environmental and natural hazards policies into planning processes.

Integrated Watershed Plan Update (in progress)

With increasing growth pressures and a changing climate, along with direction from the Province for planning and development to take an integrated watershed management approach, NVCA has decided to update its watershed plan. As part of this process, a watershed characterization report (NVCA 2018) was recently completed along with a stakeholder-driven compilation of watershed stressors. The plan is envisioned to guide the NVCA and its watershed municipalities towards sustainable growth, and the protection of important farmland and natural resources. The watershed plan is expected to be completed in 2020.

Integrated Watershed Management Plan: Characterization Report (NVCA 2018)

A watershed characterization report was completed as the first step in the development of a watershed plan update for the Nottawasaga Valley. The characterization report illustrates the current state of the natural, social and economic resources of the watershed. The report lays out the framework for how the watershed plan will be developed, including a preliminary listing of stressors and recommendations for moving forward.

Subwatershed Studies

Innisfil Creek Subwatershed Plan (NVCA 2006b)

The *Innisfil Creek Subwatershed Plan* was the legacy of an Intergovernmental Action Plan focusing on growth pressures and urban sprawl in Simcoe County, Barrie and Orillia as a result of *Places to Grow Act* (2005) guidance. The *Subwatershed Plan* was completed in 2006 to help guide watershed-based planning decisions in south Simcoe County in light of water quality and quantity issues and development pressures. In addition, the *Oak Ridges Moraine Conservation Plan* (2002) required the incorporation of watershed plans into municipal OPs.

Other uses for the Plan included highlighting local environmental targets for the aquatic ecosystem and the development of a NHS. The Plan was also the first effort to conceptualize a recently completed Assimilative Capacity Study (LSRCA & NVCA 2006).

A.5 Lake Simcoe Region Conservation Authority

Lake Simcoe Protection Plan (Ontario 2009)
Integrated Watershed Management Plan (LSRCA 2008)

The LSRCA covers only a very small portion of the Region of Peel within its jurisdiction (<1% of total area of Peel Region). The *Lake Simcoe Protection Plan* (2009) was approved under the *Lake Simcoe Protection Act, 2008* (the Act) and took effect on June 2, 2009. It has an overall goal to protect and restore the ecological health of the Lake Simcoe watershed. It follows an ecosystem, subwatershed, precautionary, adaptive management, and sustainable development approach. Implementation relies on shared responsibility and cost-effectiveness.

The Plan is focused on the issues most critical to the health of Lake Simcoe including:

- Restoring the health of aquatic life within the Lake Simcoe watershed;
- Improving water quality, including reducing loadings of phosphorus to the lake;
- Maintaining water quantity;
- Improving the health of the ecosystem by protecting and rehabilitating important areas, such as shorelines and natural heritage; and,
- Addressing impacts of invasive species, climate change, and recreational activities.

The policies in the Plan are grouped into four categories; the Act gives legal effect to the first three of these. The first category of policies is the “designated policies” in the Plan. The second category of policies is the “have regard to” policies. These first two categories of policies affect how decisions are made under specific statutes. The third category of policies relates to monitoring by public bodies. The fourth category of policies is not given legal effect by the Act. These policies set out strategic actions that public bodies should take in order to meet the Plan’s objectives.

Subwatershed Studies

West Holland Subwatershed Plan (LSRCA 2010)

The West Holland River Subwatershed Management Plan was developed by LSRCA in 2010 and was the first management plan developed for this subwatershed.

The plan was commissioned by York Region and developed to comply with the requirements under the Oak Ridges Moraine Conservation Plan (2001). However, it also built on the LSRCA’s Integrated Watershed Management Plan (LSCRA 2008) and the Province’s Lake Simcoe Protection Plan (2009). The plan complemented and supported applicable Official Plan policies and related municipal programs with similar goals related to subwatershed health. Information from this plan was intended to guide the development of an implementation plan, as well as assist in informing municipal plans and policies.

The subwatershed management plan included information regarding water budgets, climate change, hydrology, hydrogeology, and aquatic and terrestrial systems. Since 2010, further data regarding water quantity, climate change, SWM, and water quality have been compiled. Some examples of newly available information include mapping of salt vulnerable areas, climate change projections and strategies, a NHS and restoration strategy, and Ecologically Significant Groundwater Recharge Area mapping.

As the portion of the West Holland River subwatershed which falls within Peel Region is relatively small (365 ha), development pressure in this area is expected to be minimal.

B. Conservation Authority Policies, Regulations, and Regulatory Mapping

CAs regulate construction, alteration and development activities in and around valleys, streams and wetlands and along the Lake Ontario shoreline. This is done through individual conservation authority regulations under Section 28 of the *Conservation Authorities Act.* CAs also have extensive guidance materials on particular topics of relevance to municipal planning officials, such as stormwater management criteria (TRCA 2012 and CVC 2012), and headwater drainage feature assessments (TRCA and CVC 2014). These additional CA guidance materials will not be discussed as part of this Synthesis Report.

B.1 Credit Valley Conservation Authority

- *Watershed Planning and Regulation Policies (CVC 2010a)*
- *Watershed Planning and Regulation Policies Companion Document*
- https://cvc.ca/planning-permits/

CVC's *Watershed Planning and Regulation Policies (CVC 2010a)* provide the parameters against which CVC administers Ontario Regulation 160/06 under Section 28 of the *Conservation Authorities Act*. The *Watershed Planning and Regulation Policies Companion Document* is to be read in conjunction with the *Watershed Planning and Regulation Policies* document for context. It provides a brief explanation of the approach taken by CVC in updating the policies and provides the context and linkages between the process and the final policy document.

The *Watershed Planning and Regulation Policies* express the roles of CVC in protecting, restoring, and enhancing the watershed and to integrate updated science and policies related to watershed scale NHSs with the more traditional regulation of natural hazards. It also includes updated knowledge on groundwater and concepts in natural hydrological processes and applications such as natural channel design. Extensive input was sought from stakeholders to ensure the recognition of social and economic health through effective watershed management. The update is consistent with federal, provincial, and municipal legislation and guidelines. The update clarified the role of other studies at various scales, including subwatershed studies and the roles of agency partners (e.g. Ministry of Natural Resources and Forestry, Ministry of Municipal Affairs and Housing, Ministry of Environment, Conservation, and Parks). It also recognized an agreement with DFO to review projects under the *Fisheries Act*.

In general, there are natural heritage development protection policies for valleylands, environmentally significant areas, areas of natural and scientific interest, woodlands, wetlands, watercourses and fish habitat, and hazard land policies for riverine / valleyland and shoreline flooding and erosion. There are also policies directing floodproofing, SWM, and other BMPs. A future update is expected to incorporate natural heritage policies developed with the NHS in 2015 and may consider other ongoing studies, such as guidelines for ecosystem offsetting.

B.2 Toronto and Region Conservation Authority

- *The Living City Policies* (TRCA 2014)
- *Planning and Development Procedural Manual* (TRCA 2008e)
- https://trca.ca/planning-permits/

Under Ontario Regulation 166/06, TRCA is responsible for managing the renewable natural resources within nine Greater Toronto Area (GTA) watersheds. The goals of this regulation are to ensure public safety and protect property with respect to natural hazards, and to safeguard watershed health by preventing pollution and destruction of sensitive environmental areas, such as wetlands, shorelines, and watercourses. Development in a regulated area needs to consider possible constraints from natural hazards, or features, and requires a permit from the TRCA.

In addition to administering Ontario Regulation 166/06, TRCA has developed *The Living City Policies* (TRCA 2014) and a *Planning and Development Procedural Manual* (TRCA 2008e) for guiding the organization's participation in the planning and development process. *The Living City Policies* (TRCA 2014) was approved by TRCA's Board on November 28, 2014. It is a policy document to guide the implementation of TRCA's legislated and delegated roles and responsibilities in the planning and development approvals process. Comparable to a combined municipal Official Plan and zoning by-law, *The Living City Policies* represents a compilation of existing plan and permit review policies and practices that have evolved over time. It also contains new policies related to TRCA programs, scientific research, and external planning and development initiatives.

TRCA's *Planning and Development Procedural Manual* (TRCA 2008e), provides technical guidelines and procedural information for many of the policies found in *The Living City Policies*. The intent of the procedural manual is to enhance TRCA's cooperative working relationship with municipal partners, the development community, and permit applicants regarding the implementation of TRCA's planning and regulatory functions, including opportunities to increase procedural transparency and streamline the review process where feasible.

TRCA is updating its regulatory mapping across the TRCA jurisdiction. TRCA's regulatory mapping is being updated to reflect new technical information, such as new floodplain mapping, provincial wetland data, and information based on field verification. These updates more accurately capture areas regulated by TRCA. Public review of the updated regulatory mapping concluded January 31, 2019. The updated mapping is expected to be finalized in 2019.

B.3 Conservation Halton, NVCA, and LSRCA

Conservation Halton, NVCA, and LSRCA represent only a very limited area within Peel Region. Please refer to each CA's respective website for up-to-date policies, regulations, and mapping.

- https://www.conservationhalton.ca/planning-permits
- https://www.nvca.on.ca/planning-permits
- https://www.lsrca.on.ca/permits

C. Source Water Protection Assessment Reports and Plans

The *Clean Water Act, 2006* introduced a new level of protection for Ontario's drinking water resources that focuses on protecting water before it enters the municipal drinking water treatment system. The *Clean Water Act, 2006* established the locally driven, science-based, multi-stakeholder Drinking Water Source Protection program. Source protection planning is the first step in Ontario's multi-barrier approach to the protection of municipal residential drinking water sources and designated private drinking water sources. The *Clean Water Act, 2006* is not designed to protect all of Ontario's water resources. It has a narrow focus – sources of water that have been designated by a municipality as being a current or future source of residential municipal drinking water for the community. The *Ontario Water Resources Act, 1990,* the Provincial Policy Statement (2014), and the *Environmental Protection Act, 1990* as well as other provincial and federal laws remain the chief vehicles for protecting the quality and quantity of Ontario's water resources; the *Clean Water Act, 2006* provides additional protection to select sources of water.

Ontario Regulation 284/07 made under the *Clean Water Act, 2006* establishes the boundaries of each source protection area. There are 38 source protection areas in the province. As mentioned in Part A of the Peel Synthesis Report, there are three source protection plans within Peel Region.

C.1 CTC Source Protection Plan (2015)

The Credit Valley – Toronto and Region – Central Lake Ontario (CTC) region contains three source protection areas (Credit Valley, Toronto and Region, Central Lake Ontario). Technical information pertaining to the protection of municipal drinking water sources is contained in the Credit Valley, as well as the Toronto and Region Assessment Reports. The majority of Peel Region falls within the boundaries of the CTC source protection region.

Municipal Surface Water Systems

There are two water treatment plants drawing surface water in Peel Region. The Lakeview and Lorne Park Water Treatment Plants together are considered the South Peel Drinking Water System, whose source of drinking water is Lake Ontario. Policies that apply to these surface water systems are found in the CTC Source Protection Plan and are abbreviated as "LO" for Lake Ontario.

The Province has recently made changes to the provincial planning framework, including the *Conservation Authorities Act*, through Bill 108. Changes to regulations are still pending. CA's continue to advocate for operational flexibility in their mandates and for the importance of watershed-based governance models that enable innovative and practical solutions to current and emerging issues (e.g. flood management, drinking water, climate change, water quality and urbanization / growth).

Additional information about these policy documents, as well as links to each CA's respective websites, which maintain up-to-date policies, regulations, and mapping, are provided in Part B, Appendix B.

Table C.1: Description of Vulnerable Area Delineation and Threats for Municipal Surface Water Systems that Fall Within Peel Region

	Section of Credit Valley Assessment Report
Description of Drinking Water Systems	2.3.1
Intake Protection Zone Delineation and Vulnerability Assessment	4.9.1
Threats and Issues Identification	5.7

Municipal Groundwater Systems

There are four municipal drinking water systems in the Town of Caledon: Alton-Caledon Village, Cheltenham, Inglewood, and the Palgrave-Caledon East. For each of these drinking water systems, wellhead protection areas (WHPA) were delineated. A vulnerability assessment, threats evaluation, and issues assessment were also completed. The Director's Technical Rules governed the methodology through which this technical work was carried out. Based on the concentrations of total coliforms and *E. coli*, as well as the trends observed from data collected between 2004 and 2008, a pathogen water quality issue was identified at Inglewood Well 2. Many policies in the CTC Source Protection Plan apply to the municipal groundwater systems in Peel Region.

Table C.2: Description of Vulnerable Area Delineation and Threats for Municipal Groundwater Systems that Fall Within Peel Region

	Credit Valley Assessment Report	Toronto and Region Assessment Report
Description of Drinking Water Systems	2.3.2	2.3.2
WHPA Delineation and Vulnerability Assessment	4.8	4.3
Threats and Issues Identification	5.5.6	5.5.1

Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas

Although a significant drinking water threat can not occur in either of these vulnerable areas, they were delineated per the requirements of the Clean Water Act, 2006. Source Protection Committees had the option of creating policies to address moderate and low drinking water threats. The CTC Source Protection Committee wrote one land use planning policy (SAL-10) and a number of strategic action policies (SAL-11 – 13, DNAP-3, OS-3) to encourage the establishment of BMPs in these vulnerable areas.

Water Budget Assessment

Through a tiered process of water budget analyzes as set out in the *Director's Technical Rules*, water flow through the Credit Valley and Toronto and Region Source Protection Areas was characterized. This review included:

- Estimating the quantity of water flowing through a watershed;
- Describing the significant processes that affect flow;
- Characterizing the general movement of water; and
- Assessing the sustainability of drinking water supplies.

The *Director's Technical Rules* guide the completion of the tiered water budgets as a screening mechanism for gaining a progressive understanding of the characteristics of a watershed, the dynamics of surface water and groundwater interaction, and the impacts of water takings on municipal water supplies within the watershed. The higher the tier, the more complex the science involved and the narrower the geographic focus. The level of investigation required in the tiered approach depends on the severity of local water quantity issues. While the water budget analysis primarily targets municipal drinking water sources, the knowledge gained, and tools developed through the process are applicable to other areas of water resources and watershed management. At the highest tier, Tier 3, significant vulnerable areas (Wellhead Protection Areas – Quantity, WHPA-Q) are delineated and significant drinking water threat activities are identified. The WHPA-Q1 refers to the area where activities that take water without returning it to the same source may be a threat. WHPA-Q2 refers to the areas where activities that reduce recharge may be a threat. A portion of the Orangeville – Mono – Amaranth Significant Water Quantity Threat Area falls within the Town of Caledon. The WHPA-Q1 and the WHPA-Q2 in this threat area are the same size. A number of policies in the CTC Source Protection Plan written to address existing and future water quantity threat activities are required to be implemented by Peel Region and the Town of Caledon where the threat WHPA-Q extends into Peel Region.

C.2 SGBLS Source Protection Plan (SGBLS-SPC 2018)

For the South Georgian Bay - Lake Simcoe (SGBLS) source protection region, small portions of the Lakes Simcoe and Couchiching/Black River and Nottawasaga Valley Source Protection Areas fall within Peel Region. The WHPA-D (25-year Time of Travel) for the Palgrave – Caledon East Drinking Water System's Well 2 extends into the Nottawasaga Valley Source Protection Area, although no policies in the SGBLS Source Protection Plan would apply to this area. The WHPA-A (100 m), WHPA-B (2-year Time of Travel), WHPA-C (5-year Time of Travel), and WHPA-D for the Palgrave – Caledon East Drinking Water System's Well 3 also extends into the Nottawasaga Valley Source Protection Area. Since significant drinking water threats can occur in the WHPA-A through WHPA-C, several policies in the SGBLS Source Protection Plan would be applicable in these areas.

Significant groundwater recharge areas (SGRA), as well as highly vulnerable aquifer (HVA) areas have also been delineated within both fragments of the two source protection areas, which fall in Peel Region's jurisdiction. There are a number of policies in the SGBLS Source Protection Plan that apply to areas where moderate or low drinking water threats can occur, such as in SGRAs and HVAs. These

moderate/low threat policies address the future application of untreated septage to land [WAST(a)-2], undertaking research into chemical alternatives [DNAPL-3, SOLV-3], and determining the appropriate locations for stormwater pond discharges, sanitary sewers and related pipes [LUP-5].

However, threats enumeration for this system identified five threats associated with four land parcels that are considered to be potential significant drinking water threats. These threats are associated with sewage systems (4) and the handling/storage of fuel (1). It is important to note that the SGBLS and CTC count significant threats related to the subsurface storage of fuel for home heating purposes differently. The SGBLS Region counts the number of threats as the number of parcels where the vulnerability score is high enough to make the activity a potential threat. This method was adopted in order to account for the uncertainty of identifying properties with subsurface fuel storage. In contrast, the CTC Region counts every property in the vulnerable area, which would result in three significant threats related to fuel for a total of seven significant threats for the Palgrave system on four land parcels.

C.3 Halton-Hamilton Source Protection Plan

The Halton-Hamilton Region Source Protection Area includes approximately 11 km of the City of Mississauga / Region of Peel within its boundaries. These lands represent the most easterly extent of the Area and have portions extending from the Lake Ontario shoreline to Highway 401. The area is either developed or proposed for development and is primarily residential land use with residents supplied municipal water from the Region's facilities.

No municipal water systems take water within this area, however, a very small area along the lake's shoreline is captured in the intake protection zone for the Region of Halton's Oakville intake (Figure C.1). Currently, the vulnerability score for the Oakville intake is too low to have activities occurring within the zone to be classed as significant threats. However, this vulnerability score will be reassessed in 2019 under a new program technical rule, which allows for more local characterization of the intake and its vulnerability. If the score is raised and significant threats are possible, an inventory of activities in this area will be completed. Policies will be written to address the threats, if any are identified, and included in the Halton-Hamilton and CTC Source Protection Plans.

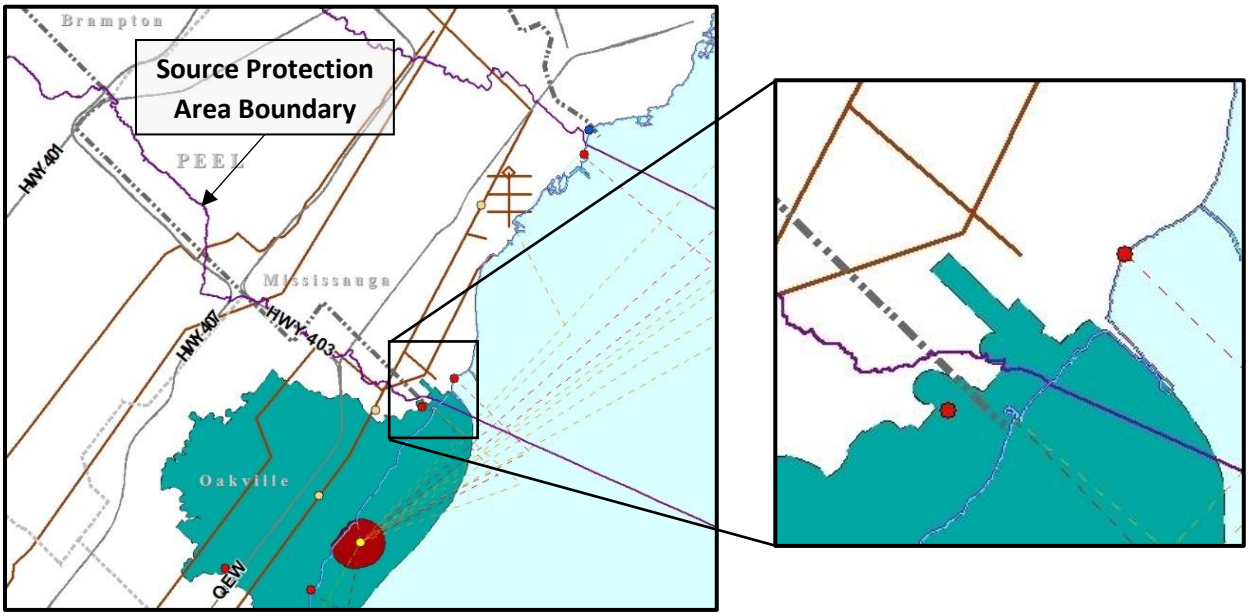
In Figure C.1, the dashed lines represent a connection between an activity and water quality impacts at Halton Region's Oakville water intake. The red dots identify the locations of wastewater treatment plants that could discharge raw sewage during an event, such as a power outage, and pose a significant risk to the source water. One plant is owned and operated by the Region of Peel. Policies within the Source Protection Plan for the CTC source protection region are to be implemented to address this threat activity.

There are no HVAs, where contaminants could easily impact underlying water sources mapped within this area of the Region. Furthermore, there are no SGRAs, where a relatively higher percentage of water infiltrates to sustain sources.

The Halton-Hamilton Source Protection Plan (HH-SPC 2015) includes strategic policies that aim to protect drinking water sources in an indirect way. These policies are discretionary (i.e. non-legally

binding), but the Halton-Hamilton Source Protection Committee asks that all bodies identified within the policies consider their implementation. The Region of Peel is asked to consider the implementation of policies O-1-S b., O-1-S e., O-1-S f., O-2-S a., and O-5-S a that help address the vulnerability posed by transport pathways, the need to collect and interpret climate data, and to increase awareness of the location of source waters and their protection areas during emergencies.

Figure C.1: Peel Region Within the Halton-Hamilton Source Protection Area



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D. Climate Change Studies

D.1 Peel Community Climate Partnership and Other Partnership Studies

In 2009, the City of Brampton, City of Mississauga, Town of Caledon, CVC, TRCA, and the Region of Peel formed the Peel Community Climate Change Partnership (PCCP) to develop an intergovernmental climate change strategy. This was in response to the urgent need to respond to climate change at the local level and was guided by senior representatives from each of the partners. The Peel Climate Change Strategy and associated Partnership Action Plan were released in 2011 and 2017 respectively. Both are discussed in Part A of this Synthesis Report.

Climate Trends and Future Projections in the Region of Peel (TRCA, Ontario Climate Consortium and Risk Sciences International 2016)

As a foundational piece and precursor to characterizing climate change vulnerability and risk across the Region of Peel, a climate trends and projections study was developed between 2015 and 2016 in partnership with TRCA and a consulting firm, Risk Sciences International (RSI). The purpose of this study was to characterize climate trends in recent past (since 1981) and future projections in climate across an array of climate indicators until the end of the century. Taking an approach recommended by the international climate science community, this study used an ensemble of global climate models to obtain the future climate conditions in the 2020s (short term), 2050s (medium term), and 2080s (long term). Future emissions scenarios, or Representative Concentration Pathways (RCPs), are provided to tell the potential range of Peel's future climate conditions.

