Lake Ontario Integrated Shoreline Strategy

Characterization Report

Prepared by: Credit Valley Conservation

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Executive Summary

Goals, Contributors, and Structure

Recognizing the need for an integrated approach to the restoration and management of the Lake Ontario shoreline, Credit Valley Conservation (CVC) initiated the Lake Ontario Integrated Shoreline Strategy (LOISS) in 2009. LOISS aims to provide guidance for local, regional, provincial and federal governments for planning restoration initiatives, developments, and land-use decisions. This study emphasizes opportunities for protecting and restoring ecosystems along the shoreline, inland to the first major barrier on the Credit River, and into Lake Ontario's nearshore environment. Capitalizing on these opportunities will help increase access and amenity value for people while maintaining and restoring healthy aquatic and terrestrial ecosystems.

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

LOISS follows the general approach to developing subwatershed studies, including the identification and evaluation of cumulative effects of land use on the overall health of the study area. Subwatershed studies typically include three separate reports. LOISS follows this structure:

1. Phase 1: Background Review and Data Gap Analysis (completed by Aquafor Beech Limited, 2011)
2. Phase 2: Characterization Report
3. Phase 3: Implementation Report

This second report provides an updated assessment of the current conditions in the LOISS study area to fill data gaps identified in the Background Review. It incorporates information contained in the Background Review as needed to provide context for new findings. In addition, LOISS Characterization identifies additional data gaps and makes recommendations (Tables 5-1 and 5-2) for consideration in the LOISS Implementation Report.

The LOISS Technical Steering Committee (TSC) provided key input into the refinement of the data gaps identified in the Background Review, in addition to ongoing reviews of the reports. The TSC includes representatives from all levels of government as well as academia (Table 1-1). CVC staff and a number of consultants directly contributed to LOISS's first two phases.

Key Results: Hydrogeology, Hydrology and Hydraulics, Fluvial Geomorphology and Coastal Processes

In general, the condition of the natural environment in the study area is typical of those in urbanized landscapes. In-stream habitat is degraded, showing signs of "Urban Stream Syndrome" (Walsh et al. 2005), including reduction in channel complexity caused by channelization and armouring of the streambed and banks in order to prevent erosion from uncontrolled runoff. Increases in peak rates and volumes of stormwater runoff increases the erosive force of uncontrolled discharge over shorter durations, which can cause geomorphic changes to downstream reaches, including widening and downcutting (i.e. lowering and flattening of the stream bed).

Changes in flows due to increased runoff and undersized stream crossing points at roads and railways may contribute to increases in flooding, both in frequency and extent, in the study area. Stormwater management and dynamically stable geomorphology controls are needed to maintain stream morphology, fish production, invertebrate production and general habitat suitability from urban flow regimes.

Development encroaching on floodplains increases the likelihood of structures being flooded during certain rain events. 342 structures in the study area are at risk of flooding under two-year to Regional storms. Of particular concern are the high number of at-risk structures in the Serson Creek (106), Cooksville Creek (133), and Turtle Creek (58) watersheds.

Further, piped (i.e., enclosed in culverts or similar engineered structures) headwaters detached from their floodplains increase downstream flood risk due to reduced attenuation of flows in these upstream areas.

Historic modifications to the nearshore as a result of "stonehooking" – gathering cobbles, boulders, gravel and sands for construction in the late 19th and early 20th centuries - and more recently creating new shorelines for development have resulted in losses in the amount and quality of substrate and associated aquatic habitat. These changes have also influenced how coastal processes interact with the shore. With less nearshore substrate to dissipate wave energy, the shoreline is less resilient to erosion. Under current conditions, waves break closer to shore with higher energy, requiring protection (i.e., hardening the shoreline) to reduce erosion. These conditions make the nearshore waters a harsh environment for both aquatic species and for human use.

Key Results: Water Quality

Levels of phosphorus and *E.coli* are routinely above Provincial Water Quality Objectives in LOISS streams. While these do not directly impact fish or benthic macroinvertebrates, there is a concern regarding *Cladophora* algae growth and the low dissolved oxygen levels it causes through decomposition of dead algae, which can cause die-off among aquatic fauna and impair the suitability of water for drinking and recreation. Fortunately, *E.coli* has not been identified as an issue for local drinking water intakes, though *Cladophora* algae clogged the Lorne Park drinking water intake in 2017 (Hennings Pers. Com. 2017).

Total suspended solids are a concern for the Credit River, Sheridan Creek, and shoreline of Richard's Memorial Park where concentrations exceed Canadian Water Quality Guidelines. Suspended solids are of particular concern due to impacts to water clarity and to the movement of sediment-bound contaminants.