In the 2050s for example, temperatures in Peel Region are very likely to continue increasing in all seasons, with the greatest increases still projected for winter. Mean annual temperatures are expected to rise 2˚C assuming business-as-usual emissions, with average winter temperatures rising faster by up to 2.2˚C and average spring temperatures rising slower by 1.8˚C. Temperature extremes are also expected to increase in frequency and intensity. Days reaching above 30˚C, for instance, will very likely increase by 14 days per year by the 2050s. Days above 35˚C, which have historically not been observed in the Region of Peel, are expected to occur twice per year by the 2050s as well. Geographically, higher temperatures are typically found in southern Peel rather than in the northwest regions; however, northern Peel can be expected to warm at a faster rate than southern Peel, with Lake Ontario remaining a critical driver of Peel's temperature into the future.

Total precipitation is likely to increase overall by the 2050s along with the most increase in precipitation in the winter and spring seasons, while summer and autumn precipitation are projected to remain steady or slightly decrease. Geographically, northwestern Peel is typically the wettest area within Peel Region while the southern portion receives the least precipitation. Into the future, the north-south gradient is likely to increase due to an increase in lake-effect precipitation with increasing ice-free conditions over Lake Huron to the northwest. Instances of extreme precipitation are likely to become more severe and frequent on a regional scale, resulting in further shortening of return periods associated with historical storm intensities. For example, 1- day and 5-day maximum precipitation amounts (historically 37mm and 59mm) are expected to increase by 8% and 10%, respectively in the

2050s. The worst 1% and 5% of extreme precipitation events are expected to increase by 51% and 28% in magnitude, respectively, should business-as-usual emissions continue.

Climate projections produced in this report have been leveraged across vulnerability assessments and other studies produced by TRCA and CVC within the Region of Peel. Ongoing work in 2019 seeks to update these climate projections in Peel but also across all of TRCA's watersheds based on more localized, regional climate models to explicitly capture and model the influence of the Great Lakes (being led by OCC).

Peel Region Natural Systems Vulnerability Assessment (TRCA and Ontario Climate Consortium 2017)

In 2017, a natural systems climate change vulnerability assessment was completed, which studied the impacts of climate change on natural systems in the Region of Peel. Urbanization is the principal land use stress on natural systems in Peel. Climate change will interact with other stressors to amplify and exacerbate impacts on natural systems (Table D.1).

Table D.1: Expected Climate Change Impacts to Natural Systems in Peel Region

System Component	Predicted Climate Change Impacts
Groundwater	• Reduced groundwater levels in shallow systems • Reduced volume of water discharging to surface waters • Increased risk of shallow aquifers drying out in summer • Loss of stream habitat • Local areas already under stress, such as Fletcher's Creek, the West Humber and Etobicoke Headwaters may be adversely affected
Aquatic System	• Elevated stream temperatures • Increased stream erosion and flooding due to more frequent and intense storms • Lower seasonal water levels and summer flows, compromising fish movement and survival • Increased spread of invasive species, as well as levels of pollutants and nutrients, through changes to flooding patterns • Favourable conditions for algal blooms, making them more common and intense
Terrestrial System	• Approximately 55% of the terrestrial system is considered highly vulnerable to increased air temperatures and longer summer dry periods • Drying of wetlands (swamps far from watercourses and bogs are believed to be most vulnerable) • Increased heat stress for vegetation • Intensified heat island effect in urban areas • Shift in tree species from northern to southern species

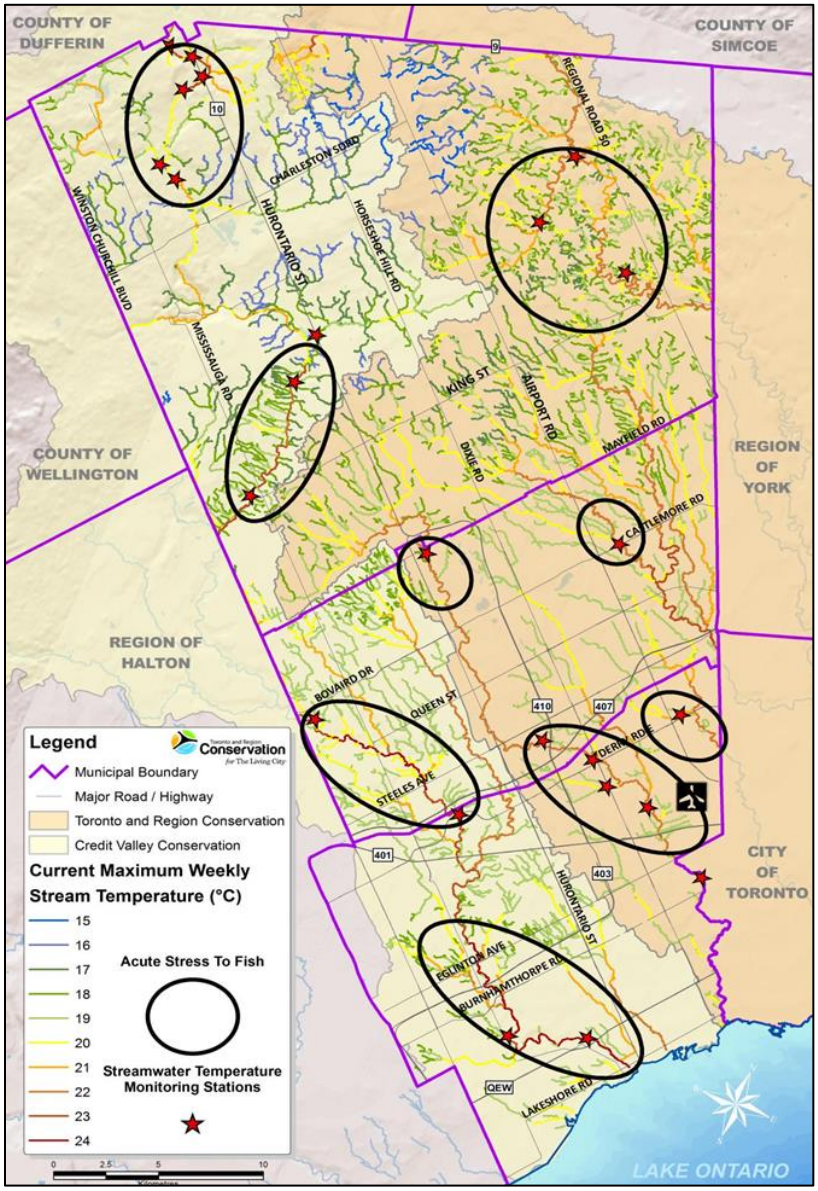
The groundwater, aquatic and terrestrial systems examined in this vulnerability assessment are tightly linked, and climate change will have complex and overlapping effects on them. Because many aspects of Peel's natural systems display a generally north-south gradient in condition, climate change will have uneven effects throughout the Region.

The stresses of urbanization on groundwater resources will increase with climate change. These impacts, in turn, will affect a variety of ecosystem services in Peel, such as regulation of water quality and quantity. Groundwater delivery to surface waters is projected to be more variable and intermittent, especially during summer months. While this is not expected to be a problem for potable water supply due to the Region's proximity to Lake Ontario, it may adversely affect non-potable water use, particularly in local areas already under stress, like Fletcher's Creek, and the West Humber and Etobicoke Headwaters.

The aquatic system delivers numerous ecosystem services, including a clean and stable water supply, control of flooding and erosion, and many recreational opportunities. Most watercourses are fed by groundwater in Peel. Streams south of the escarpment tend to have more intermittent headwaters and gather groundwater as they flow downstream, while streams above the escarpment and in the Oak Ridges Moraine are typically fed by groundwater-dominated headwaters.

Some parts of the aquatic system are in good ecological condition and support an abundance and diversity of aquatic plants and animals. Other parts of the system, however, are not faring so well, especially in the highly urbanized lower portion of Peel. These areas will be particularly hard hit by climate change. Nine highly vulnerable stream reaches (Figure D.1) have been identified in the Region due to their current low flows and elevated stream temperatures in summer. Under climate change, these hotspots may no longer be able to support sensitive fish species, such as Brook Trout and Redside Dace. Three aquatic species at risk are found in the Humber River and Credit River watersheds (two endangered fish, Redside Dace and American Eel, and one endangered dragonfly, Rapid Clubtail).

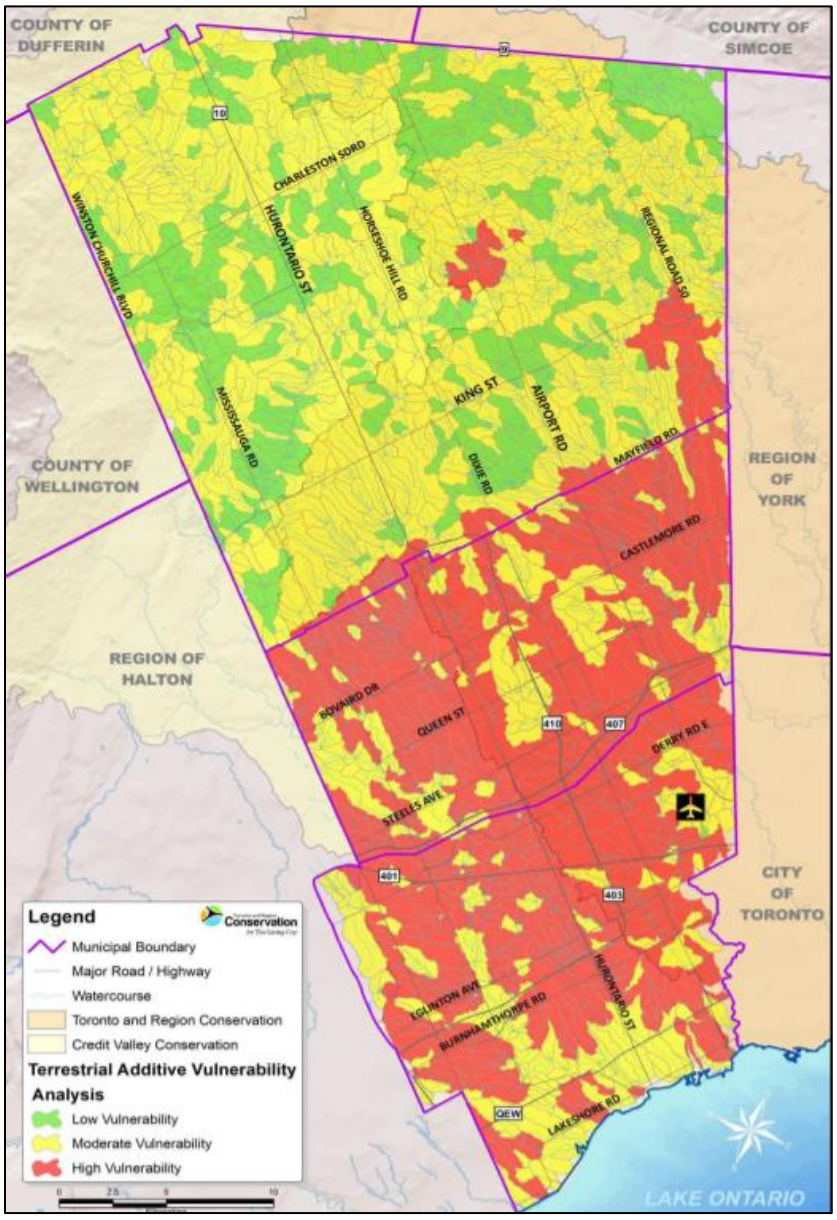
Figure D.1: Location of Nine Highly Vulnerable Stream Reaches Based on Stream Flow and Water Temperature



Climate change will amplify the effects of urbanization on the terrestrial system. Most of the vulnerable areas within the terrestrial system are small isolated patches of natural habitat located close to urbanization, where they already face the following pressures:

- A shift from natural cover (which is 'pervious', allowing water to soak into soil and minimize flooding) to paved cover (which is 'impervious')
- Loss of habitat connectivity (which reduces species movement and gene flow)
- Increased habitat fragmentation (which makes habitat patches unsuitable for some species and more vulnerable to invasive species and disease)
- Reduced forest canopy (which reduces shading and cooling effects of vegetation

Figure D.2: Terrestrial Systems Vulnerability Ratings in Peel Region



Natural areas in the northern part of Peel Region tend to be more widespread and well-connected. Although northern natural areas are currently in good ecological condition, they may experience drastic declines and shifts in species in the future, because they contain many climate sensitive plant communities, such as those found in swamps, marshes and fens far from watercourses.

Priorities for Action from this Vulnerability Assessment include:

1) Increase connectivity of natural areas by enhancing or expanding areas that currently function well and have low to moderate vulnerability to climate change.
2) Protect and restore natural features, such as forests, meadows and wetlands.

3) Enhance urban forest canopy by initially focusing on areas that currently have little to no ability to effectively regulate summer land surface temperatures.
4) Lower maximum water temperatures by prioritizing the protection of coldwater habitats.
5) Protect and improve stream baseflow to minimize vulnerability to aquatic systems.
6) Reduce surface water pollution by focusing on areas with degraded water quality and / or algal blooms.
7) Protect shallow water flow paths between shallow groundwater and surface features, such as streams and wetlands.
8) Review natural system monitoring programs to ensure they include a focus on climate change impacts.
9) Implement and update conservation policies to reduce natural system vulnerability.
10) Promote effective collaboration, cooperation and streamlined information sharing.

Peel Region Water Infrastructure Systems Vulnerability Assessment (CVC 2017)

A vulnerability assessment of the effects of climate change on water systems within the Region of Peel was completed in 2017. Many of the existing vulnerabilities in the Region's water infrastructure systems stem from the location and timing of urban development. Climate change is anticipated to exacerbate the impacts of future growth pressures on existing water infrastructure (Table D.2).

Table D.2: Expected Climate Change Impacts to Infrastructure Systems in Peel Region

Municipal Planning	Predicted Climate Change Impacts
Stormwater	With expected increases in extreme precipitation events due to climate change, there is an increased risk of riverine and urban flooding, as well as increased water quality concerns. Outdated stormwater infrastructure, particularly in older parts of Peel Region, may not have any flood controls. Vulnerability to climate change may occur in stormwater control (measures used to regulate flows and remove pollutants) and in stormwater conveyance (measures used to drain runoff to waterbodies). Most SWM ponds that exist in Peel Region do not meet current best practice standards and many parts of Peel lack these stormwater controls altogether. As a result, much of Peel is vulnerable to flooding and erosion, and pollution of receiving waters.
Wastewater	Peel's wastewater infrastructure consists of over 35,000 km of sanitary sewer main, 36 sewage pumping stations, and three treatment facilities. The Clarkson Wastewater Treatment Plant and G. E. Booth (Lakeview) Wastewater Treatment Facility are in Mississauga on the shores of Lake Ontario, and their treated effluent is discharged directly into the lake. The Inglewood Communal Wastewater Treatment Plant is in Caledon, and

	discharges into the Credit River. Peel's wastewater system also provides service to parts of York Region and the City of Toronto. In areas not serviced by the municipal wastewater system (mostly in Caledon and Brampton), there is private sewage disposal through septic systems. Although this infrastructure is outside the scope of the assessment, it can affect other water resources. Private septic systems in parts of Peel, for example, have degraded local groundwater and surface water quality.
Drinking Water	The Region of Peel takes its municipal drinking water from Lake Ontario (95%) and groundwater sources (5%). Two water treatment plants on the shores of Lake Ontario (Lakeview and Lorne Park) supply residents in Mississauga, Brampton and parts of Caledon with lake water. In the headwater areas, 15 wells and 10 small-scale groundwater treatment plants supply other parts of Caledon. Peel's drinking water system also provides service to York Region. Peel's water distribution system consists of transmission mains, feeder mains, and service connections. In general, the system is fairly resilient to climate impacts, especially extreme cold events. The system may be vulnerable in certain circumstances; such as when transmission mains cross, or follow a floodplain, and risk becoming exposed due to erosion. The water treatment systems on Lake Ontario have shown vulnerability to climate impacts. In 2012, an algal bloom in Lake Ontario clogged the intake of the Lorne Park water treatment facility, causing a temporary pump shutdown and damage to 27 intake baskets. The event cost the Region approximately $350,000. Algal blooms are predicted to increase in frequency and severity in the future under climate change, and their occurrence may be further exacerbated by watershed conditions, such as nutrient inputs, reduced streamflow and increased sun exposure of streams. Extreme rainfall events may also affect lake-based water treatment systems by degrading water quality at water intakes.

Priorities for Action from this Vulnerability Assessment include:

1) Strengthen planning, coordination, and collaboration among the Region of Peel, local municipalities, and CAs relating to SWM, water-related climate change research, and the development of an integrated watershed management framework and plan.
2) Incorporate climate change planning, and risk and vulnerability assessment into municipal Official Plans and infrastructure programs.
3) Improve weather-related monitoring to enhance emergency notification and response through an early warning system and enhanced public outreach.
4) Evaluate and report performance of existing design standards for water infrastructure and update where necessary to reflect future climate conditions.

5) Conduct further research on emerging threats, best practices, and the cost / benefit of increasing adaptation measures like green infrastructure.
6) Many of the existing vulnerabilities in Peel's water infrastructure systems stem from the location and timing of urban development. Climate change is anticipated to exacerbate the impacts of future growth pressures on existing water infrastructure.

Patterns of Growth

Urbanization in Peel has generally proceeded from the downstream shoreline of Lake Ontario upstream to headwater areas. This pattern means that impacts of future development upstream (including that occurring beyond Peel) may be felt downstream in already developed parts of the Region. For example, monitoring by CVC has shown that streamflow downstream of development areas can increase by up to two orders of magnitude compared with pre-development flows, due to increases in discharge and impervious surfaces. Intensification and redevelopment in existing urban areas can also affect water management through an increase in impervious areas. Local municipalities should ensure that these additional impacts are reflected in planning policy (such as by requiring specific lot-level controls to handle excess stormwater).

Aging Infrastructure

The age of development can be an indicator of the age of water infrastructure (unless replacement has occurred), and the level of service provided. This is particularly important for SWM infrastructure. Not only has stormwater technology evolved considerably over the last 40 years, but many older areas in Peel were built prior to flood control requirements and thus lack stormwater controls entirely. This discrepancy in stormwater infrastructure and level of service across the Region means that older areas (especially in Mississauga) are highly vulnerable to riverine and urban flooding, as well as increased water quality concerns.

D.2 Credit Valley Conservation Authority

CVC Climate Change Strategy (in progress; expected 2019)

In recognition of the risks that climate change poses to CVC's operations and the health of our communities and watershed, the *CVC Strategic Plan 2015-2019* provides direction to consider climate change in all of our management decisions and activities (Goal 1) and to ensure that our business is well managed, sustainable and service driven (Goal 7) which must include the anticipated impacts of climate change.

This Strategy is being developed in alignment with direction from the *CVC Strategic Plan 2015-2019,* CVC's Corporate Social Responsibility Strategy 2018, the Region of Peel Partner Climate Change Strategy 2011, Peel Community Climate Change Partnership Implementation Priorities 2018-2022 and the Conservation Authorities Climate Change Budget Risk Methodology (a methodology to ensure that programs funded by special levy funding provided by Peel for climate change work meet the criteria for climate change mitigation and or adaptation).

The CVC Climate Change Strategy will provide a framework and goals to guide priority climate change actions through the services CVC provides to the community and how CVC runs its operations over the next five years. CVC identified long term goals and short-term objectives through lessons learned from a decade of climate change action, extensive staff engagement and alignment with corporate and partner strategies.

The ten priority objectives for the Strategy are:

- Implement climate change detection and impact monitoring within existing programs and use monitoring results to inform science-based decision making internally and with our partners.
- Maintain and enhance flood forecasting and real-time flood monitoring, prediction and warning systems.
- Manage, restore and enhance the natural heritage system to increase natural system resiliency to current and predicted climate conditions.
- Work with partners to enhance emergency management preparedness and local messaging to the community.
- Develop and implement action plans to respond to urgent emerging climate change threats to our natural heritage system such as invasive species.
- Support Peel Climate Change partners in implementing the Low Carbon, Green Natural Infrastructure, Public Education and Flood Resiliency Strategies.
- Use and expand Sustainable Neighbourhood Action Plans to embed climate sustainability and resilience into watershed communities.
- Reduce CVC's corporate carbon footprint by identifying and implementing actions to achieve an emissions reduction target.
- Complete risk assessments of department program(s) considering climate change and incorporate into department business plans.
- Develop and report performance measures for climate change programs recognizing that environmental action today translates to long-term benefits.

CVC will report on progress and revisit the Climate Change Strategy in 2024 to assess progress and inform corporate business planning process. Priorities will be updated in 2024 as new information becomes available.

Assessment of Standards and Systems for Quality and Risk Management for Stormwater Infrastructure considering Existing and Future Climate Change Impacts: For the Region of Peel (CVC 2018a)

Climate change is expected to increase the strain on existing stormwater systems. Stormwater management is a shared responsibility between provincial authorities, municipalities and conservation authorities. This report assessed existing standards for applicability to stormwater and their ability to integrate flood resiliency and climate change solutions to build stormwater system resilience. The report also makes recommendations for the feasibility of a Municipal Stormwater Risk Management Framework (MSW-RMF).

Cooksville Creek Vulnerability Assessment: Phase 1 and 2 Summary (CVC, no date)

Phase 1 of this study revealed that short duration, high-precipitation events are projected to increase in frequency and intensity in the future. Cooksville Creek's vulnerability to extreme rainfall stems from the impervious surface cover and urbanized nature of the watershed. The urbanized area was primarily developed prior to modern stormwater management standards, so it lacks flood control and overland flow routes. Phase 2 tested the efficacy of different risk management scenarios under current and future climate. The utilized modelling framework demonstrates that there are financial benefits that accrue to the municipality for implementing land acquisition, LID and pond programs.

D.3 Toronto and Region Conservation Authority

TRCA Climate Change Strategy (In Progress)

TRCA is currently in the process of scoping and developing a Climate Change Strategy. This strategy is meant to leverage the TRCA Action Plan from 2008 and resources available through The Atmospheric Fund. This scope of work is expected to be undertaken in 2019 and 2020, and will involve staff engagement, identification of action areas and approaches to further implementation. Through the completion of this process, municipal partners can benefit from further understanding the breadth of climate change programs and services being provided by TRCA, and consistent messaging on how climate change is relevant to the TRCA mandate and actions being taken.

TRCA Action Plan for The Living City: Meeting the Challenge of Climate Change (TRCA 2008f)

This proactive strategy was intended to address the impacts of climate change within the TRCA jurisdiction and provided a business planning framework. Climate adaptation and mitigation are at the core of TRCA efforts, and TRCA is in a strong position to exemplify leadership and support our communities and partners in dealing with climate change. This Action Plan builds on CA strengths in adaptive watershed management and leadership in the application of sustainability at the local level.

Climate trends and projections are provided across southern Ontario based on Government of Ontario data and analyses, and a series of impacts and system responses in TRCA's jurisdiction are identified. A subset of which include:

- Northward expansion of the Carolinian Zone, with woodlots more likely to become stressed or die out due to loss of native biodiversity;
- Species loss as a result of inability to compete with invasive species;
- Uncertain impacts on wetland structure, function and hydrology;
- Extreme weather events may further cause risks to human life and property due to flooding;
- Rapid spring warming leading to shallower and steeper thermoclines
- Increased risk to municipal infrastructure, and insurance costs; and
- Positive and negative impacts on agriculture (e.g., frost free periods could extend growing season, but a longer growing season may support the invasion of pests and disease).

Through the completion of this strategy, the following key priority action areas were determined, each with specific actions and recommendations:

Adaptation

- Increase our knowledge and understanding
- Reduce risk to communities
- Build a resilient natural system in the GTA

Mitigation

- Promote a culture of conservation through market transformation
- Green TRCA's Operations
- Lead through Partnerships

The Living City Policies (TRCA 2014)

Climate change is expected to have a significant effect on temperature, precipitation and weather patterns in southern Ontario. Predicted changes include:

- hotter summers with more heat waves and droughts;
- warmer winters with less snow and more rain and freezing rain;
- disappearance of the spring melt or freshet; and
- increase in extreme weather such as thunderstorms, tornados and high wind events.

These changes to the local climate are expected to cause other environmental and socio-economic impacts such as: poorer air quality; damage to crops; health-related impacts such as new insect-borne diseases, loss of native plants and animals, the proliferation of invasive species, and increased erosion and water damage to property and infrastructure.

A comprehensive approach to addressing climate change is required that includes both mitigation - actions to reduce greenhouse gas emissions – and, adaptation - actions to cope with the potential effects of climate change. In many cases, actions to address climate change can be taken that have both adaptation and mitigation benefits, such as reforestation.

TRCA is committed to acting and exemplifying leadership to support our communities and partners in dealing with climate change mitigation and adaptation. Examples of TRCA actions related to climate change include:

- Updates to watershed plans with modelling that incorporates climate change predictions
- Flood management to reduce risk
- Enhancing greenspace

D.4 Lake Simcoe Region Conservation Authority

The Lake Simcoe Climate Change Adaptation and Mitigation Strategy (in progress)

The LSRCA is in the process of developing a *Climate Change Adaptation Strategy* and a *Climate Change Mitigation Strategy*, both to be completed in 2019. These were identified as a priority action under Goal 2 of the LSRCA Strategic Plan: Improve knowledge and increase certainty through excellence in research and scientific knowledge.

The *Climate Change Adaptation Strategy* will focus on several themes, including climate change projections, aquatic systems, terrestrial natural heritage, water quality, water quantity, and Lake Simcoe. The process of developing the plan has several steps: collect data, assess vulnerability, generate adaptation solutions, develop the plan, implement the plan, and monitor and adjust. Each section will consist of an overview of the current status, projected climate impacts and recommendations for action. These recommendations will then be incorporated into annual work plans through the development of an implementation plan.

The *Climate Change Mitigation Strategy* will create a carbon budget for the watershed, which will help guide municipal carbon reduction efforts. As part of the strategy, the LSRCA has developed a watershed-wide GHG emissions inventory based on downscaling provincial and national inventory emissions. This will help to determine where the hot spots for GHG emissions are in the watershed across various sectors, and where efforts can be focused to reduce these emissions.

E. Great Lakes Studies

E.1 Ontario's Great Lakes Strategy

The Great Lakes Strategy is intended to empower action by all stakeholders in the Great Lakes Basin. The Strategy was created following extensive engagement since the release of the Draft Great Lakes Strategy (June 2012) and the discussion paper, *Healthy Great Lakes, Strong Ontario* (MOE, MNR, OMAFRA 2009). The Strategy outlines how the Government of Ontario proposes to work with partners, individuals and communities to support the vision of healthy Great Lakes ecosystem.

Six principles will guide efforts to achieve Ontario's Great Lakes goals:

- Use of an ecosystem approach
- Applying the precautionary approach
- Promoting accountability
- Applying adaptive management
- Fostering an environment of collaboration and engagement
- Recognizing First Nations and Métis communities

Ontario's Great Lakes Goals:

- *Goal 1: Engaging and Empowering Communities*
  Focuses on providing opportunities to enjoy, benefit from, and connect with the Great Lakes.

- *Goal 2: Protecting Water for Human and Ecological Health*
  Focuses on helping to keep the Great Lakes drinkable, swimmable and fishable.

- *Goal 3: Improving Wetlands, Beaches and Coastal Areas*
  Focuses on keeping these areas biologically diverse and usable.

- *Goal 4: Protecting Habitats and Species*
  Focuses on restoring and protecting the natural habitats, biodiversity and resilience of the Great Lakes and St. Lawrence River Basin ecosystem.

- *Goal 5: Enhancing Understanding and Adaptation*
  Supports science that improves the understanding and management of the Great Lakes and St. Lawrence River.

- *Goal 6: Ensuring Environmentally Sustainable Economic Opportunities and Innovation*
  Enriches the quality of life in Great Lakes and St. Lawrence River watershed communities through environmentally sustainable economic opportunities, innovation, and sustainable use of natural resources.

E.2 Toronto and Region Remedial Action Plan

Toronto and Region is one of 43 locations around the Great Lakes where local environmental degradation may be causing harm to the wider Great Lakes system. These locations, referred to as Areas of Concern (AOCs), are in Canada (12 sites), the United States (26 sites), and in some cases are shared between the two countries (5 sites). AOCs were formally recognized by the governments of Canada and the United States in the 1987 amendments to the Great Lakes Water Quality Agreement. This Agreement committed the governments of each country to clean up AOCs within their respective jurisdictions.

The status of an AOC is determined by assessing the state of local environmental conditions against fourteen different Beneficial Use Impairments (BUIs), as identified in the Great Lakes Water Quality Agreement. Each BUI describes a human or ecological use of the ecosystem that has been lost or impaired as the result of environmental degradation; an AOC is therefore considered impaired when local conditions meet the descriptions of one or more BUIs. The clean-up, or remediation, of an AOC occurs through a mandated process called a Remedial Action Plan (RAP). An individualized RAP is required for each AOC.

The Toronto and Region AOC extends along the north shore of Lake Ontario from Etobicoke Creek in the west to the Rouge River in the east. The 2,000 km^2 area includes six watersheds and 42 km of waterfront, spanning eleven municipal jurisdictions with over 3 million residents.

Toronto and Region is currently in Stage 3 (implementation) of the RAP process. Three major interim progress reports, *Clean Waters, Healthy Habitats: 2001 RAP Progress Report* (TRCA 2001), *Moving Forward: 2007 RAP Progress Report* (TRCA 2009), *Within Reach: 2015 RAP Progress Report* (TRCA 2016a) have been issued that detail environmental monitoring results, achievements in remediation initiatives, as well as how conditions in the Toronto region compare against the BUI criteria. Although the challenges are many, the Toronto and Region RAP team believes that completing all restoration actions by 2020 is within reach (TRCA 2016a).

E.3 CVC Lake Ontario Integrated Shoreline Strategy (LOISS)

Recognizing the need for an integrated approach to the restoration and management of the Lake Ontario shoreline, CVC initiated LOISS in 2009. LOISS aims to provide guidance to local, regional, provincial, and federal governments for planning restoration initiations, developments, and land use decisions.

LOISS' study area extends the length of the shoreline within CVC's jurisdiction, from the Harding Estates in the west to Marie Curtis Park in the east. It extends inland approximately 2 km from the shoreline (but 5 km up the Credit River) and 6 km into Lake Ontario. LOISS emphasizes Lake Ontario's nearshore area, defined as extending from the shoreline to 20 m in depth.

The LOISS has three distinct phases:

- Phase 1: Background Report and Data Gap Analysis
- Phase 2: Characterization Report
- Phase 3: Implementation Report

Background information from existing reports and data sources was compiled, and where necessary field assessments were completed to evaluate conditions in the study area (Aquafor Beech 2011). Ten different subject areas were investigated, and data gaps identified. The subject areas were:

1) Hydrology and hydraulics
2) Fluvial geomorphology
3) Coastal processes
4) Water quality
5) Terrestrial natural heritage
6) Hydrogeology
7) Aquatic natural heritage
8) Stewardship, education, and communications
9) Ecological goods and services
10) Conservation lands

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F. Natural Systems Studies

The natural system is made up of the NHS and Water Resource System (WRS) that often coincide given ecological linkages between terrestrial and water-based functions (Growth Plan, Greenbelt Plan). Natural systems protect natural heritage, hydrologic, and landform features and their functions. Natural systems provide ecosystem services, including water storage and filtration, habitat provision, carbon storage, and resilience to climate change. The following studies are relevant to NHS planning and development. CAs have extensive mapping data on the WRS and continue to refine this data. A WRS for Peel will be provided as part of the Municipal Comprehensive Review process.

F.1 Credit Valley Conservation Authority

Credit River Watershed Natural Heritage System Strategy (CVC 2015b)

CVC undertook development of a NHS Strategy in 2005. The strategy was developed in four phases. Phases 1 and 2 were completed in 2011 and involved researching background information and characterizing existing conditions in the Credit River watershed. Phases 3 and 4 were completed in 2015. Phase 3 involved the development of scientific criteria, a methodology, and mapping for the Credit River Watershed NHS. Phase 4 developed recommendations for implementation, including actions for protection, restoration, stewardship, and land securement.

The Credit River Watershed NHS is made up of three interrelated components:

1) Natural heritage features, including valleylands, wetlands, woodlands, aquatic habitat, Lake Ontario shoreline, significant wildlife habitat, as well as habitat of endangered and threatened species that provide important ecological functions in the watershed.

   Features were classified as:

   - high functioning - essential to maintaining biodiversity, function, integrity, and resiliency of the NHS
   - supporting - enhances quality and function, and collectively, are highly likely to improve NHS resiliency
   - contributing - generally small and could be isolated, but may act as habitat or could be contributing in other ways

2) Minimum buffers have been applied to natural heritage features, such as valleylands, wetlands, woodlands, and aquatic habitat based on current science. Buffers protect the features and their functions and help to reduce impacts of abutting land uses on the ecological function of natural heritage features.

3) Natural heritage areas are made up of Centres for Biodiversity within the Credit River watershed. A total of eleven Centres for Biodiversity has been identified. These areas contain concentrations of high-quality natural heritage features as well as areas with non-natural land

uses that provide some ecological function due to their location in the system. Collectively, these areas are important for supporting native biodiversity in the watershed over the long term. They represent 10% of the watershed and 26% of the NHS.

A map of the NHS (Figure F.1) depicts that it occupies 39% of the watershed. Woodlands represent 23% of this area (short of the target of 30%), with 3.8% as interior habitat that is also short of a 10% target. Wetlands occupy 6.7% of the watershed that is short of a 10% target. The river valleys have natural cover of 74% compared to a target of 90%. Generally, the NHS of the watershed reflects good conditions in rural areas, however there is with room for improvement through restoration.

Priority recommendations include:

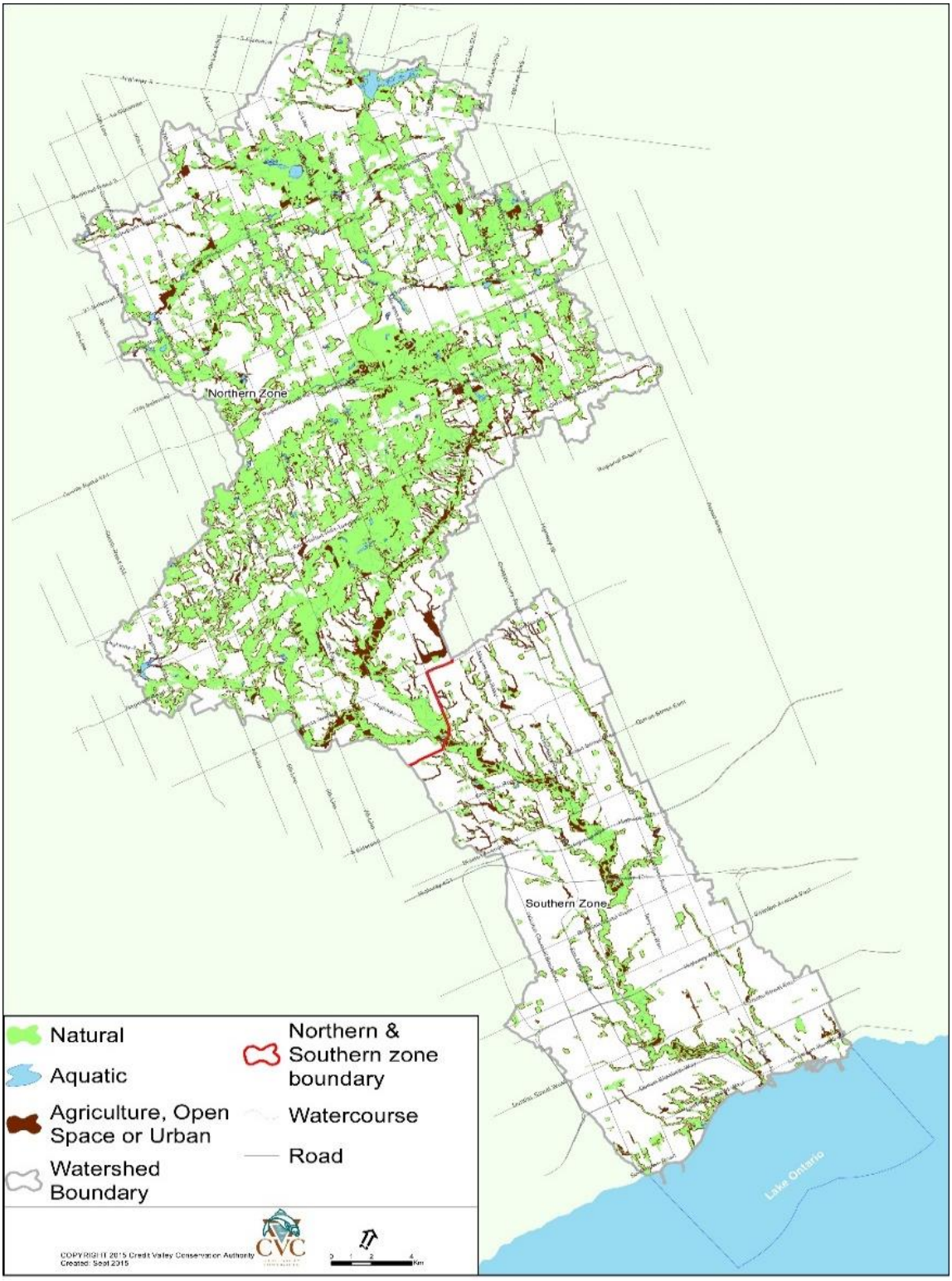
- integrate the NHS into an update of CVC Watershed Planning and Regulation Policies, including the development of model policies
- collaborate with municipalities to refine and incorporate into OPs
- develop biodiversity offsetting guidelines to achieve net gains; incorporate into CVC Greenlands Securement and Conservation Areas Management Strategies
- focus inventories, research, and restoration in priority areas such as Centres for Biodiversity, buffers, and connecting corridors
- identify and map significant wildlife habitat; develop ecohydrology targets for wetlands and streams
- assess land use changes and impacts to ecosystem services
- educate and communicate about NHS values
- monitor the NHS to detect and mitigate stresses and cumulative impacts
- integrate with subwatershed studies and other strategies under a new watershed plan

The NHS is being used to strategically direct CVC programs. It is also used to develop tools to assist provincial and municipal partners, private landowners, non-profit organizations and other stakeholders to protect, manage, and enhance natural heritage protection of the Credit River watershed. The NHS specifically provides a watershed and science-based approach that:

- provides an integrated system of terrestrial and aquatic features and functions to enable better management of the watershed's natural resources
- enables CVC to provide consistent and efficient plan input and plan review on provincial, regional, or area municipal initiatives as part of its technical advisory role, using a common NHS across the watershed
- supports CVC's Strategic Plan 2015-2019 and existing watershed management programs such as the Greenlands Securement Strategy, the Credit River Fisheries Management Plan, the Credit River Water Management Strategy, the Lake Ontario Integrated Shoreline Strategy, and current and future programs, including subwatershed studies and a watershed plan
- provides partners, including municipalities and the Province, with a science-based NHS based on ecological and hydrological principles within a watershed ecosystem context, and with extensive data

The NHS can be used to help support and refine existing municipal NHSs or can be adapted for development of municipal level NHSs in municipalities that currently lack such systems.

Figure F.1: CVC's Natural Heritage System



Credit River Fisheries Management Plan (CVC 2002, 2015a)

The *Credit River Fisheries Management Plan* was first published in 2002 (CVC 2002) and is a cooperative product of the Ministry of Natural Resources (MNR) and CVC with assistance from DFO, the Ministry of the Environment, regional/local municipalities, and other local NGOs. The purpose was to protect and restore aquatic ecosystems and recognize fish communities as indicators of watershed health, and to manage for economic and social benefits, particularly as related to the recreational fishing. It includes a comprehensive list of 90 issues, 140 strategies, and 350 specific, measurable and accountable tactics for the agencies and the public to consider. Guidelines for land use planners prescribe in-water construction seasons, buffer widths, and other fish community sensitivities and requirements. The plan also provides guidance for NGOs and the public on responsibilities and how to get involved in advocacy and rehabilitation projects.

Guiding principles adopted included:

- watershed ecosystems and adaptive management approach
- priority for native and naturally reproducing species
- integration with Lake Ontario fish community objectives
- protection and restoration of habitat with a “no net loss” policy
- more effective education
- improved fishing opportunities and enforcement of habitat protection and fishing regulations

Fish communities were classified for management purposes based largely on thermal requirements and stream size. There were also species barrier partitioning recommendations to reduce competition with non-native species, including operation of the Streetsville and Norval dams as barriers with passage for selected species. Re-introduced Atlantic salmon would be given passage above Norval, but rainbow trout would be stopped here pending further studies. Pacific salmon would mostly be stopped at Streetsville. The Streetsville dam would also be used to prevent sea lamprey migrations in addition to lampricide treatments of the river.

A report card review and unpublished update to the plan occurred in 2015 (CVC 2015a). Overall, aggregated fish scores degraded from a good to fair condition over the 13-year period.

New priority recommendations were made in the Credit River Fisheries Management Plan Update including:

- review and revise the water budget completed for source water protection and participate in the Low Water Response Team to define and implement environmental flow needs
- formalize a Memorandum of Understanding review process and guidelines for permits to take water (PTTWs)
- consider cumulative effects of water taking with climate change
- investigate opportunities to improve flows through dam regulation at Island and Fairy lakes
- endorse and require higher standards for LID and retrofit of older areas and SWM ponds

- improve storage and infiltration at all restoration sites and implement more projects as per the CVC Wetlands Restoration Strategy
- identify recharge areas specific to critical cold water reaches to improve protection and restoration efforts
- fund real-time monitoring, reinstate CVC inspector, and enforce sediment controls on construction sites
- revise and expand SWM effectiveness monitoring and implement appropriate maintenance and retrofits
- protect and restore 30 m stream buffers in NHS policies and adopted in Official Plans
- work with MNRF to improve outreach and implementation of dam mitigation and removal projects
- research and address potential competition with Brook Trout from Atlantic Salmon stocking
- resolve remaining issues with Rainbow Trout competition
- develop a list of CVC Fish Species of Conservation Concern and develop appropriate actions for conservation
- complete the CVC Integrated Restoration Strategy to provide high level guidance for watershed and fish habitat restoration
- integrate and implement buffer and dam priorities seen as the most important elements of a climate change strategy related to temperature impacts

CVC Ecological Restoration Strategy and Guidelines (in progress)

The Ecological Restoration Strategy and Guidelines (ERSG) will guide restoration planning and implementation at the watershed and site scale to assist the recovery of ecosystems to reinstate stability and resiliency, protect human health and safety, and maximize ecological goods and services for communities. This document is designed as a high-level strategy to incorporate more specific plans for wetlands, forests, grasslands, and invasive species. Guidelines for planning and prioritizing restoration projects are also included that were identified as gaps in the *Integrated Watershed Restoration Strategy* (CVC 2015c) that focused on geographic priorities only.

The ERSG will document ecological and socio-economic guiding principles. Most of the scientific principles are adopted from the Society of Ecological Restoration, Parks Canada, and from the European perspective on watershed management in Riverine Ecosystem Management (Sendzimir and Schmutz 2018). Principles and guidelines are also discussed from the local perspective of CVC programs in the context of the past, present, and future recommendations. Issues related to reference ecosystems, climate change, assisted migration, and novel ecosystems will be addressed.

One of the objectives of the ERSG is to encourage more integration of disciplines and programs, particularly between water and natural heritage. The Integrated Watershed Restoration Strategy identified two different approaches to restoration priorities that need to be better integrated. Water programs tend to focus first on restoring more degraded waterways, whereas the natural heritage approach is to restore and maintain the best natural areas first. Even if priority projects are completed by different programs this does not ensure an integrated watershed ecosystems approach, nor does

location in priority catchments assess and ensure the project is properly planned and implemented. Socio-economic principles ensure that projects are implemented that will maximize societal benefits or ecological goods and services, and economic principles ensure projects are implemented in the most cost effective and efficient manner.

The ERSG will provide an implementation plan of short to longer term actions and outline roles and responsibilities. A landowner outreach plan will also be important in contacting, assessing, and delivering restoration projects on private lands.

Wetland Restoration Strategy (CVC 2009a)

The purpose of the *Wetland Restoration Strategy* (CVC 2009a) is to prioritize areas for restoration defined as creation and re-creation of lost wetlands in order to meet area targets consistent with historical coverage, and Environment and Climate Change Canada guidance, in the order of 10% of each watershed. Rehabilitation, or improvement, of existing wetlands is also supported.

There is a priority on restoring hydrology (depth, timing, duration) within a natural range and controlling nutrient enrichment that, together, are most important to supporting biota and human benefits. There is also an emphasis on original swamps and ephemeral wetland cover.

Stressors that need to be addressed include:

- habitat removal and fragmentation
- nutrient enrichment
- contaminants
- sedimentation
- water taking and diversions
- invasive species
- unsustainable human use
- climate change

Wetlands are to be treated as an integrated system with headwater swales and streams. Small wetlands are important when linked together and integrated into urban SWM source and conveyance systems. An adaptive management approach is essential given the complexity of wetlands and in context of climate change. Climate change will alter the surface water component of wetlands such that more groundwater fed wetlands are less vulnerable and should be the focus of restoration that is less risky over the long term. Monitoring is to be based on water quantity, quality, primary productivity, decomposition, and biological diversity.

F.2 Toronto and Region Conservation Authority

Terrestrial Natural Heritage System Strategy (2007)

TRCA's TNHSS is a significant initiative that was developed, through support of TRCA municipal partners, to establish, protect and restore a network of natural cover (forest, wetland, meadow, successional, bluffs and beach) across the TRCA's jurisdiction. The Strategy will facilitate partner municipality's goals and objectives for terrestrial biodiversity and ecosystem health. The core principles of the TNHSS are to improve the quantity, quality, and distribution of terrestrial biodiversity across the entire jurisdiction. These principles also enable a steady provision of other ecosystem services that are vital for human well-being, including flood protection, pest reduction, increased recreation, and aesthetic opportunities.

TRCA has collected natural heritage inventory and monitoring data on an ongoing basis since the mid-1990s. Analysis of TRCA natural heritage information determined that 'business as usual' had not resulted in the protection of ecological function and biodiversity, especially in the urban and urbanizing portions of TRCA's jurisdiction. TRCA had documented a significant decrease in the abundance and diversity of species (flora and fauna) within the nine watersheds of the jurisdiction. As well, the distribution of many of these species had been restricted to the very northern parts of our watersheds. The TNHSS was developed to address this decline.

The regional NHS[1] defined in the Strategy aimed to protect and improve terrestrial biodiversity by increasing the quantity and quality of habitats (e.g. forest and wetlands) by building upon the existing terrestrial natural cover and optimizing the opportunities for species diversity. It used a number of ecological and policy criteria to develop a raster analysis tool to identify areas that have the greatest potential to contribute to improvements in habitat attributes (e.g. size, shape, and matrix influence). The tool also included areas with policy support to develop a robust target NHS. The target NHS includes both existing natural cover (25% of the TRCA jurisdiction) and potential areas (5% of the TRCA jurisdiction) that could be acquired and restored to natural cover. Using this approach, TRCA would achieve a well-connected and well-distributed network of mostly good quality natural cover throughout its jurisdiction. Nevertheless, a gradient of habitat quality from poor to excellent across the urban-rural parts of the jurisdiction is included in the target NHS, emphasizing that each has a contribution to make in the regional system.

Since 2007, the principles, science, and tools developed during the development of the TNHSS have assisted in informing the development of NHSs that have been incorporated into municipal Official Plans as required by the province and supported TRCA in its role as a public commenting body under the *Planning Act*. Since the NHS is a model and not based on the most current land use information, it was intended to be refined for specific municipal use and supported by a policy framework that allows for site specific assessment, where appropriate. TRCA recognized the considerable challenges facing municipalities in accommodating the growth expected for this region. To this end, TRCA has committed to working with its municipal partners to use the tools developed for the TNHSS to assist in re-evaluating

[1] Also known as the Terrestrial Natural Heritage System (TNHS). NHS will be used in this Report for consistency with provincial terminology and to avoid confusion with the acronym for the overall strategy (TNHSS).

and refining the system to meet their sustainability goals. Over the past decade, TRCA has worked very closely with its municipal partners to help design their NHSs.

TRCA has completed refinements to the regional NHS for each watershed at various times since according to funding availability and municipal needs. A summary of these updates is outlined in the following sections. In addition, TRCA is currently updating the technical components of the NHS (2018-2020) to incorporate the most up-to-date information.

Watershed-based Refinements to the NHS

Humber River Watershed Plan (TRCA 2008a)

The *Humber River Watershed Plan* (TRCA 2008a) highlights two main objectives for the NHS, which are:

1) to protect, restore and enhance natural cover to improve connectivity, quality, biodiversity and ecological function, and

2) to minimize negative influences from surrounding land uses on terrestrial NHS quality and function. The current conditions analysis identified the following main issues in the Humber watershed at the time:

    - poor quality of natural cover
    - existing natural cover patches are poorly connected, especially in the east-west directions
    - distribution of natural cover is weighted to the northern portions of the watershed
    - invasive species that threaten native ecosystems
    - impacts of human activities on plants, animals and their habitats

To address these issues the TRCA regional target NHS was used as the foundation to delineate an updated watershed-based refined target NHS for Humber watershed. The refined target NHS was expected to achieve ecological objectives (e.g. providing wildlife habitat) as well as provide various other ecosystem services (e.g. maintaining the water balance and stream stability, protect aquatic ecosystems, moderate climatic conditions, absorb air pollution, create recreation opportunities for people etc.). The watershed plan recognized that the target NHS can be accomplished by protecting existing natural cover as assets, securing additional lands, regenerating degraded areas and improving stewardship of public and private lands.

The target NHS in the watershed plan highlighted that the first priority is the land in the potential greenfield development areas outside the Niagara Escarpment, the Oak Ridges Moraine and Greenbelt. The second priority is the Protected Countryside areas of the Greenbelt and Oak Ridges Moraine Conservation Plan and the rural area of the Niagara Escarpment Plan. The third priority is in Natural Core and Linkage areas of the Oak Ridges Moraine Conservation Plan and natural areas of the Niagara Escarpment Plan.

At the time of analysis, the existing natural cover extended about 32% of the watershed, which included forest cover (19%) cultural meadow (11%), wetland (<2%) and coastal communities. This was a relatively high percentage in comparison with many other watersheds in the GTA, which made the Humber River watershed an important component of the regional NHS. Implementation of an expanded target NHS would result in a substantial increase in natural cover, up to 42% of the watershed. It would also improve the overall quality, distribution and connectivity of habitats to a significant degree. For example, the total area of natural cover patches ranked as "good" quality would increase by approximately 10,000 ha in the Main Humber subwatershed and 5,000 ha in the East Humber subwatershed.

Improvements in connectivity would be mainly through valleyland connections, with some improvements to tableland connections in the northern reaches of the watershed. This enhanced terrestrial system would be better able to withstand the negative influences of urbanization and would also be more resilient to impacts from invasive species and climate change. The larger habitat areas would provide more space to accommodate both wildlife and nature-based recreation opportunities.

Etobicoke and Mimico Creek Technical Update (TRCA 2011)

Historically, the NHS of the Etobicoke and Mimico Creeks watersheds has gone through several periods of change with agricultural settlement followed by urbanization. Through the 20th century these watersheds became completely urbanized apart from 20% of Etobicoke Creek, mostly in the headwaters, where agriculture prevailed. In 2011, the regional target NHS developed in 2007 was refined for Etobicoke and Mimico watersheds to reflect more up-to-date information from the newer data sets as well as local details that could not be captured at regional scales.

Producing a map illustrating the refined watershed-based NHS for the Etobicoke and Mimico Creek watersheds showing the existing, potential and refined natural cover was a gradual process that considered a number of criteria and involved several TRCA staff with particular local knowledge. The process was conducted using more recent 2005 orthophotography (as compared to 2002 for regional NHS). Given that a suite of analyses had already delineated the regional NHS in 2007, this refinement was scoped to tweaking the lines for existing and potential natural cover, rather than to recreate the entire system. Thus, the refinement process was limited to areas in and around the regional NHS that were not likely to be associated with future development plans. This focused the refinements in areas that were mostly urban open space / recreational lands, agricultural lands, hydro corridors, and golf courses. The refinement method respected the need for various land uses in these areas such as active use, agricultural use, and sensitivities associated with utility corridors. However, in areas that contributed to significant gains in ecological function, such as connectivity and / or protection of sensitive features, recommendations were made for specific management actions, if opportunities arise, that would achieve ecological gains.

In terms of methods used, the regional target NHS line was refined using the following data:

- Updated refined land use layer 2004
- ArcHydro lines based on 30 ha catchments (for selecting priority locations for new terrestrial and hydrological connections)
- Local knowledge of TRCA biologists and planning ecologists regarding opportunities that had been lost to urbanization or gained through development permitting
- Species of concern and vegetation communities of concern mapping
- Previous TRCA work refining the terrestrial NHS executed in 2004 that contributed to the Greater Toronto Airports Authority (GTAA) Living City project
- Existing management plans, such as the Heart Lake Conservation Area
- The Greenbelt Plan NHS

Refinement of the regional terrestrial NHS line resulted in the following:

- Where existing habitat was lost to urbanization, it was replaced as habitat within the targeted system as close to the site as possible while respecting the limiting land use categories
- Land was captured/added into the target system where it represented a potentially significant wildlife corridor between patches (e.g. along watercourses and hydro corridors)
- Land was captured/added into the target system where it improved the size/shape of a habitat patch
- Land was captured / added into the target system where it buffered sensitive species of concern or vegetation communities of concern, or captured existing habitat that had species of concern or vegetation communities of concern within it
- “Holes” in the target system (patches with small exclusions within them) and “slivers” (small, isolated patches of potential habitat) were filled/deleted and corrected (such holes and slivers were often the result and relic of the modelling algorithms)

The preceding process was conducted on hard-copy orthophotos; the resulting hand-drawn refinements were then passed to TRCA GIS to digitize and produce a final map. This allowed for updated watershed-based targets and priorities to be set for the Etobicoke and Mimico watersheds that informed specific management recommendations related to natural heritage objectives.

Municipal-based Refinements to the NHS

Peel-Caledon CA NHS Refinement (Excerpts from Phase I Report, 2019 – Draft) (TRCA 2019)

The Region of Peel has identified the need for a regional scale update of its Greenlands System using a watershed approach to promote sound land use planning. The update process will include scoped consultation with key stakeholders and the Region’s consultants to assist in framing a Regional Official Plan Amendment (ROPA) discussion paper. The Region requested in 2018 that CVC and TRCA integrate their NHSs for the Region to inform its upcoming ROPA, recognizing the scientific basis of the systems and the considerable investments made by the Region in their development.

The Region requested that multiple NHS systems be integrated across its remaining constituent conservation authorities namely LSRCA and NVCA. This project, termed *Regional NHS Integration Project* would consist of two phases: Phase 1 would include the integration of CA systems with local refinements for the Town of Caledon. The Town would use the mapping to inform its own Official Plan update as appropriate for its needs and context. Phase 2 would include the integration of CA systems across the remaining portion of Peel, namely Mississauga and Brampton, to create a CA NHS map product for all of Peel Region. The NHSs developed by CVC and TRCA were successfully scaled to the municipal level in the City of Mississauga and City of Brampton a few years ago. A similar systems approach was developed to merge existing watershed scale mapping within the Town of Caledon and for the Region of Peel as a whole.

CVC, as the project manager, worked collaboratively with member municipalities and CAs to produce CA NHS mapping within the Town of Caledon and an accompanying methodology report that supports the requirements of the PPS and Provincial Plans in the local context. The mapping was developed by integrating and building upon existing CA data and reflects detailed stakeholder consultation that has already occurred within the CVC, TRCA and LSRCA watersheds. The result is a cost effective, defensible, and technically sound product which provides a consistent and watershed-based approach across the Region of Peel with respect to NHS planning.

Refinement Methodology for a CA NHS in Caledon included:

1) updates to land cover
2) development of a CA NHS in Caledon
3) integration of a CA NHS in Caledon at watershed boundaries
4) incorporating the aquatic system
5) accounting for the small natural heritage feature screening areas

Natural cover mapping based on aerial photography is the base data used to map the CA NHSs. As a first step for this project, natural cover mapping in CVC, TRCA, and NVCA jurisdictions in Caledon was reviewed and updated based on Region of Peel 2017 aerial photographs. Major updates to natural cover included areas that had been urbanized, natural cover that had been removed due to an approved permitting process (e.g. aggregate pits), and areas that had undergone succession from potential natural cover or enhancement areas in older natural heritage systems to existing natural cover.

Development of a CA NHS in Caledon included refined individual CA NHSs within Caledon using a manual, vector-based digitization approach. CVC refined its watershed-based NHS boundaries by applying its existing NHS criteria to the updated land cover mapping. TRCA refined its Etobicoke terrestrial NHS and Humber terrestrial NHS, which was originally based on the regional terrestrial NHS. These watershed-based NHSs reflect further refinement that was completed earlier for watershed planning purposes. The NHS was further refined by removing areas that had been converted to and / or approved for new development and other urban infrastructure. Additionally, the SWM infrastructure was excluded from the NHS. Additional areas were added to the NHS that have undergone succession to natural cover based on updated natural cover mapping and land use information. No new potential

natural cover areas were added to the system. It should be noted that no additional modelling work and habitat patch L-ranking analysis was done to reflect the updated L-ranks of habitat patches for the refinement. LSRCA's system did not require refinement as it was recently created and consequently reflects updated land cover. NVCA did not have an existing NHS. Based on available data and resources, CVC adapted its NHS criteria to develop an NHS for the portion of NVCA within the Region of Peel; the criteria and mapping were reviewed and approved by NVCA staff.

After updates to the individual systems were complete, major roads were removed from the systems. In addition, "natural cover" and "enhancement areas" were attributed for the CA NHS in Caledon. A more detailed GIS methodology that outlines the process for updating the mapping is available upon request.

CA NHSs were reviewed at their boundaries to resolve inconsistencies, such as system overlaps at watershed boundaries. We followed and expanded upon a process used to edge-match the NHSs of five CAs for the Region of Durham (Durham Region 2012). CA boundaries within Caledon were examined at a map scale of 1:2,000 to identify any edge matching issues.

To provide an integrated aquatic and terrestrial NHS to the Region of Peel and Town of Caledon, an aquatic system was mapped. Watercourses, lakes and other waterbodies are included as part of the CA NHS for Town of Caledon presented herein. Since the TRCA NHS was originally focussed on terrestrial biodiversity, it only uses some aquatic features (e.g. general regulatory lines including water courses and valley features) as the general criteria for mapping. This was further expanded in Caledon's CA NHS, explicitly including all the aquatic features, such as mapped watercourses and water bodies. These were incorporated through the refinement process using a vector-based methodology, similar to the process used for the CA NHS for Brampton. Many watercourses and some other waterbodies were already included in TRCA's NHS given that much of the system's existing and potential natural cover falls within valley and stream corridors that contain these aquatic features. Known SWM ponds managed for water quality and/or water quantity, irrigation ponds, wastewater treatment ponds, and active aggregate pits are not considered aquatic features within the NHS. SWM ponds are considered infrastructure that maintain water quality and provide flood control functions. Nevertheless, where these features fell entirely within another feature of the CA NHS (e.g. within valleylands) they were included in the system with the recognition that they would continue to be managed as necessary.

In some instances, features exist outside the mapped NHS that may be necessary to ensure ecosystem function over the long term. Small natural heritage feature screening areas outside the CA NHS in Caledon were mapped to act as a screening tool when development applications occur, to evaluate if these features or their functions need to be maintained on the landscape. These features include small woodlands, wetlands and meadows that did not meet the criteria for inclusion in the NHS or were not captured by the NHS modelling.

TRCA Update to the Regional Terrestrial NHS (in progress; expected completion 2020)

The overarching goal of this current project is to update the technical components and maps of the TRCA TNHSS (TRCA 2007) to build an integrated NHS. The integrated NHS will incorporate municipal NHS priorities in the OPs and include most up-to-date information on current and future needs of terrestrial and aquatic biodiversity, habitat, and ecosystems. Hydrological linkages between these integrated systems in the face of continued urbanization and climate change will be included.

Terrestrial and aquatic integration is a current gap in our science and planning tools, which needs to be addressed to support robust and timely decision-making accounts for the uncertainties associated with future land use and climate changes. The series of technical outputs delivered by this project in future phases will be timely and will inform responsible growth planning while achieving TRCA's stated objectives for biodiversity, habitat, and ecosystems for a sustainable and resilient Toronto region.

The seven specific objectives of this update to the NHS project are as follows. Each of these objectives will deliver distinct output(s) that will inform various TRCA and municipal partner initiatives that are planned or underway.

1) Incorporate partner municipalities' NHSs into the TRCA updated NHS as appropriate
2) Incorporate existing climate change vulnerabilities of terrestrial and aquatic systems into the TRCA updated NHS
3) Incorporate terrestrial biodiversity, habitat, and connectivity needs under current and future urbanization and climate change scenarios into the TRCA updated NHS
4) Incorporate aquatic biodiversity, habitat, and connectivity needs under current and future urbanization and climate scenarios into the TRCA updated NHS
5) Incorporate critical hydrological linkages between aquatic and terrestrial systems under current and future urbanization and climate change scenarios into the TRCA updated NHS
6) Complete a rapid assessment of other ecosystem services as co-benefits provided by current and future landscape under different urbanization and climate change scenarios and by the TRCA updated NHS
7) Develop the TRCA updated NHS and interactive mapping tool at the regional scale with management directions for implementation

The updated TRCA NHS will continue to build on the systems thinking and the guiding principles of the TNHSS (TRCA 2007).

A series of outputs and tools will be generated at every phase of the project in a timely manner. In addition to forming the foundation of the TRCA's updated NHS, these outputs and tools will be the stand-alone products that can be applied proactively at regional and local scales to support municipal growth planning decisions. They will also inform TRCA's watershed planning, land use development, Environmental Assessment planning, and restoration processes. Overall, the updated TRCA NHS will facilitate implementation of TRCA and its partner municipalities NHSs across the Toronto region for resilient biodiversity, habitat, and ecosystems. This will ensure continued provision of various ecosystem services in the face of changing climate and continued urbanization.

Fisheries Management Plans

Humber River Fisheries Management Plan (MNR & TRCA 2005)

The *Humber River Fisheries Management Plan* is a cooperative resource management plan developed by the MNR and TRCA (TRCA & MNR 2005). The plan provides direction on three Remedial Action Plan (RAP) goals and actions:

- Goal 2a) a self-sustaining fishery
- Goal 2b) rehabilitation of fish and wildlife habitat
- Action 21) protect and restore fish and wildlife habitat

Implementation of RAP recommendations, in conjunction with the recommendations of watershed-based rehabilitation plans, will eventually lead to the delisting of watersheds within the Toronto and Region Area of Concern. Development of the fisheries management plan was guided by a steering committee made up of representatives from government agencies, NGOs, the public, and comments from two rounds of public meetings.

Etobicoke Creek: The Aquatic Ecosystem (TRCA 2006a)

The *Etobicoke Creek: The Aquatic Ecosystem* (TRCA 2006a) report was prepared specifically for the GTAA Etobicoke Creek Living City Project. Although not an official "fisheries management plan", the plan was developed to be consistent with MNR's *Watershed-Based Fisheries Management Plan Guideline* (MNR 2005). The draft plan was developed to protect and enhance the aquatic ecosystem within the watershed and serve as a guide for land use planners, consultants, farmers, private landowners, land developers, anglers, and nature enthusiasts. The plan features the most updated and comprehensive collection of current and historical information relevant to the aquatic ecosystem, as well as resource protection and restoration recommendations meant to provide direction for future fisheries management. The plan is a companion document to the *Greening Our Watersheds: Revitalization Strategies for Etobicoke and Mimico Creeks* (TRCA 2002) and uses seven general principles to guide management directions:

1) The natural cycle of water is one of, if not the main driving force affecting the aquatic community. Where possible, the natural variability of flows should be maintained or where impacted, restored to the historical flows.
2) A continuous band of woody and herbaceous vegetation in the riparian zone and its associated functions should be protected and/or restored.
3) All barriers to the passage of desirable species should be mitigated. If necessary, a sea lamprey barrier is an option to protect native communities.
4) The preferred mitigation technique for online ponds is removal. If removal is not an option, bypass or conversion to bottom draw are the preferred alternatives.
5) The protection and enhancement of native fish communities are of highest importance.
6) Where exotic species are present and desirable, they should be managed for but not at the expense of native aquatic communities.

7) Self-sustainability, not stocking is the priority. Aquatic habitat should be present, accessible and healthy enough to support a self-sustaining population of an appropriate species.

DRAFT Mimico Creek Fisheries Management Plan (TRCA 2004)

The draft *Mimico Creek Fisheries Management Plan* (TRCA 2004) is available for information only. Due to changes at the provincial level, the plan was not approved by MNR before the fisheries management program was changed. The document provides current (at-the-time) and historical information relevant to the aquatic ecosystem, as well as resource protection and restoration recommendations meant to provide direction for future fisheries management.

The draft plan was based on the following objectives:

1) Protect and enhance the biological integrity of the aquatic ecosystem
2) Describe the existing conditions of the fish community to establish a benchmark of ecosystem health
3) Provide a framework for fisheries management at subwatershed, reach and site scales
4) Promote the sustainable utilization of fisheries resources
5) Achieve “no net loss” of fisheries habitat
6) Rehabilitate degraded fish communities and fish habitat, for self-sustaining, native stocks
7) Develop a greater knowledge of fish populations, fish habitat and aquatic ecosystems
8) Promote public awareness, appreciation and understanding of fisheries resources and the aquatic habitats on which they depend
9) Involve organized angling associations, environmental interest groups and the general public in fisheries management activities

Restoration Strategies

Integrated Restoration Prioritization: A Multiple Benefit Approach to Restoration Planning (TRCA 2016b)

The Integrated Restoration Prioritization framework addresses two objectives of the Living City Strategic Plan by ensuring that restoration activities will have multiple benefits to rivers, shorelines and biodiversity. This framework will help select priority restoration areas. The objectives of this framework include:

1) Restore natural hydrologic processes and associated ecological systems by reversing, repairing or mitigating alterations and impairments (e.g. drained headwater features, poor water quality)
2) Restore and / or increase natural cover (e.g. wetland, riparian, forest and meadow)
3) Maximize size, shape and connectivity of natural heritage features
4) Enhance landforms and restore soil and soil processes to promote self-sustaining natural communities

F.3 Lake Simcoe Conservation Authority

Natural Heritage System and Restoration Strategy for the Lake Simcoe watershed (LSRCA 2018)

The LSRCA has developed a Natural Heritage System and Restoration Strategy (LSRCA 2018) for the Lake Simcoe watershed. The development and implementation of the Strategy was identified as a priority action to achieve Goal One of the LSRCA Strategic Plan (LSRCA 2016): to support a safer, healthier and more livable watershed through exceptional integrated watershed management. This NHS is an update to the previous LSRCA Natural Heritage System for the Lake Simcoe Watershed, Phase 1 (Beacon Environmental & LSRCA, 2007).

This NHS was developed with a three-step approach:

1) Minimum policy standards
2) Enhanced ecological system
3) Systems-based approach

This approach supports an NHS that includes a combination of landscape and species spatial analysis incorporating both planning and science rationale to be defensible, flexible, measurable and repeatable. The development of the NHS reinforces the understanding that individual areas and features have strong ecological ties to each other that contribute to the overall landscape. A GIS approach defined and categorized the NHS into core features, targeted areas that enhance the NHS, and buffers.

F.4 Conservation Halton

Conservation Halton and NVCA do not have CA specific NHS systems. Rather, CA staff work with partner municipalities to develop natural heritage strategies for inclusion in their Official Plans. CVC did NHS mapping for the NVCA portion of Peel Region.

NVCA does have a *Fisheries Habitat Management Plan* that includes the small portion of the Innisfil Creek subwatershed that extends into Peel Region (NVCA and DFO 2009).

G. Flood Hazard and Water Quantity Studies

Natural hazards, such as flooding hazards and erosion hazards, affect all regions of Ontario. Conservation authorities, where they exist, are responsible for delineating natural hazards and allowances as per regulations approved under the *Conservation Authorities Act*.

G.1 Credit Valley Conservation Authority

Conservation Halton and NVCA do not have CA specific NHS systems. Rather, CA staff work with partner municipalities to develop natural heritage strategies for inclusion in their Official Plans. CVC did NHS mapping for the NVCA portion of Peel Region.

Credit River Flow Management Study (CVC 2007)

This study represents one component of the *Credit River Water Management Strategy Update* (the Strategy Update) with the purpose to assess conventional SWM for flood protection and determine the fairest and most cost-effective means into the future. The methodology updates the Credit River Flood Damage Reduction Study (1984) for identified flood damage centres.

The HSP-F model was used to assess the implications of land use scenarios on flooding and focused on the main river and contributions from subwatersheds. Impact assessment of land use scenarios were consistent with the Strategy Update and considered SWM control for the lower river and supplemental flood control storage along the main river to complement local SWM. Peak flow rates are predicted to increase under future development scenarios, particularly in the lower river and below Orangeville.

The same protection and restoration of natural features and functions and lot-level BMPs recommended by the Strategy Update are endorsed. In addition, retrofits to 15% of the subwatershed are recommended to reduce peak flows at flood damage centres on the lower river and to maintain 2001 peak-flow levels in Orangeville. Targets are set by subwatershed along the main river and future subwatershed studies will verify flood control requirements at the site scale. Climate change impacts based on emerging research will also be assessed.

Implementation requires revision of development standards and bylaws for lot-level controls and to promote LID principles and BMPs (e.g., pervious pipes, slopes <1% for drainage swales and infiltration trenches, depressed curbs, smaller pavement widths, biofilters, green roofs, pervious pavement, and enforce downspout disconnections).

It is still expected that new watershed and subwatershed studies, including climate change assessments, will confirm SWM needs. In the interim, it should be recognized that there has been low uptake of BMPs with no indication of reaching a 15% retrofit, although there has been some progress on development standards and bylaws. Land use scenarios will have to consider land uses other than urban uses, and other stressors, as well as any net progress of natural heritage restoration efforts.

G.2 Toronto and Region Conservation Authority

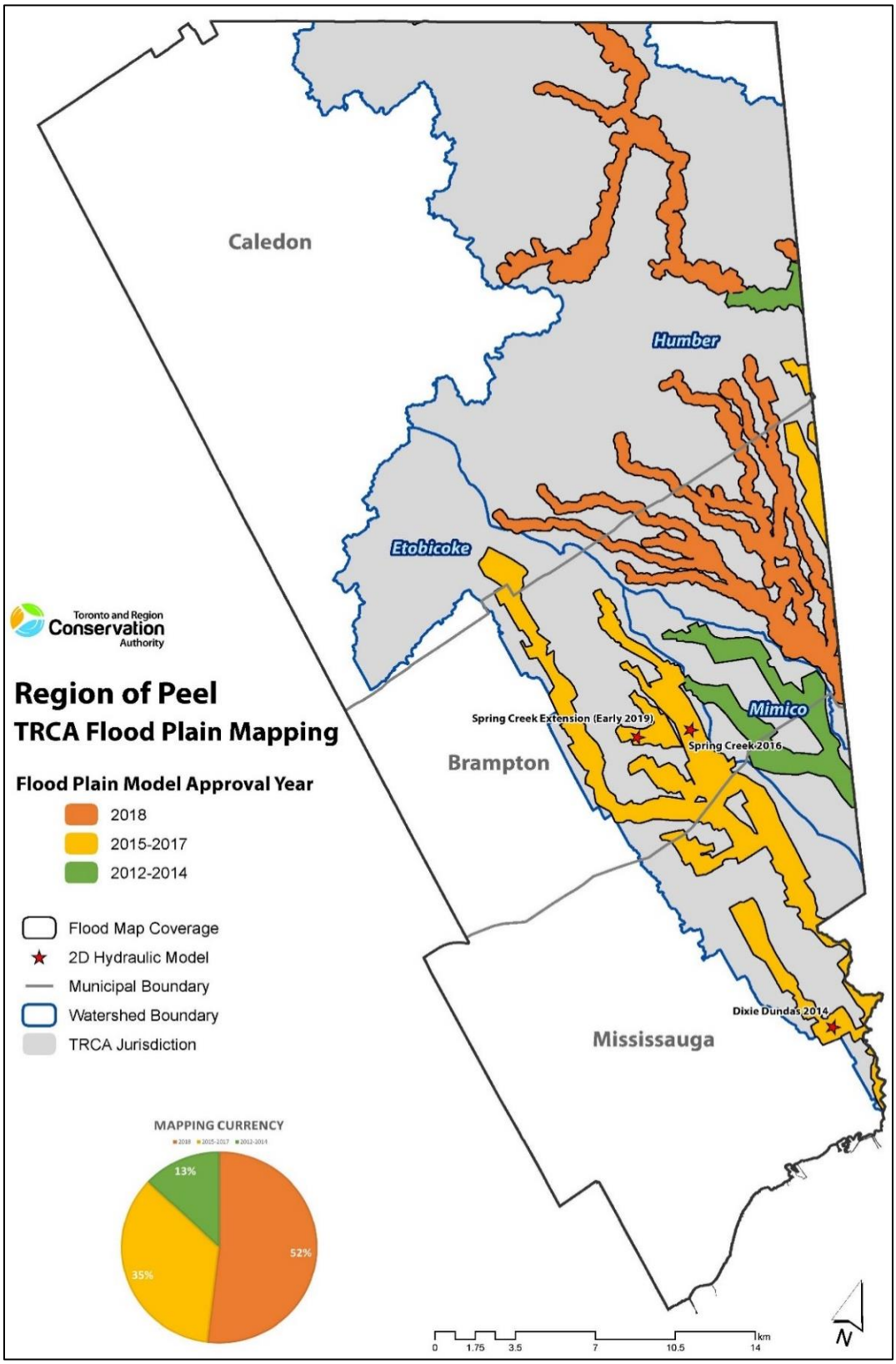
This section of the report summarizes TRCA hydrology in Peel Region as it pertains to water quantity and flood hazards, including summarizing hydrologic model outputs, hydraulic models, SWM strategies to control peak flows of design, flood hazards, and water balance.

Floodplain Mapping

Floodplain management is a fundamental objective of TRCA. This objective is achieved through policies that limit development within the floodplain. Knowing the extent of the floodplain is an important tool for land use planning and emergency management. This knowledge helps guide sensitive land uses away from high-risk areas, and, for areas where historical development has already occurred, helps to identify ways to mitigate flood risk. The aim is to better protect people and property and improve the resilience of our urban areas. There are approximately 1,900 flood vulnerable buildings located in the flood plains within TRCA's jurisdiction in Peel Region. These flood vulnerable buildings exist either because they pre-date flood plain management planning policies and regulations, or because they were permitted under special policy and planning provisions.

The regulatory flood plain is the approved standard used in a watershed to define the limit of the flood plain for regulatory purposes. The extent and age of the available regulatory flood plain in the Region of Peel is shown on Figure G.1. The framework for flood plain management is set through the PPS and associated technical guidelines.

Figure G.1: Floodplain Mapping for the Region of Peel



Humber Hydrology Study

TRCA completed the *Humber River Hydrology Update* (Civica 2015) using the Visual Otthymo model for the Humber River watershed. Prior to 2015, the hydrologic model for the Humber River watershed was previously updated in 2002. Since the 2002 update, a significant amount of change had occurred within the watershed, including Official Plan updates by municipalities within the watershed showing key new development areas in Brampton, Vaughan, and Caledon. In addition, new hydrologic information has been collected that has been incorporated into the model, including additional flow and rainfall data throughout the watershed. As such, the hydrology model has been updated to reflect the proposed land use changes and improved information.

The *Humber River Hydrology Update* (the Update) provides insight into the impacts of future development on the watershed. The modelling update identified the potential impacts of the full development plans for Brampton, Caledon, and Mississauga on peak flows within the watershed.

Facilitating the creation of new watershed-scale hydrologic models, the Update examined and compared existing and future land use conditions. The existing land use condition models were locally calibrated at eight stream gauges using data from five historical storm events. Historical rainfall data from seventeen rain gauges were used to spatially distribute the rainfall over the watershed for the calibration storm events. The calibration was validated using data from five different historical storm events using historical flow data at the eight stream gauge locations, and spatially distributed historical rainfall data from twelve rain gauges. The final hydrologic models generate runoff hydrographs and peak flow rates for 2-year through 100-year design storms and the Regional Storm event for both existing land use conditions and future land use conditions.

Peak flows generated by the future condition land use model predominantly show decreases for the 2-year through 100-year storms at selected nodes within Peel Region. This is a result of a successful quantity control release rate strategy for these storm events that was developed as a part of the previous hydrology update. TRCA implements this strategy through review and permitting requirements for SWM measures that are designed to service new areas of development. Figure G.2 shows the current quantity control release rate requirements for the Humber River watershed.

The peak flows generated by the future condition land use model show that the Regional Storm peak flows will remain largely unchanged in the Upper Humber. However, significant increases are anticipated for Clarkway and the Gore Road Tributaries in the West Humber, as well as the small tributary of Rainbow Creek that flows to York Region. These anticipated changes highlight the need for SWM controls in excess of the 100-year storm.

The hydrology model was updated in 2015 and did not include any possible urban expansion areas outside of current Official Plans (Brampton 2015, Caledon 2016, Mississauga 2017). A new SWM control strategy for Humber River watershed is being established in 2019. This process will show the results of the increase in the regional flows and establishes the control criteria. This information should be incorporated into the Municipal Comprehensive Review watershed planning process.

In order to reduce the risk of flooding impacts during a Regional Storm event, TRCA is in the process of completing further modelling to develop SWM targets for the Regional Storm, which will be available mid-2019. Moving forward, TRCA will use these targets to work with our municipal partners and the development industry on developing solutions using a risk-based approach that could include a number of options, including but not limited to:

- Control post-development peak flows to pre-development levels for all storms up to and including the 100-year storm (i.e. 2, 5, 10, 25, 50, and 100-year storms) except for the main branches of the Lower, Main, East, Upper and West Humber where no quantity control is required.
- Unit flow relationships have been established and should be used for all other sites located in the Humber River watershed not discharging to the main channels.
- Development outside of the approved 2015 urban boundary when the hydrology study was finalized may require Regional Storm protection, proponents should consult with TRCA staff to confirm, and this information should be assessed as part of watershed planning work.

It should be noted that the reduction in peak flow rates and risk reduction associated with Regional Storm controls will not be used in assessing the Regulatory floodlines in the Humber River watershed as mandated by MNRF.

Figure G.2: Quantity Control Release Rates for the Humber River Watershed

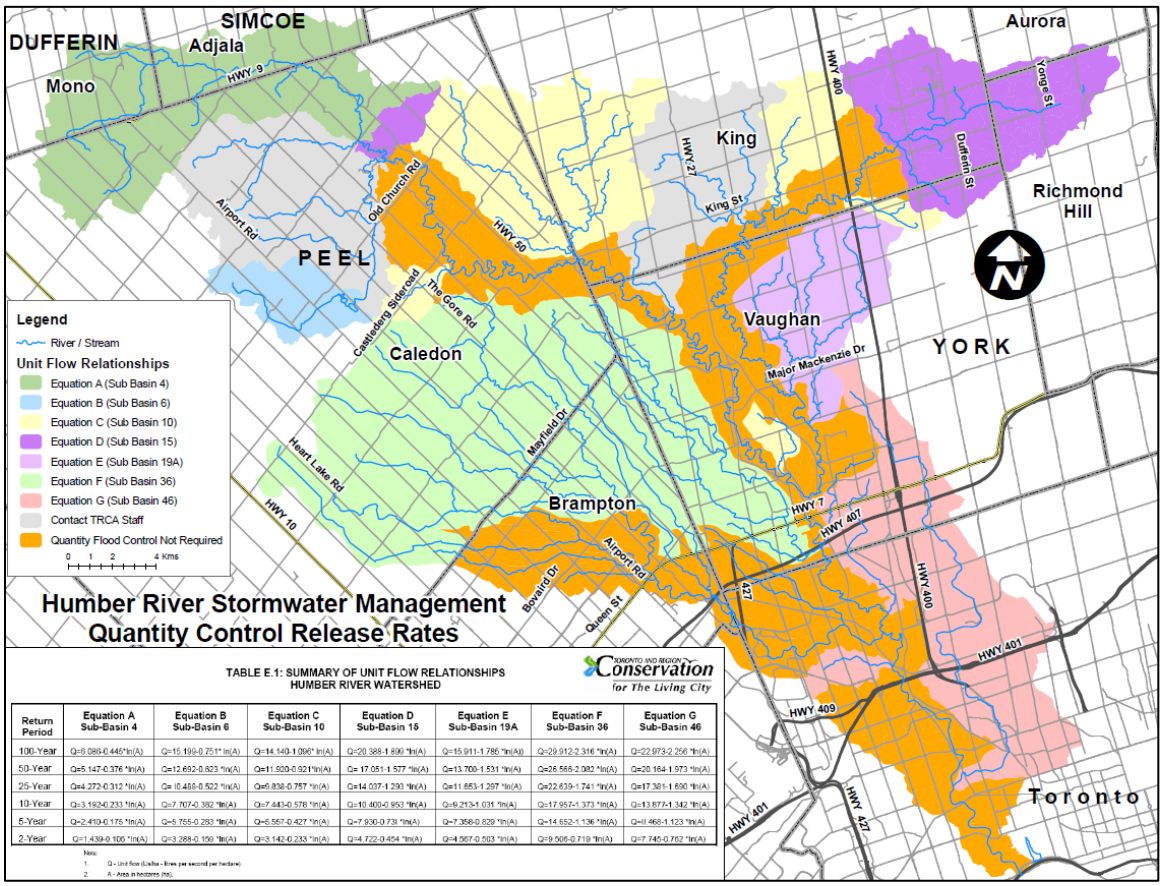


TABLE E.1: SUMMARY OF UNIT FLOW RELATIONSHIPS
HUMBER RIVER WATERSHED

Return Period	Equation A Sub-Basin 4	Equation B Sub-Basin 6	Equation C Sub-Basin 10	Equation D Sub-Basin 15	Equation E Sub-Basin 19A	Equation F Sub-Basin 36	Equation G Sub-Basin 46
100-Year	Q=6.086-0.446*ln(A)	Q=15.199-0.751* ln(A)	Q=14.140-1.096* ln(A)	Q=20.388-1.896 *ln(A)	Q=15.911-1.786 *ln(A))	Q=29.912-2.316 *ln(A)	Q=22.973-2.256 *ln(A)
50-Year	Q=5.147-0.376 *ln(A)	Q=12.692-0.623 *ln(A)	Q=11.929-0.921*ln(A)	Q= 17.051-1.577 *ln(A)	Q=13.709-1.531 *ln(A)	Q=26.566-2.082 *ln(A)	Q=20.164-1.973 *ln(A)
25-Year	Q=4.272-0.312 *ln(A)	Q= 10.468-0.522 *ln(A)	Q=9.838-0.757 *ln(A)	Q=14.037-1.290 *ln(A)	Q=11.683-1.297 *ln(A)	Q=22.639-1.741 *ln(A)	Q=17.381-1.690 *ln(A)
10-Year	Q=3.192-0.233 *ln(A)	Q=7.707-0.382 *ln(A)	Q=7.443-0.576 *ln(A)	Q=10.400-0.953 *ln(A)	Q=9.213-1.031 *ln(A)	Q=17.957-1.373 *ln(A)	Q=13.877-1.342 *ln(A)
5-Year	Q=2.410-0.175 *ln(A)	Q=5.755-0.283 *ln(A)	Q=5.557-0.427 *ln(A)	Q=7.930-0.731 *ln(A)	Q=7.358-0.829 *ln(A)	Q=14.652-1.136 *ln(A)	Q=11.468-1.123 *ln(A)
2-Year	Q=1.439-0.105 *ln(A)	Q=3.388-0.159 *ln(A)	Q=3.142-0.233 *ln(A)	Q=4.722-0.454 *ln(A)	Q=4.567-0.563 *ln(A)	Q=9.506-0.719 *ln(A)	Q=7.745-0.762 *ln(A)

Note:
1. Q - Unit flow (L/s/ha - litres per second per hectare)
2. A - Area in hectares (ha).

Etobicoke Creek Hydrology Study

The *Etobicoke Creek Hydrology Study* (MMM Group Limited 2013) involved updating the hydrologic models for the Etobicoke Creek watershed and developing SWM quantity control criteria for the subject watershed. Similar to the Humber River watershed, the results of the updated Etobicoke watershed hydrology model will be used to update floodline mapping and flood remedial plans. In addition, flood control criteria have been developed that are important in achieving TRCA's goal of mitigating and reducing the risk to life and property caused by flooding.

For hydrological study purposes, the future conditions model was revised to reflect two additional development conditions:

- *Ultimate Development Conditions*: Areas beyond OP boundary within the headwaters were developed, while environmental protection area and Greenbelt area remained in their existing condition.

- *Full Development Conditions*: This is a hypothetical scenario where entire areas within the headwaters were developed, including environmental protection area and Greenbelt areas. Furthermore, all watercourses within headwaters were removed (e.g. there are no channel routing commands within headwaters in the VO2 model).

The study shows that the majority of the modelled flow node locations show consistently higher values for build out scenarios compared to existing conditions. This is not unexpected; as urban expansion and impervious cover tends to increase peak flows within the respective subwatersheds. This suggests that SWM controls are required in order to effectively control the impacts of development on peak flow rates up to and including the 100-year storm events. As part of this study, flood control criteria were developed and applied to the model to reduce the impacts of proposed development. There are significant increases in peak flows resulting from ultimate and full development conditions at upstream flow node locations. However, the effect of impacts reduces gradually in downstream portions of the watershed. Detailed information about the modelled flow rates can be found in the report.

Stormwater Watershed Quantity Control Strategy for the Etobicoke Creek Watershed

As part of the 2013 *Etobicoke Creek Hydrology Update*, TRCA developed the SWM criteria for 2- to 100-year design storm and Regional Storm for the entire watershed to protect downstream properties from flood increases due to upstream development. The recommendations from the study will provide guidance to local, regional and provincial government agencies and the private sector in managing and planning existing and future developments. The following sections discuss the established quantity control strategy for the Etobicoke Creek watershed for the 2- to 100- year design storms and Regional Storm.

Quantity control target for 2 to 100-year design storms

Developments are required to be controlled so that there are no increases of peak flows from existing levels for Etobicoke Creek watercourses for 1:2 to 1: 100-year design storm events.

The following three development scenarios were considered to assess their impacts on the peak flows at different flow nodes within the Etobicoke Creek watershed:

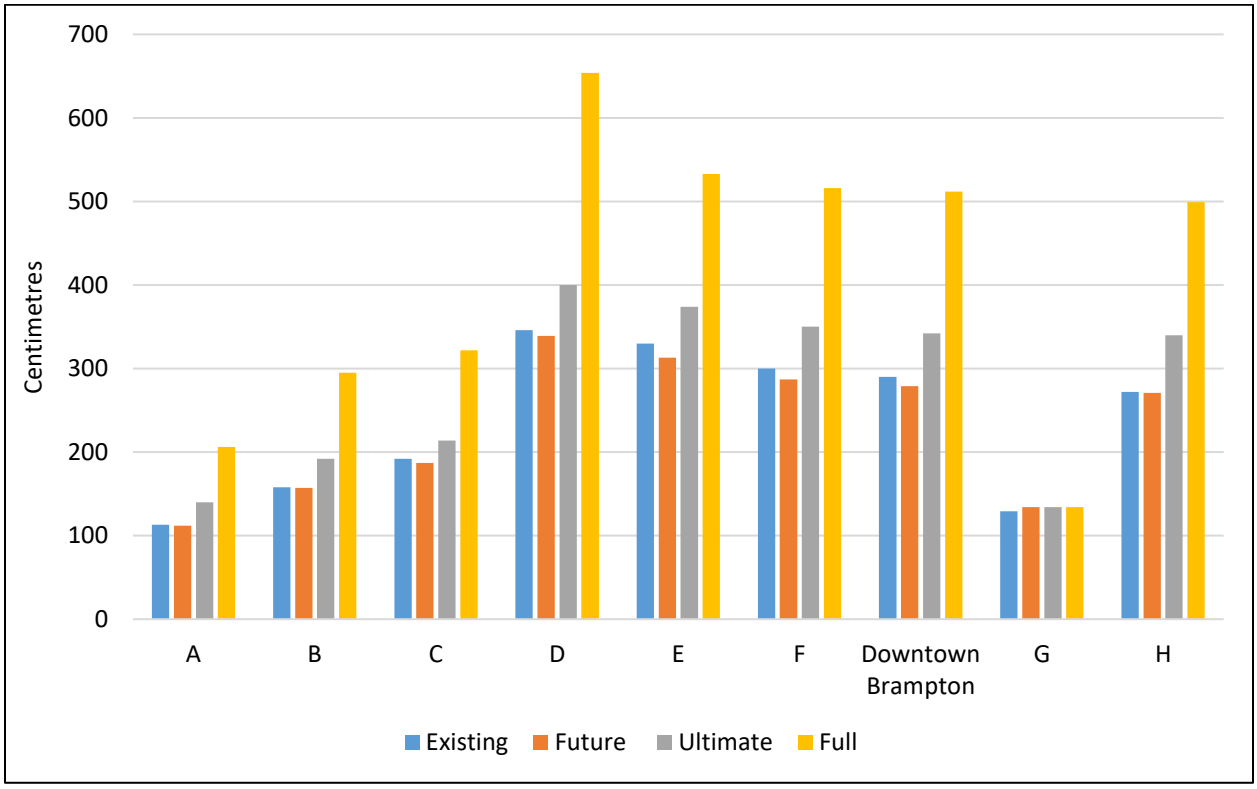
- Future Development condition - approved Official Plans from each municipality that is located within the Etobicoke Creek watershed.
- Ultimate Development Conditions (assumed average imperviousness of 62%)– Areas beyond Official Plan boundary within the headwaters are developed, while environmental protection area and Greenbelt area remain in their existing condition.
- Full Development Conditions (assumed average imperviousness of 62%)– This is a hypothetical scenario where entire areas within headwaters are developed, including environmental protection areas and Greenbelt areas. Furthermore, all watercourses within headwaters are removed (e.g. there are no channel routing commands within headwaters in the hydrology model).

Required Additional Storages for Regional Controls

Historically, quantity control measures focused on storms from 2 to 100-year return period event as impacts from land use changes on Regional (Hurricane Hazel) flows were considered minor. However, recent studies (including TRCA's Watershed Plans and Hydrology updates) have demonstrated that upstream urbanization has the potential to increase flood risk in downstream areas for the Regional Storm.

Hurricane Hazel is a 48-hour duration historical storm. The hydrology update identified that the final 12-hours of Hurricane Hazel should be utilized as Regional Storm for Etobicoke Creek watershed. The saturated antecedent moisture condition (AMC III Saturated soil conditions for model purposes) is required to be applied for the catchment to simulate the wet soil conditions resulting from the first 36-hours of Hurricane Hazel. As such, when determining the required detention storage for regional controls, it is necessary to provide additional storage to accommodate the first 36- hours of Hurricane Hazel. The hydrology update analyzed two hypothetical distributions of the first 36-hour Hurricane Hazel historical storm (constant intensities and increased intensities, both with a total depth of 73 mm) in the existing model to determine the storage volumes used by the existing SWM ponds within the Etobicoke Creek watershed. The results indicated that a unit storage volume of 214 m^3/ha will be required as additional storages for Regional controls. Such storages should be added to the calculated storage volumes to control the post- development peak flows to the identified Unit Flow Rates for the Regional Storm.

Figure G.3: Regional Peak Flows Within the Headwaters of Etobicoke Creek Watershed Under Different Scenarios



Additional Measures in Reduction of Flood Risk

In order to reduce the risk of flooding impacts during a Regional Storm event, TRCA will work with our municipal partners and the development industry on developing solutions using a risk-based approach that could include a number of options, including but not limited to:

- apply the targets developed in storage facilities;
- further investigate downstream impacts to determine appropriate SWM measures; and
- investigate off-site remedial works to mitigate flood risk, such as crossing infrastructure improvements.

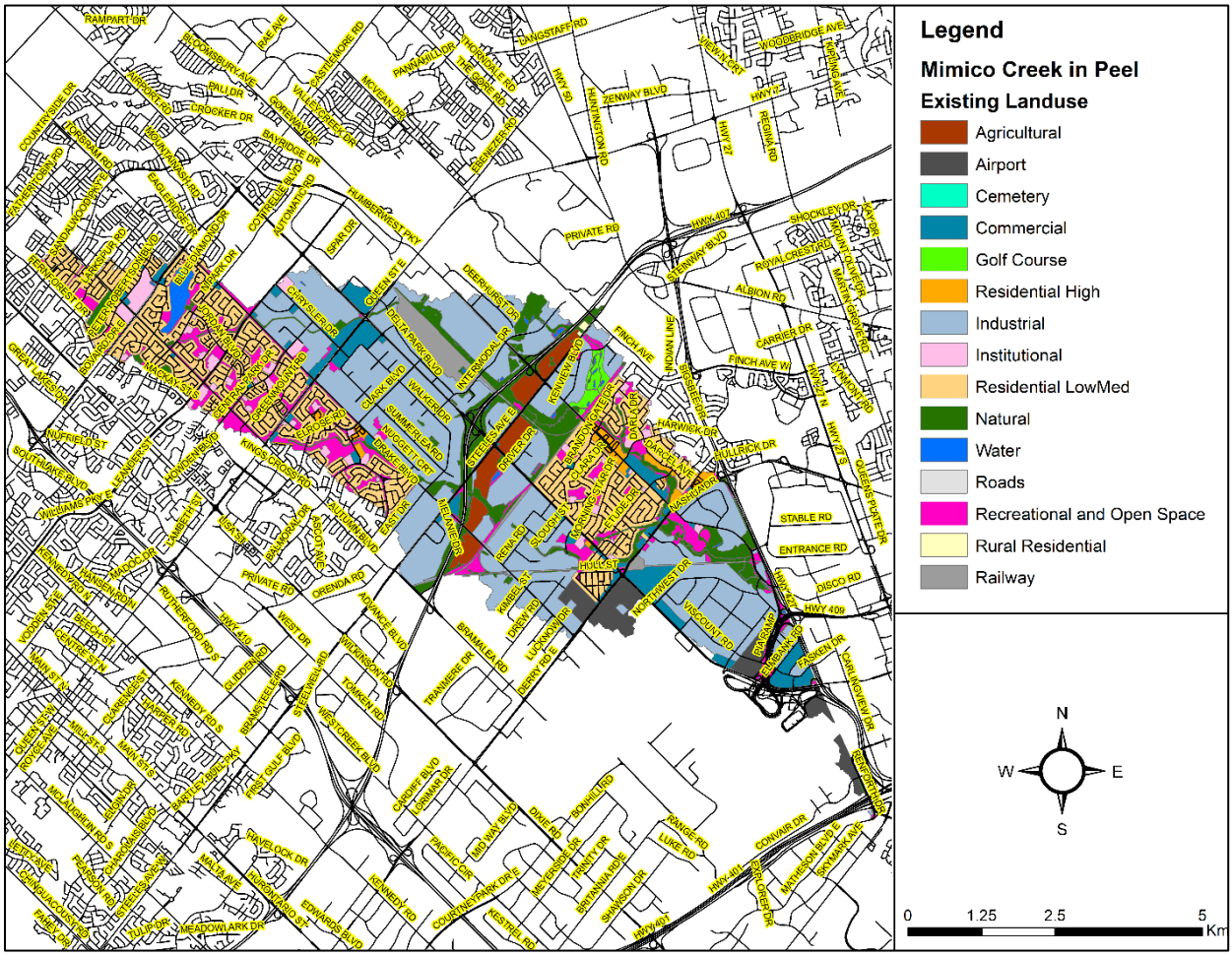
Stormwater Watershed Quantity Control Strategy for the Etobicoke Creek Watershed

The *Mimico Hydrology Study* was last updated in 2009 (MMM Group Limited 2009). The model is currently in the process of being updated due to extensive development in the Mimico Creek watershed, new data, and improvements to modelling technology.

The Mimico Creek watershed is a completely urbanized watershed within TRCA's jurisdiction, with over 30% of its landmass featuring industrial land uses and over 60% of its reaches artificially channelized. As a watershed shaped so extensively by human intervention, its management requires close attention to

the protection, enhancement, and expansion of its remaining natural systems and the improvement of its water quality by improving and limiting urban storm water runoff.

Figure G.4: Mimico Creek Watershed Existing Land Use (December 2009)



The Regional Storm simulations were performed without any of the stormwater quantity controls implemented in the watershed, since TRCA and MNRF policy does not account for storage not specifically designed to control Regional Storm flows.

TRCA Stormwater Quantity (Flood) Control Criteria: Control post-development peak flows to pre-development levels for all storms up to and including the 100-year storm (i.e. 2, 5, 10, 25, 50, and 100-year storms).

Flood Risk in Peel Region

With funding from the federal government, and in conjunction with the Province of Ontario, TRCA has mapped large portions of the flood hazard area. This has enabled TRCA to take a lead role in flood control and water management by using the most recent information available and considering the impacts of climate change on human activities in the urban environment. The development of flood risk maps will continue to evolve in 2019 by implementing flood risk zone maps and identifying emergency evacuation routes.

An original database of TRCA's Flood Vulnerable Areas was created in the early 2000s that took stock of all the buildings and roads located within the regulatory floodplain. This database has recently been updated, expanding it to include 2-dimensional updates, such as inundation areas mapped to return-period storm events.

TRCA recently assessed flood risk in the Region of Peel by utilizing the flood hazard information from the hydrology and hydraulic modelling summarized for seven different return period storm events (2 - 350 year and Regional) at all the historic flood vulnerable areas in the region. The purpose of the assessment was to combine current riverine flood hazard information and flood exposure information to calculate flood vulnerability and quantify flood risk at both the individual structure level and at a flood vulnerable cluster level. Flood exposure information includes flood depth and velocity at each building and road subject to flooding for each of the seven return-period storms relative to the first-floor elevation of the building.

Flood vulnerability is divided into four categories:

1) Building related tangible damages, which include structure and content damage, loss of revenue due to business interruption, and cost of residential displacement, each of which are calculated using depth-damage curves.
2) Social Vulnerability, which takes into consideration the affected population, and indexes the population based on five demographic factors that are known to increase flood vulnerability.
3) Community Impacts, which takes into consideration institutional buildings which provide critical community functions, such as emergency services, schools, cultural and religious buildings, community associations, and indoor recreation facilities.
4) Disruption to infrastructure, which focuses on overall depth of flooding on roadways, and well as number of impassible road segments, both weighted by road class.

The variables that were used to assess vulnerability for each of the four categories were quantified for each return-period storm event. Vulnerability-probability curves were plotted for the variables, and the area under the curve yielded the average-annual damage / vulnerability for each variable. The information produced provides improved estimation of functional flood risk at a granular level, which is important for risk mitigation and remediation planning, and for emergency and disaster response planning. The data produced provides valuable data for further analysis to allow remediation and mitigation efforts to be focused where maximal benefits will be realized, by providing the baseline for

damage avoidance estimates that can quantify the benefits for cost-benefit analysis of mitigation projects.

There are seven flood vulnerable clusters within the Region of Peel as shown on Figure G.5.

For each of the seven high-risk flood vulnerable clusters within TRCA's portion of the Region of Peel, TRCA has developed maps, which display the flood extents for storms of various return-periods. These maps are shown on Figure G.6 through Figure G.12.

Figure G.5: Flood Vulnerable Clusters located in the Region of Peel

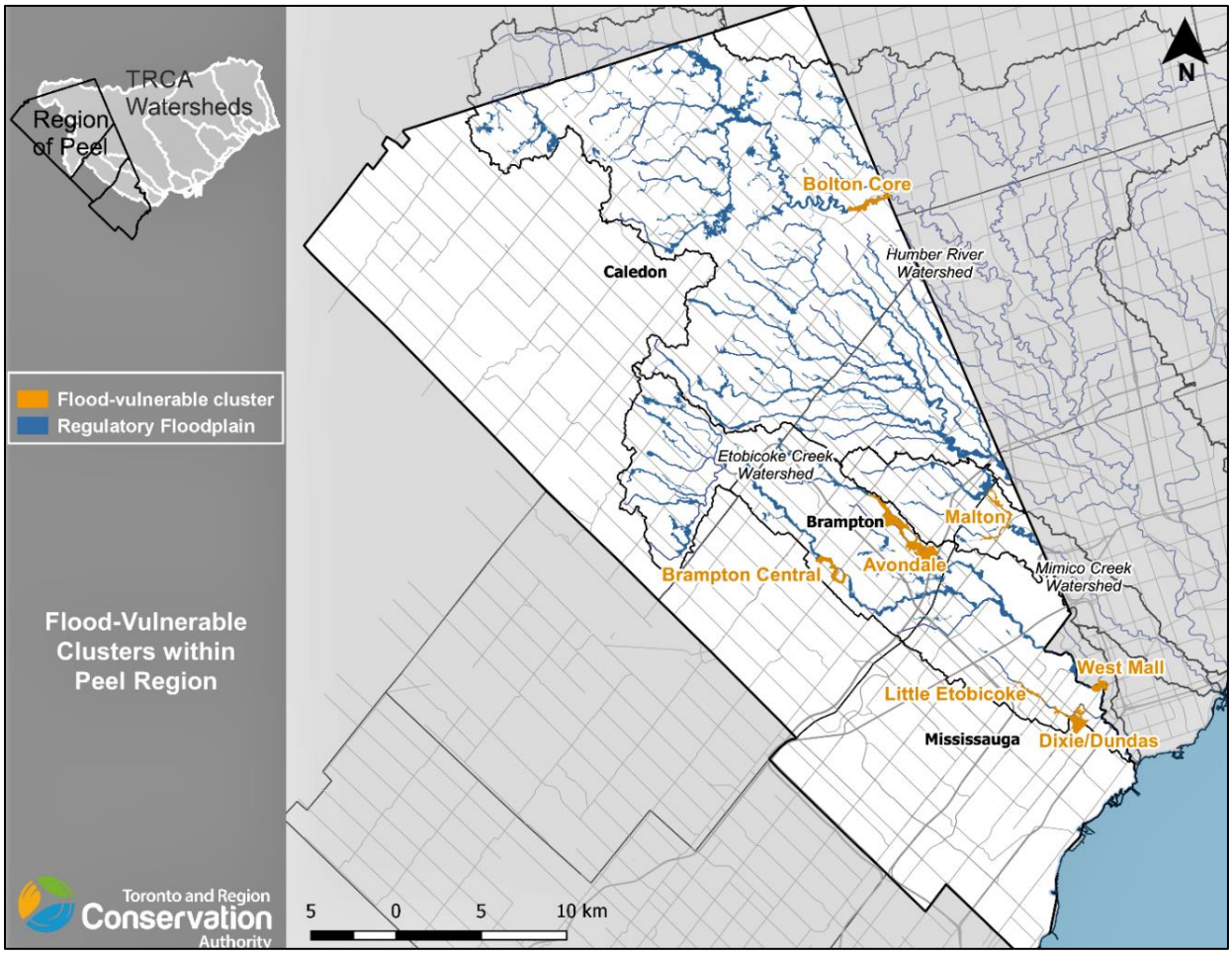
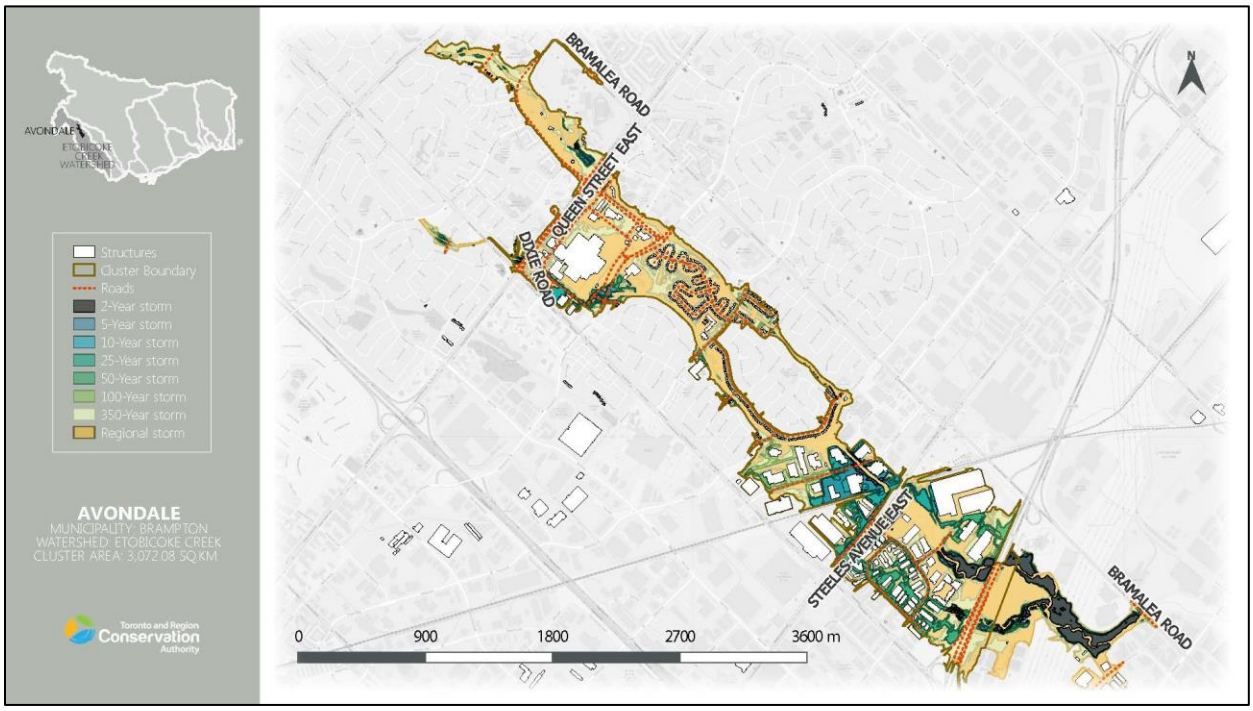


Figure G.6: Flood Extent Map for the Avondale/Spring Creek Area*



*6th most flood vulnerable area within TRCA's jurisdiction

Figure G.7: Flood Extent Map for the Brampton Central Area

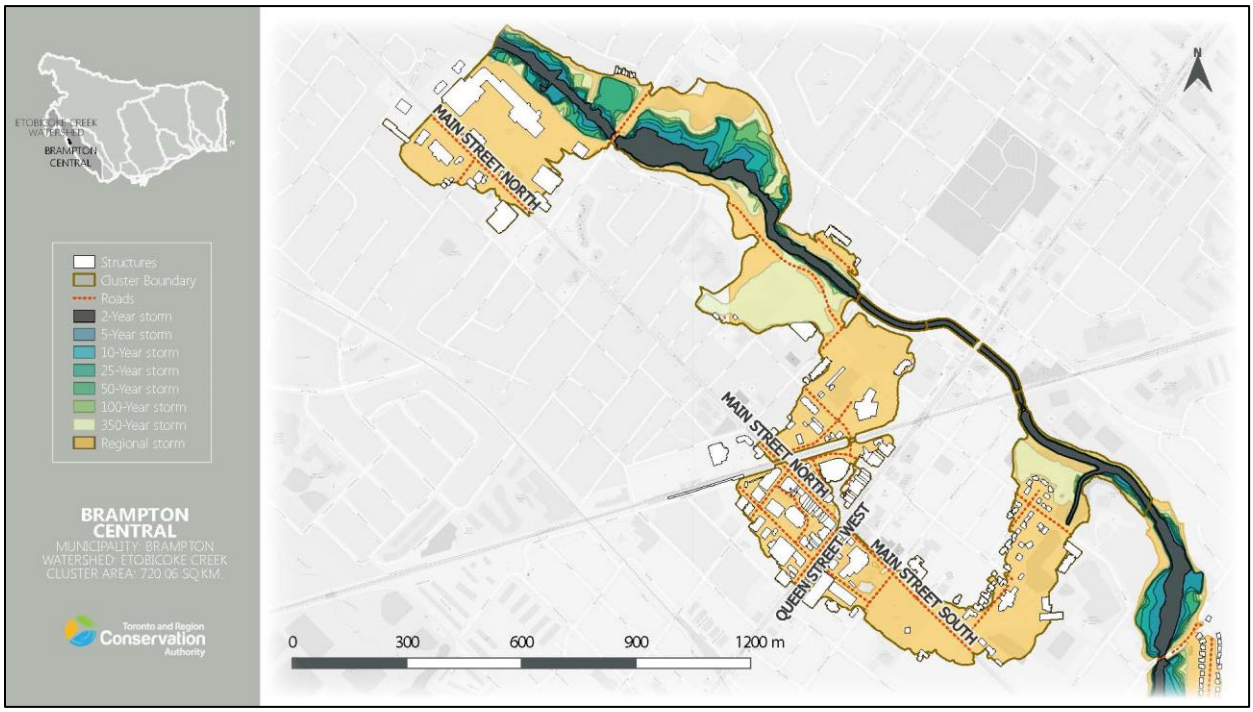
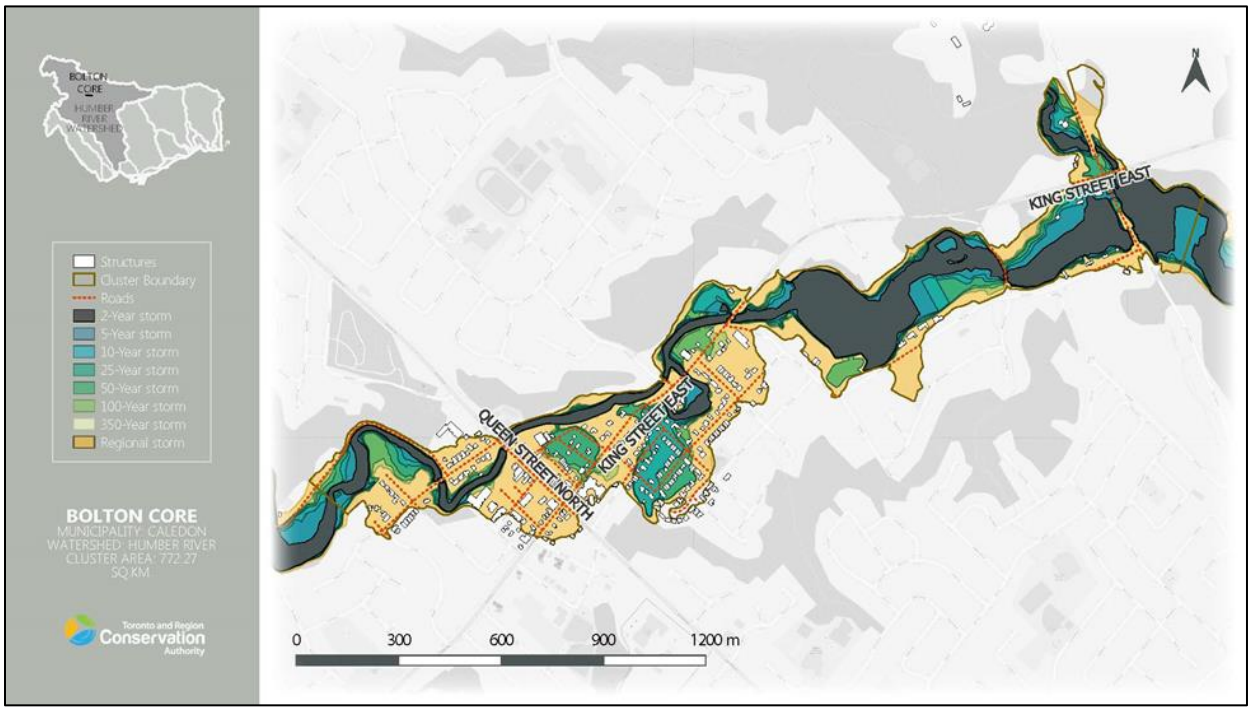


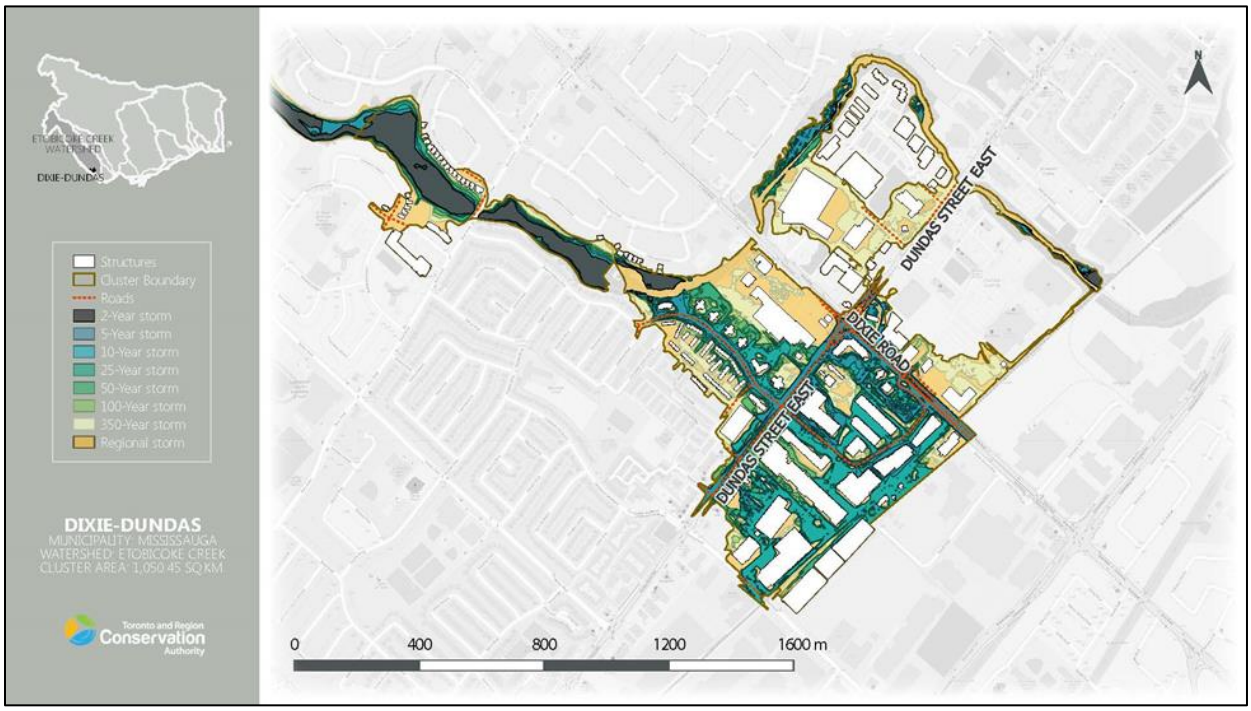
Figure G.8: Flood Extent Map for the Bolton Core Area*



*5th most flood vulnerable area within TRCA's jurisdiction

Figure G.9: Flood Extent Map for the Little Etobicoke Area

Figure G.10: Flood Extent Map for the Dixie-Dundas Area*



*3rd most flood vulnerable area within TRCA's jurisdiction

Figure G.11: Flood Extent Map for the West Mall Area

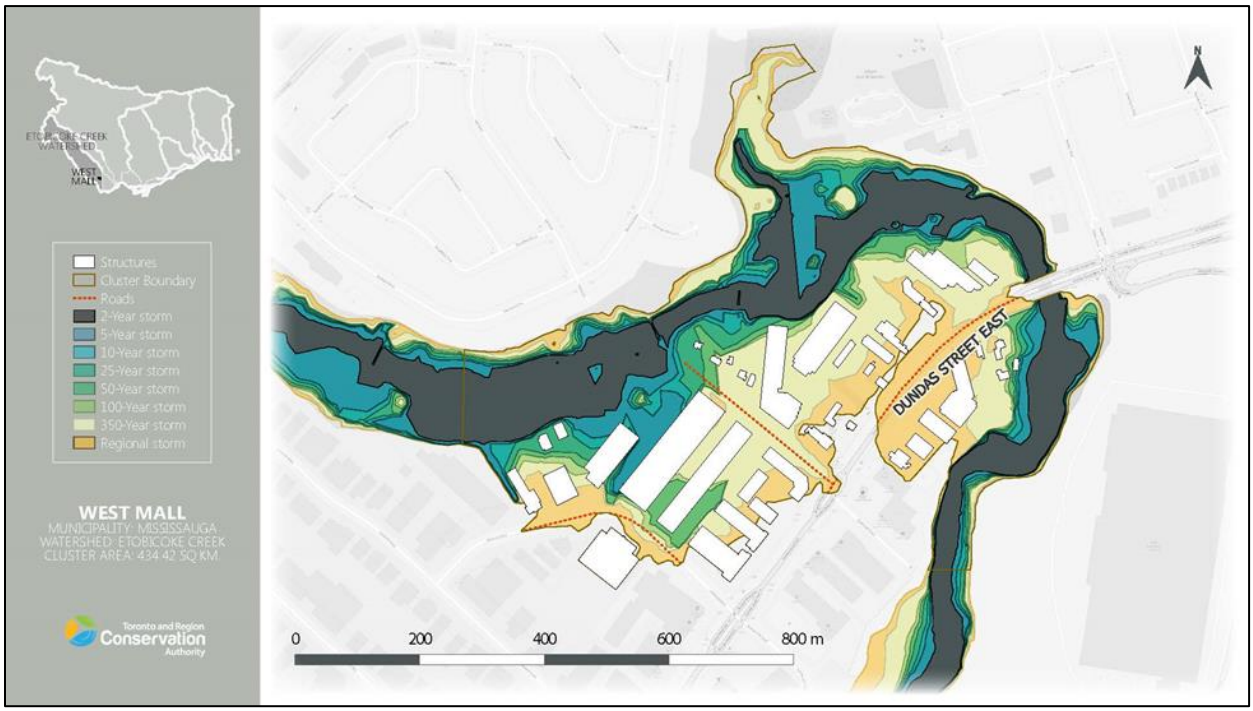
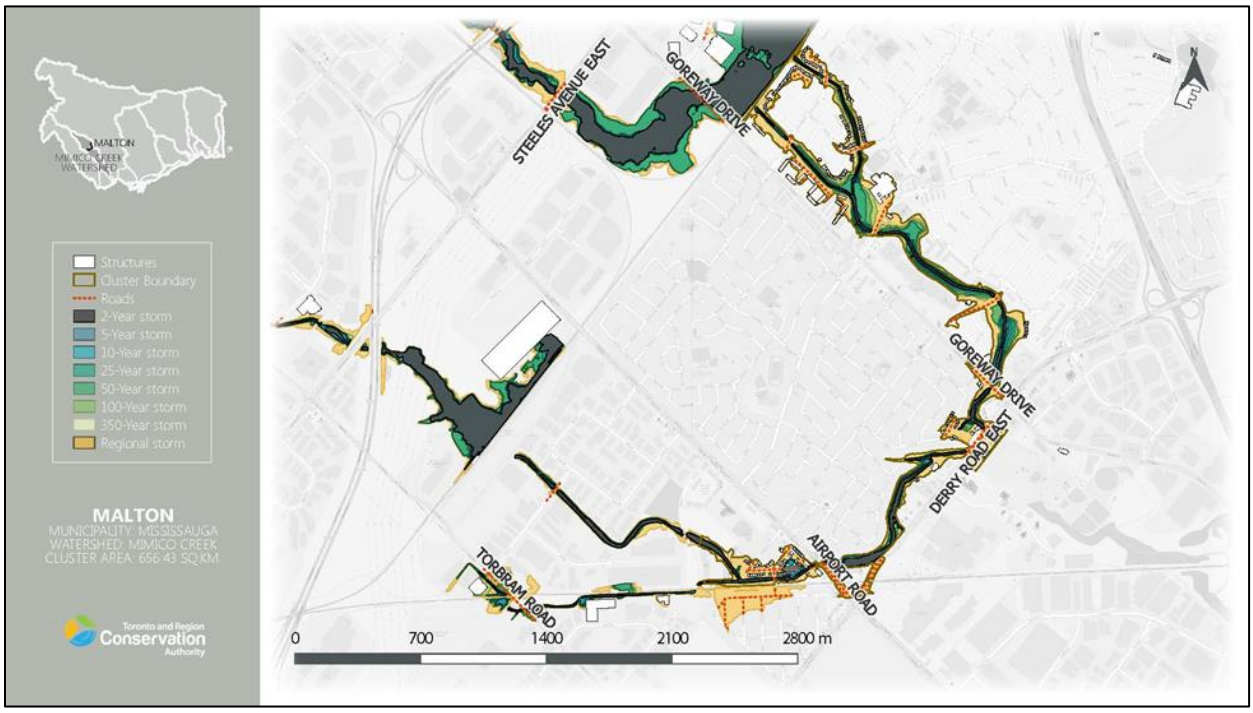


Figure G.12: Flood Extent Map for the Malton Area



G.3 Lake Simcoe Region Conservation Authority

Updated Flood Forecasting and Warning Emergency Management System (in progress)

The current Emergency Management System (EMS) database identifies the locations of structures that would be impacted by specific storms. It consists of a database and mapping for York and Durham Regions. The next steps are to develop GIS-based flood inundation and risk assessment mapping, including a database, for the entire watershed by 2021. This was identified as a priority action under goal one of the LSRCA Strategic Plan (LSRCA 2016): support a safer, healthier and livable watershed through exceptional integrated watershed management.

The updated EMS would include mapping and associated GIS layers showing the expected extent of flooding for each of the 1:5 year, 1:25 year, 1:50 year, 1:100 year and Regional Storm events, as well as the extent of Lake Simcoe shoreline flooding for five-year and 100-year events. The risk assessment method to be used has been adapted from the Ontario Provincial Hazard Identification and Risk Assessment Report. This project is in progress and is dependent on funding.

G.4 Nottawasaga Region Conservation Authority

No engineered flood studies have been completed by the NVCA within the Town of Caledon. NVCA flood estimation mapping extends part way into the Town but does not fully map all watercourses within its boundaries. In general, developments near watercourses have been required to have site specific flood studies completed to confirm the extent of flooding.

G.5 Conservation Halton

Regulatory floodplain mapping for the Sixteen Mile Creek system in the Ninth Line corridor of Mississauga is currently being updated through the City's Ninth Line Lands Scoped Subwatershed Study (Amec Foster Wheeler, 2017).

H. Erosion Hazard Studies and Mapping

Estimated erosion hazard mapping is available for all watercourses identified by each respective CA. Different components of erosion (e.g. slope stability, toe erosion, streambank erosion) are addressed through provincial policies, guidance or technical documents (e.g. SWM guidance) and the development review process.

H.1 Credit Valley Conservation Authority

Sediment Budget and Erosion Control Strategy (proposed)

CVC has a history of engineered approaches that channelized and hardened streams but has also recognized early their associated impacts. Priority erosion site inventories were first systematically documented in the 1984 watershed plan with subsequent updates intermittently to 2006. Criteria were related to safety and property damage that still justify engineering approaches as a last resort. An integrated watershed approach has long promoted the role of reforestation, protection, and restoration of wetlands and floodplains. In the 1980s an erosion control planting program for lower priority erosion sites was implemented as part of a fish habitat restoration program. Due to financial constraints and consistent with the emerging preference away from structural engineered approaches, CVC decided to no longer fund and promote such practices. Source controls and SWM retrofits were also being promoted through subwatershed planning. CVC expected the municipalities to justify, plan, fund, and implement any instream erosion control works after 1992 with CVC approval. A recent review of planning files suggests there was no reduction in such projects and erosion control continues to be an issue.

The *Credit River Adaptive Management Strategy* (CVC 2005) made recommendations against erosion control to allow for channel adjustment in balance with the upstream water and sediment regimes. It also recognized benefits, such as dam removals, supply of gravels for invertebrates, fish spawning and other complex floodplain habitats. This approach was consistent with new policies being promoted by the Province in *Adaptive Management of Stream Corridors in Ontario* (MNR 1991) and *Natural Channel Systems, An Approach to Management and Design* (MNR 1994).

Although primarily intended to address stream erosion hazards, this proposed Sediment Budget and Erosion Control Strategy will integrate and better implement science-based policies in managing functional stream valleys for the broader range of ecological services including fish and wildlife habitat, water quality, and protecting valuable soil resources in the uplands. Any sediment budget approach needs to begin with identifying soil loss from uplands based on GIS mapping of variables, including soil texture, slopes, vegetative cover, and land use practices using the universal soil loss equation and delivery to the stream network. Deposition and erosion areas within stream reaches will be assessed. This includes impacts to sediment transport with storage behind dams and subsequent sediment armouring and channel erosion downstream in an attempt by a stream to recover its natural bedload and suspended loads.

Impacts during urbanization include the greatest inputs identified as being from construction sites. Sediment controls at these sites have seen as much as 80% failure rates on the Credit River that led to the need for real-time monitoring. Impacts to the sediment regime are then followed by unnaturally low inputs from uplands due to impervious cover that pave over soils, eliminate infiltration and increase runoff and flow rates and volumes. This increased runoff devoid of a sediment load then entrains it from channel erosion to make up the difference, similar to processes downstream of dams. In many cases, especially where banks have been armoured for protection, bed erosion or down-cutting will dominate the channel enlargement process. Unlike bank erosion that will increase the meander belt and floodplain to a new stable state to dissipate the increased energy, down-cutting will also cause knick-point erosion in an upstream direction and disconnect the floodplain flows that are important for nutrient cycling, floodplain wetlands, and fish migration.

More effective channel erosion control can be achieved working with upstream water and sediment processes and the application of natural channel design as an option to channelization and hardening, where feasible. This strategy can provide some information and analysis at a watershed scale, such as universal soil loss equation mapping using existing GIS layers. However, it is likely to recommend which components, such as reach scale characterization of sediment transport, is best done at the subwatershed scale. At present CVC is engaged with the City of Brampton in an Erosion Mitigation Strategy that is taking a more holistic approach with geomorphological assessment and recommendations that could act as a pilot study with recommendations to be expanded watershed-wide.

H.2 Toronto and Region Conservation Authority

A comprehensive erosion study for all areas of TRCA land within Peel Region has not been conducted. A series of site-specific erosion studies have been undertaken throughout Peel Region, and hazard mitigation was completed at each site. Examples of projects include:

Archdekin Park Bank Stabilization Project: A scour on the left bank of Etobicoke Creek West Branch was placing an asphalt park trail and a Region of Peel sanitary line at risk. The scour at Archdekin Park was first identified by TRCA Erosion Hazard Monitoring in 2009. Annual inspections determined the scour was 35.8 m and was within 1 m of the asphalt path and approximately 5 m to the sanitary line. Bank stabilization works were completed to protect the City of Brampton trail and Region of Peel sanitary sewer.

Bolton Sanitary Infrastructure Protection Project: A Region of Peel sanitary line encasement was exposed along the bed of the Humber River near the northeast corner of King Street East and Humber Lea Road in the Community of Bolton, Town of Caledon. The exposed encasement was first identified by TRCA Erosion Hazard Monitoring staff in 2015. During an inspection in July 2015, it was determined that 3.7 m of the sanitary line was exposed and a crack along its surface was observed.

Other site-specific projects include:

- Bren Road Sanitary Infrastructure Protection Project
- Centennial Park Outfall repair and Bank Stabilization
- Humber Station
- Maitland Park
- Malton Greenway
- Sheffield Park
- Snelgrove Drainage Channel
- Stephen Llewellyn Trail
- Valleywoods Trail
- Wegenast Valley Project

H.3 Conservation Halton, NVCA, and LSRCA

Estimated erosion hazard mapping is available for all watercourses identified by each respective CA.

Erosion hazard mapping for the Sixteen Mile Creek system in the Ninth Line corridor of Mississauga is currently being updated through the City's Ninth Line Lands Scoped Subwatershed Study (Amec 2017).

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I. Water Quality Studies

I.1 Credit Valley Conservation Authority

Credit River Water Quality Strategy (2003)

The purpose of this strategy was to assess larger watershed scale water quality issues and trends with respect to Provincial Water Quality Objectives (PWQO) standards for human and ecological health. This included identification of stakeholder issues, developing a priority list of parameters of concern and a river zonation map to summarize further analyses, and as a communication tool. This study was incorporated and refined as part of the Credit River Water Management Strategy Update, including land use scenarios, climate change, and management options.

Issues were grouped into three categories related to increasing contaminant loading, baseflow dilution, and erosion / sediment budget. These issues are associated with urbanization, loss of natural features, well extraction, agricultural erosion, pesticides, fertilizers, drainage and irrigation (including golf courses), sewage treatment, spills, channelization, on-line ponds, and climate change.

Parameters of concern were identified as excess nutrients (P and N), suspended solids, water temperature, dissolved oxygen (DO), metals (Ni, Cu, Al, Zn, Fe), organic/pesticides, chlorides, and bacteria. Phosphorous is generally in decline but exceeds targets in the upper and middle watershed and an apparent increasing trend in the middle watershed. The lower watershed is below standard and is also increasing over time. DO is impacted downstream of Orangeville, main branch of East Credit, and Fletchers Creek; impacted by wastewater treatment plant, urban, and agricultural runoff. Nitrates issues were identified in the West Credit and increasing trends were detected in the upper and middle watershed. Chlorides are increasing watershed-wide and exceed targets in the lower watershed, Fletchers and Sheridan Creeks. Heavy metals generally increase as one progresses down the main river and with urbanization where there are a few values exceeding targets. Suspended solids are generally increasing over time watershed wide. Bacteria exceedances occur in Fletchers and Sheridan and throughout the watershed during rain events and trends are increasing watershed wide.

River zonation mapping summarizes water quality impairment as unimpaired in smaller cold-water headwater streams and some tributaries in the middle watershed. Two reaches downstream of Orangeville are impaired as an exception to the upper watershed. The middle watershed is showing increasing signs of impairment. Impaired reaches are more typical of the lower watershed clay plain and urbanized streams.

A second phase of the study involved HSP-F modelling to assess the watershed's sensitivity to future climate, development, and management scenarios. Model outcomes were combined with the Flow Management Study and Water Budget Study in the Credit River Water Management Strategy Update. Key findings were that current planning and development practices are not sustainable over the long term. Monitoring and model results show that it is not possible to offset impacts from land use change entirely and that extreme climate scenarios extenuate the deterioration of watershed conditions. There

are limits to how much environmental features and functions within the watershed can adapt to change. This important finding needs to be incorporated into long-term plans and policies in the watershed.

Water quality monitoring can now be updated with additional sampling and analysis. Other emerging parameters of concern such as microplastics, pesticides, and endocrine disruptors may also deserve further attention.

IWMP and Real-time Water Quality Summaries

CVC summarizes their Integrated Watershed Monitoring Program (IWMP) data, which includes water chemistry sites in annual, biennial, and 10-year reports (for more information see Appendix J). These reports are available on CVC's website at https://cvc.ca/watershed-science/watershed-monitoring/iwmp-annual-report/. CVC uses the Water Quality Index (CCME 2003) to summarize key parameters of concern to rank water quality conditions throughout the watershed.

The raw real-time water quality data is available for download on CVC's website at: https://cvc.ca/watershed-science/watershed-monitoring/real-time-monitoring/.

I.2 Toronto and Region Conservation Authority

Routine Monthly Surface Water Quality Sampling

Since 2002, TRCA has partnered with the Ontario Ministry of the Environment, Conservation and Parks (MECP) to monitor surface water quality across the Region's watersheds. Water quality samples are collected monthly at sites that are part of MECP's Provincial Water Quality Monitoring Network (PWQMN) and at additional sites across the Region as part of TRCA's Regional Watershed Monitoring Program (RWMP). The surface water quality grab samples are collected once per month, independent of precipitation. The samples are analyzed for a standard suite of water quality parameters, including heavy metals, nutrients, and bacteria. A total of nine sites are located in Peel Region – six in Etobicoke Creek watershed, and three in Humber River watershed.

TRCA's Environmental Monitoring and Data Management business unit produces a surface water quality report on a five-year cycle for the entire jurisdiction. The report looks at spatial and temporal water quality trends. The following reports have been produced:

- *1990-1996 Water Quality Data for Toronto (TRCA 1998)*
- *A Summary of Water Quality Data in the Region from 1996 to 2002* (TRCA 2003)
- *Regional Watershed Monitoring Program: Surface Water Quality Summary 2006-2010 (TRCA 2011)*
- *Regional Watershed Monitoring Program: Surface Water Quality Summary Temporal Trends Update, 2011-2015 (TRCA 2017a)*
- *Regional Watershed Monitoring Program: Surface Water Quality Summary Spatial Trends Update, 2011-2015 (TRCA 2017b)*

Digital copies of the most recent reports can be found at: https://trca.ca/conservation/environmental-monitoring/environmental-monitoring-resource-library/

Surface Water Quality Modelling

Large-scale, watershed-wide surface water quality modelling was conducted for the Humber River watershed as part of the technical work for the Humber River Watershed Plan (TRCA 2008a). The surface water quality monitoring for the Humber River watershed was conducted using HSP-F computer modelling with several possible future land use scenarios. Water quality simulations were performed using meteorological input data for a seven-month period from April to October 1991. This period was determined in the City of Toronto Wet Weather Flow study to be representative of average meteorological and flow conditions for the Greater Toronto Area. Winter conditions were not modelled because water quality monitoring data used to calibrate the model were collected primarily during the growing season (Note: The RWMP started collecting monthly winter water quality samples in 2004 at a few sites and in all Humber sites in 2006). Water quality calibration was undertaken using information collected at seven water quality stations within the Humber watershed collected between 2002 and 2005. Samples were from the MECP's Lake Ontario Tributary Priority Pollutant Monitoring Program and TRCA's RWMP.

The HSP-F analysis attempted to model water quality predictions for TSS, nutrients (nitrates NO_2+NO_3), total kjeldahl nitrogen (TKN), phosphorus (P), bacteria (*E. coli*), chloride, and heavy metals (copper [Cu], zinc [Zn], and lead [Pb]). The modelling outcomes for *E. Coli*, chloride, and organic contaminants did not meet calibration standards and therefore were predicted based on professional judgement, with support from model simulations (in terms of directional change), empirical evidence of past watershed water quality responses to land use changes and examination of current water quality downstream of areas with varying land use and land cover types. Local data were used to support conclusions wherever possible, with the literature serving as a secondary source. Model results for TSS, TKN, NO_2+NO_3, TP, Pb, Zn and Cu were used more directly to evaluate the scenario outcomes in relation to the numerical targets.

Further details about the modelling work can be found in *Humber River Watershed Scenario Modelling and Analysis Report* (TRCA 2008g).

I.3 Conservation Halton, NVCA, and LSRCA

Keeping in mind that Conservation Halton, NVCA, and LSRCA comprise less than 2.5% of the total area in Peel, no detailed information about water quality sampling and reporting is provided. All three CAs participate in MECP's PWQMN but no sites are located in Peel Region. A grab sample is usually collected once per month during the ice-free season and analyzed for a number of parameters, including total and dissolved nutrients, metals.

Data from the PWQMN can be accessed here: https://www.ontario.ca/environment-and-energy/map-provincial-stream-water-quality-monitoring-network.

LSRCA, in partnership with MECP, collect additional water quality data above and beyond the PWQMN. LSRCA operates a total of 32 ambient water quality monitoring sites to look at nutrients, metals, and general water quality throughout their watersheds.

J. Monitoring Programs

Information on the routine monitoring programs for CVC and TRCA is provided in this section. Additional data outside of the monitoring programs may be available for use and each CA should be contacted directly for the information. No information about Conservation Halton, NVCA, and LSRCA monitoring has been provided since these CAs comprise less than 2.5% of the total area in Peel.

J.1 Credit Valley Conservation Authority

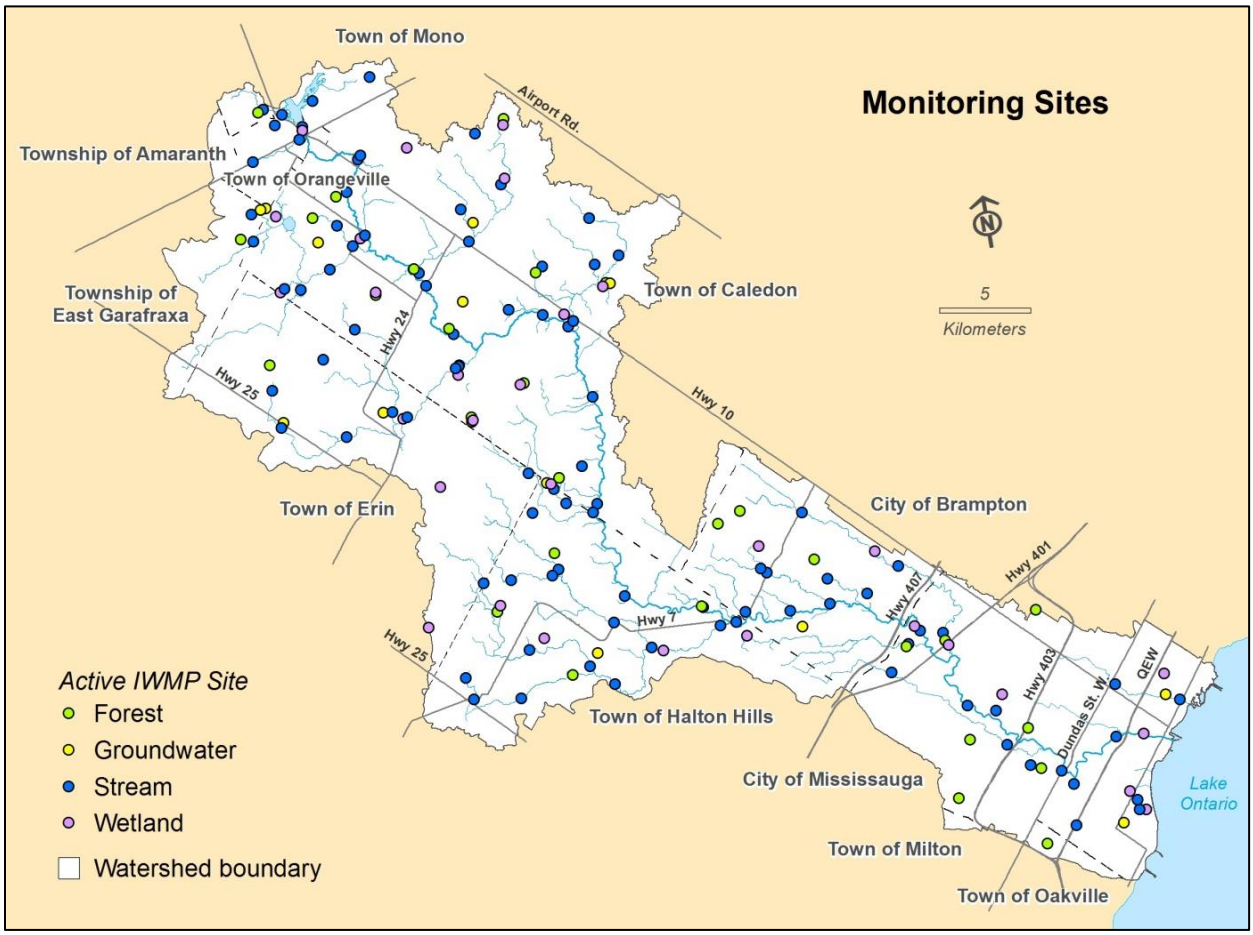
CVC Integrated Watershed Monitoring (IWMP) Program

In 1999 CVC established a long-term ecological monitoring program to provide information on the status and trends of groundwater, stream, forest, wetland ecosystems, and the drivers of land use and climate to guide and inform management programs. The intent was to support adaptive environmental management using an ecosystems approach in concert with subwatershed planning. The program was refined after a 10-year comprehensive review in 2014 (Figure J.1). A detailed analysis report 1999-2017 is now underway as part of the new Credit River watershed plan that is currently being developed.

The overall goal of the IWMP is to track water quantity and quality, biodiversity and productivity. The intent is to determine whether watershed conditions are deteriorating due to stresses associated with land use and climate change or improving due to protection and restoration efforts. The results can also act as early warnings to improve programs and take remedial actions including adaptive management approaches. To date, IWMP data has been useful in formulating Brook Trout Recovery, Invasive Species, and Water Quality Strategies.

The document *CVC Integrated Watershed Monitoring Program Reference Series Volume 1: Program Overview and Monitoring Plan* (CVC 2018b) provides a detailed overview of the monitoring program. Additional information can be found on the CVC website at: https://cvc.ca/watershed-science/watershed-monitoring/

Figure J.1: CVC's Integrated Watershed Monitoring Program Sites



J.2 Toronto and Region Conservation Authority

Regional Watershed Monitoring Program (RWMP)

TRCA's RWMP is a science-based, long-term monitoring initiative that was developed in 2001 to update "state and condition" information for the region's nine watersheds. Its purpose is to collect aquatic and terrestrial ecosystem data at the watershed and subwatershed scale, and across the region. Long-term ecological data is essential to identify physical and biological changes in the local environment over time, to distinguish between natural trends and human-caused changes, and to evaluate the success of conservation management efforts.

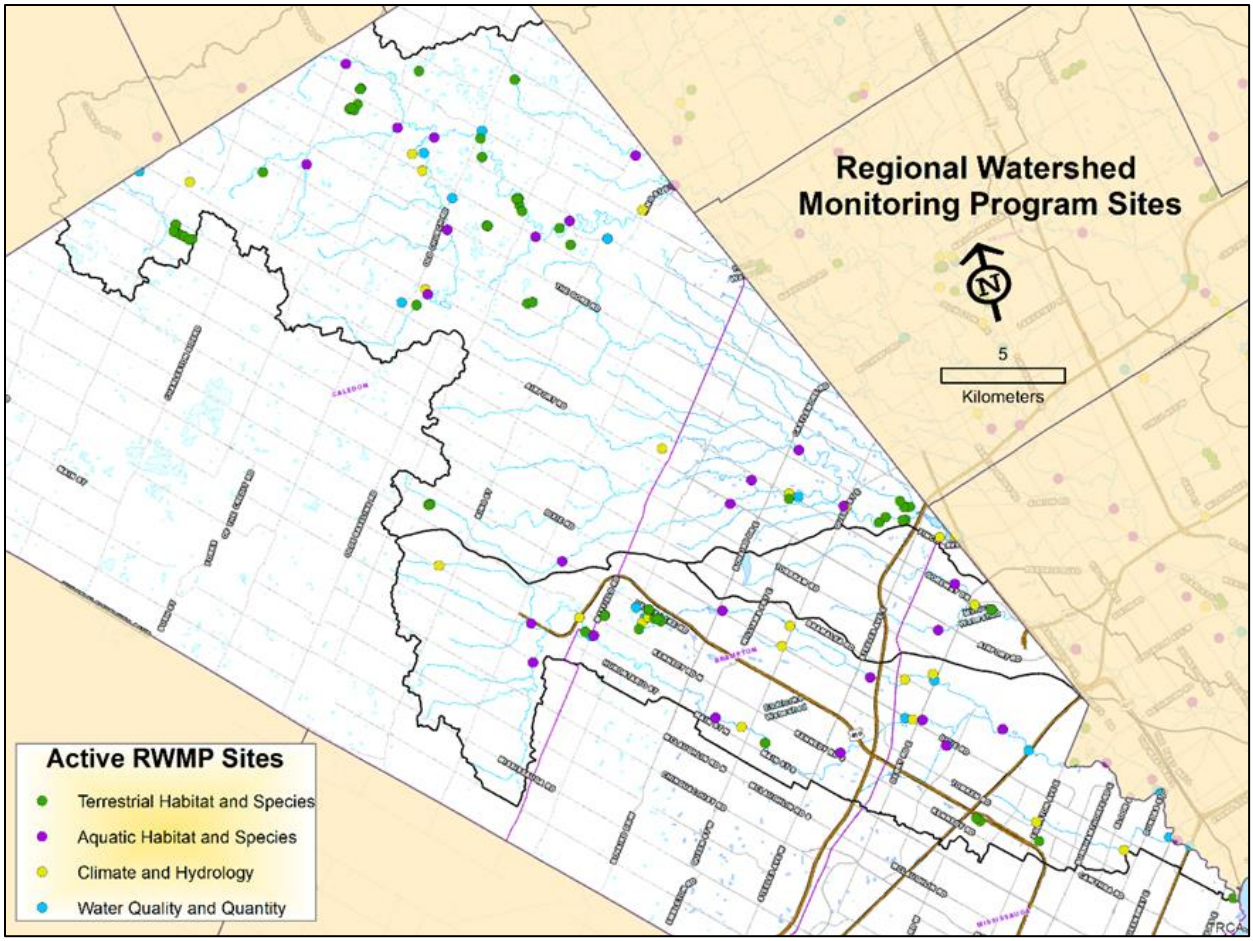
The ability to assess the biodiversity and ecological function of regional greenspace and water resources directly supports TRCA's 2013-2022 Strategic Plan (TRCA 2018). The data collected are used to inform the organization's key planning, implementation and reporting activities (e.g. Toronto Remedial Action Plan, water quality studies) and to support major capital and infrastructure projects (e.g. Downtown Brampton River Walk Project). Data are shared externally with partner municipalities, consultants, academic institutions and other agencies. Since its inception, the program has enhanced the planning and coordination of monitoring activities, standardized protocols, and filled several key data gaps.

The following data sets allow for interpretation at the watershed and regional scales:

- *Aquatic Habitat and Species:* aquatic insects, fish communities, and the physical features and temperature of rivers and streams;
- *Climate and Hydrology:* contributions of rain and snow to regional watersheds;
- *Terrestrial Habitat and Species:* species of amphibians, breeding birds; salamanders, plants as well as vegetation communities;
- *Water Quality:* water chemistry parameters such as nutrients, metals, and bacteria found within regional rivers, streams and groundwater tables; and,
- *Water Quantity:* changes in the water levels of rivers, streams and groundwater wells.

More program information (including reports) can be found on the TRCA's Environmental Monitoring and Data Management webpage: https://trca.ca/conservation/environmental-monitoring/. Many of the recent datasets are available through TRCA's Open Data portal: https://trca.ca/about/open/.

Figure J.2: TRCA's Regional Watershed Monitoring Program Sampling Sites in Peel Region



Terrestrial Inventory and Assessment

Since 2000, TRCA has collected inventory data on flora and fauna species as well as vegetation communities. These sites change from year to year based on funding, as well as land planning and management priorities. Information about biological inventories that have been conducted at TRCA can be found at: https://trca.ca/conservation/environmental-monitoring/terrestrial-habitat-species/biological-inventories/. Please contact TRCA to determine if additional / more recent information is available.

Additional Monitoring Data

In addition to the RWMP, TRCA collects monitoring data in support of regional habitat restoration projects, EAs and research studies. Examples of special environmental monitoring projects undertaken by TRCA in Peel Region include natural heritage data collection for the *Mayfield West Comprehensive Adaptive Management Program*, the *Caledon East Existing Water Supply System*, and the existing conditions information for the *Airport Road EA*. Where possible the monitoring for special projects follows the same sampling methodology and protocols as the RWMP.

References

AMEC Foster Wheeler and Region of Peel, 2018. *Protecting Water Resources: Policy Options – Peel 2041 Discussion Paper.*

AMEC Foster Wheeler, 2017. *Ninth Line Lands Scoped Subwatershed Study, Phase 2: Impact Assessment and Management Strategy*.

AMEC Foster Wheeler, 2015. *Ninth Line Lands Scoped Subwatershed Study, Phase 1: Background Report Study Area Characterization*.

Aquafor Beech, 2011. *Lake Ontario Integrated Shoreline Strategy: Background Review and Data Gap Analysis Report*. Prepared for Credit Valley Conservation.

Aquafor Beech, 2005. *Credit River Adaptive Management Strategy: Development of a Rehabilitation Plan for the City of Mississauga*. Prepared for City of Mississauga, Works and Transportation.

Beacon Environmental and the Lake Simcoe Region Conservation Authority, 2007. *Natural Heritage System for the Lake Simcoe Watershed*.

City of Mississauga, 2012. *Natural Areas Survey: 2012 Update*.

City of Toronto, 2017. *Wet Weather Flow Master Plan Implementation Status Update*.

City of Toronto, 2003. *Wet Weather Flow Management Master Plan.*

Civica, 2015. *Final Report: Humber River Hydrology Update*. Prepared for the Toronto and Region Conservation Authority.

Conservation Halton and Halton Urban Structure Review Consulting Team, 1996. *Sixteen Mile Creek Watershed Plan.*

Credit Valley Conservation, no date. *Phase 2: Cooksville Creek Risk and Adaptation Evaluation Progress Report – July 2016 – March 2018.* Unpublished.

Credit Valley Conservation, no date. *Phase 1: Integrated Climate Change Vulnerability Assessment: Water, Wastewater and Stormwater Infrastructure in the Cooksville Creek Watershed.* Unpublished.

Credit Valley Conservation, 2018a. *Assessment of Standards and Systems for Quality and Risk Management for Stormwater Infrastructure in Light of Existing and Future Climate Change Impacts: For the Region of Peel.*

Credit Valley Conservation, 2018b. *CVC Integrated Watershed Monitoring Program Reference Series Volume 1: Program Overview and Monitoring Plan.*

Credit Valley Conservation, 2017. *Peel Region Water Infrastructure Systems Vulnerability Assessment.*

Credit Valley Conservation, 2015a. *Credit River Fisheries Management Plan Update 2015.* Unpublished.

Credit Valley Conservation, 2015b. *Natural Heritage System Strategy*.

Credit Valley Conservation, 2015c. *Integrated Watershed Restoration Strategy.*

Credit Valley Conservation, 2014. *Our Future to Shape: Strategic Plan 2015 – 2019*.

Credit Valley Conservation, 2012. *Credit Valley Conservation Stormwater Management Criteria*.

Credit Valley Conservation, 2011. *Thermal Impacts of Urbanization Including Preventative and Mitigation Techniques*.

Credit Valley Conservation, 2010a. *Watershed Planning and Regulation Policies*.

Credit Valley Conservation, 2010b. *Survey of Municipal Policies and Administrative Approaches for Overcoming Institutional Barriers to Low Impact Development*.

Credit Valley Conservation, 2009a. *Wetland Restoration Strategy.*

Credit Valley Conservation, 2009b. *Rising to the Challenge: A Handbook for Understanding and Protecting the Credit River Watershed*.

Credit Valley Conservation and EBNFLO Environmental, 2009c. *Water Quality Strategy – Phase II: Watershed Model Development and Application to Future Management Scenarios*.

Credit Valley Conservation, 2008. Credit Climate Change Strategy.

Credit Valley Conservation, 2006. *Credit River Water Management Strategy Update.*

Credit Valley Conservation, 2003. Credit River Water Quality Strategy.

Credit Valley Conservation and Ministry of Natural Resources, 2002. *Credit River Fisheries Management Plan*.

Credit Valley Conservation, 1984. *Credit River Watershed Plan.*

Credit Valley Conservation and Toronto and Region Conservation Authority, 2014. *Evaluation, Classification and Management of Headwater Drainage Features Guidelines.*

CTC Source Protection Region, 2015. *Approved Source Protection Plan: CTC Source Protection Region.*

Environment and Climate Change Canada and the United States Environmental Protection Agency, 2017. *Lake Ontario Lakewide Action and Management Plan: 2017 Annual Report*.

Golder Associates, 2015. *Maskinonge, East Holland and West Holland River Subwatersheds: Ecologically Significant Groundwater Recharge Area Assessment.* Prepared for the Lake Simcoe Region Conservation Authority.

Green Infrastructure Ontario Coalition and Greenbelt Foundation, 2017. *A Green Infrastructure Guide for Small Cities, Towns and Rural Communities.*

Halton-Hamilton Source Protection Committee, 2015. *Source Protection Plan for the Halton and Hamilton Source Protection Areas.* Amendment approved January 30, 2019.

Lake Simcoe Region Conservation Authority, 2018. *Natural Heritage System and Restoration Strategy.*

Lake Simcoe Region Conservation Authority, 2016. *Strategic Plan 2016 – 2020: Vision to Action, Action to Results.*

Lake Simcoe Region Conservation Authority, 2010. *West Holland River Subwatershed Management Plan.*

Lake Simcoe Region Conservation Authority, 2008. *Integrated Watershed Management Plan.*

Lake Simcoe Region Conservation Authority and Nottawasaga Valley Conservation Authority, 2006. *Assimilative Capacity Study for the Lake Simcoe Watershed and Nottawasaga River.*

MacLaren Plansearch, 1988. *Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers, Black Ash, Silver and Sturgeon Creeks.*

Marshall Macklin Monaghan, 1997. *Environmental Implementation Report for Fletcher's Meadow Secondary Planning Area.*

Matrix Solutions Inc., 2018. *Brampton Integrated Riverine and Urban Flood Risk Analysis (Part 1).*

Ministry of Natural Resources, 1994. *Natural Channel Systems: An Approach to Management and Design.*

Ministry of the Environment, Ministry of Natural Resources and Ministry of Agriculture, Food and Rural Affairs, 2009. *Healthy Great Lakes, Strong Ontario: Talking with Ontarians about Protecting, Restoring Using and Enjoying the Great Lakes – Discussion Paper.*

Ministry of the Environment and Energy, 1994. *Water Management: Policies, Guidelines, Provincial Water Quality Objectives.*

MMM Group Limited, 2013. *Draft Final Report: Etobicoke Creek Hydrology Update*. Prepared for TRCA.

Nottawasaga Valley Conservation Authority, 2018. *Integrated Watershed Management Plan: Characterization Report.*

Nottawasaga Valley Conservation Authority, 2006a. *Watershed Plan Strategic Review and Update 1996 – 2015.*

Nottawasaga Valley Conservation Authority, 2006b. *Innisfil Creek Subwatershed Plan.*

Nottawasaga Valley Conservation Authority, 1996. *Nottawasaga Valley Watershed Management Plan.*

Nottawasaga Valley Conservation Authority and Fisheries and Oceans Canada, 2009. *Fisheries Habitat Management Plan.*

Ontario, 2009. *Lake Simcoe Protection Plan.*

Ontario Ministry of Natural Resources and the Toronto and Region Conservation Authority, 2005. *Humber River Fisheries Management Plan.*

Ontario Ministry of Natural Resources and Watershed Science Centre, 2001. *Adaptive Management of Stream Corridors in Ontario.* Peterborough, Ontario, Trent University.

Paragon Engineering Ltd., 1996. *Fletcher's Creek Subwatershed Study.*

Peel Climate Change Partnership, 2017. *Peel Climate Change Partnership Action Plan.*

Peel Climate Change Partnership, 2011. *Peel Climate Change Strategy: A Strategic Plan for Climate Change for the Geographic Region of Peel.*

Phillips Engineering Ltd., 2004. *North Sixteen District Scoped Subwatershed Study and Ninth Line District Floodplain Mapping.* Prepared for City of Mississauga.

Region of Durham, 2012. *Mapping a continuous Natural Heritage System for the Region of Durham*. 10p.

Schmutz, S. and Sendzimir, J., 2018. *Riverine Ecosystem Management: Science for Governing Towards a Sustainable Future.*

SGL Planning and Design Inc., Forrec Inc., and Matrix Solutions Inc., 2018. *Brampton Riverwalk Urban Design Study.*

South Georgian Bay Lake Simcoe Source Protection Committee, 2015. *South Georgian Bay Lake Simcoe Source Protection Plan.* Amended February 15, 2018.

Toronto and Region Conservation Authority, 2019. *Peel-Caledon CA NHS Refinement.* Draft available.

Toronto and Region Conservation Authority and Ontario Climate Consortium, 2017. *Natural Systems in Peel Region: Vulnerability Assessment.*

Toronto and Region Conservation Authority, 2017a. *Regional Watershed Monitoring Program: Surface Water Quality Temporal Trends Update 2011 – 2015.*

Toronto and Region Conservation Authority, 2017b. *Regional Watershed Monitoring Program: Surface Water Quality Summary Spatial Trends Update, 2011-2015*

Toronto and Region Conservation Authority, Ontario Climate Consortium and RSI, 2016. *Climate Trends and Future Projections in the Region of Peel: Technical Report*. Prepared for Region of Peel.

Toronto and Region Conservation Authority, 2016a. *Within Reach: 2015 Toronto and Region Remedial Action Plan Progress Report.*

Toronto and Region Conservation Authority, 2016b. *Integrated Restoration Prioritization: A Multiple Benefit Approach to Restoration Planning.*

Toronto and Region Conservation Authority, 2014. *The Living City Policies for Planning and Development in the Watersheds of the Toronto and Region Conservation Authority.*

Toronto and Region Conservation Authority, 2012. *Stormwater Management Criteria.*

Toronto and Region Conservation Authority, 2011. *Regional Watershed Monitoring Program: Surface Water Quality Summary 2006 – 2010.*

Toronto and Region Conservation Authority, 2010. *Etobicoke and Mimico Creeks Watersheds: Technical Update Report.*

Toronto and Region Conservation Authority, 2009. *Moving Forward: 2007 RAP Progress Report*. Remedial Action Plan

Toronto and Region Conservation Authority, 2008a. *Humber River Watershed Plan: Pathways to a Healthy Humber.*

Toronto and Region Conservation Authority, 2008b. *Humber River Watershed Plan Implementation Guide.*

Toronto and Region Conservation Authority and CH2MHILL, 2008c. *Etobicoke Creek Headwaters Subwatershed Study Synthesis Report.*

Toronto and Region Conservation Authority, 2008d. *Centreville Creek Subwatershed Study Synthesis Report.* In partnership with Region of Peel and Town of Caledon.

Toronto and Region Conservation Authority, 2008e. *Planning and Development Procedure Manual.*

Toronto and Region Conservation Authority, 2008f. *TRCA Action Plan for The Living City: Meeting the Challenge of Climate Change.*

Toronto and Region Conservation Authority, 2008g. *Humber River Watershed Scenario Modelling and Analysis Report.*

Toronto and Region Conservation Authority, 2007. *Terrestrial Natural Heritage System Strategy.*

Toronto and Region Conservation Authority, 2006a. *Etobicoke Creek: The Aquatic Ecosystem.*

Toronto and Region Conservation Authority, 2006b. *Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watershed Report Card.*

Toronto and Region Conservation Authority, 2004. *Draft Mimico Creek Fisheries Management Plan.* Unpublished.

Toronto and Region Conservation Authority, 2003. *A Summary of Water Quality Data in the Toronto Region from 1996 to 2002.*

Toronto and Region Conservation Authority, 2002. *Greening Our Watersheds: Revitalization Strategies for Etobicoke and Mimico Creeks.* Prepared by the Etobicoke and Mimico Creek Watersheds Task Force.

Toronto and Region Conservation Authority, 2001. *Clean Waters, Healthy Habitats: Progress Report 2001.* Toronto and Region Remedial Action Plan.

Toronto and Region Conservation Authority, 1998. *1990-1996 Water Quality Data for Toronto.*

Toronto and Region Conservation Authority, 1997. *Legacy: A Strategy for a Healthy Humber.*

WSP, 2018. *Palgrave Estate Residential Community Policy Review: Growth Analysis and Policy Options Report*. Prepared for the Town of Caledon.