Nitrate-Nitrogen levels in Lornewood Creek and Serson Creek suggest potential septic leakage in these watersheds, but this it is not considered a limiting factor for instream and nearshore productivity.

Temperature is important for understanding water quality in the study area. Delivery of water from the streams to the lake is dependent on the temperature of both stream and lake water. When stream water is warmer than lake water, the plume from the stream will enter the lake as overflow, permitting contaminants to travel further into the lake before mixing. In the presence of high in-stream chloride levels stream water enters the lake as underflow and settles to the bed of the lake in the nearshore making contaminents such as phosphorus more available to nuisance *Cladorphora* algae, hence increasing its productivity. Road salt is the main source of water-borne chloride in urban areas.

Key Results: Terrestrial Habitat, Aquatic Habitat and Wetlands

Terrestrial habitats are fragmented and generally restricted to hazard lands associated with stream and shoreline corridors. While they provide some stepping-stone resting areas for migratory wildlife, overall, these habitats are degraded, with low-quality food sources and limited diversity. Three higher quality areas of note are Rattray Marsh Conservation Area, Cawthra Woods, and the Credit River Marshes, all of which provide a diversity of habitats and have lower occurrences of invasive plants.

Few wetlands are present in the study area, with remaining wetlands and historic references suggesting they were much more commonplace before manipulation of streams to accommodate development. Smaller lake-associated wetlands are present in embayments along the shore at Lakefront Promenade Park and the Port Credit Harbour Marina. These habitats provide the highest fish biomass of all sites sampled in the study area.

Streams in the study area support a low diversity of fish and benthic macroinvertebrates, since survival in these urban streams requires tolerance of poor water quality and higher water temperatures. Fish passage barriers are common, impacting fish species diversity and the resilience of the fish community to unfavourable conditions.

Priority Recommendations

The results of the analysis point to the need for five priority actions:

- Manage stormwater quality and quantity
- Improve habitat quality
- Manage existing habitats
- Connect habitats
- Outreach, communications, and education

Manage stormwater quality and quantity: Improved stormwater management should be a priority for the LOISS study area. Reducing the amount of stormwater runoff that reaches natural waterways would improve flow conditions and help to restore streams' natural form and function, increasing their capacity for supporting robust ecosystems, reducing erosion, and mitigating flood risk. Improved stormwater quality controls would help to meet federal and provincial water quality targets, allowing greater access to the lake for recreation and improving pre-treatment drinking water quality. Implementing salt-application best management practices is especially encouraged.

Many structures in the LOISS study area, especially those downstream of stream diversions, are vulnerable to flooding. The City of Mississauga and CVC should conduct more thorough assessments of these structures' vulnerability to flooding and feasibility studies on removing them from the floodplain.

Improve habitat quality: Much of the Lake Ontario shoreline is hardened to protect it from erosion, and much of this erosion-protection material needs reinforcing or replacing to mitigate the potential for damage to property and to make a safer shoreline. Efforts to restore habitat-generating substrate to the nearshore can proceed concurrently with shoreline reinfocement, improving the shoreline for both human use and aquatic species.

Regarding terrestrial habitats, managing invasive species is an important priority for improving the lower-quality terrestrial habitats along the Lake Ontario coast. Since 1992, invasive species management efforts undertaken by CVC in partnership with the Rattray Marsh Protection Association have focussed on removal of Garlic Mustard (*Alliaria petiolate*), Purple Loosestrife (*Lythrum salicaria*), Periwinkle (*Vinca minor*) and others. This work should continue in order to protect the Rattray Marsh Centre for Biodiversity.

Manage exiting habitats: While high-quality natural areas – Rattray Marsh and the Credit River Marshes, for example – have high levels of native species diversity, invasive species threaten their ability to maintain this diversity. Invasive Common Carp destroy natural vegetation and reduce water clarity in Rattray Marsh, reducing habitat quality for native fauna. Yellow Floating Heart in the Credit River Marshes, if left unchecked, has the potential to crowd out other native species. While efforts are already underway to combat Common Carp in Rattray Marsh, a program for managing Yellow Floating Heart has yet to be implemented.

Efforts to combat invasive species should be continued and initiated, where needed, to protect existing high-quality habitats.

Increase habitat connectivity: Where feasible, both aquatic and terrestrial isolated habitats should be connected. Many barriers prevent fish from accessing LOISS streams from the lake or from moving from one stretch of stream to another. Again, public works projects can proceed concurrently with efforts to remove barriers to fish movement. Recent culvert works completed by the City of Mississauga on Serson Creek and Applewood Creek at Lakeshore Road included improvements to fish passage as an objective to be achieved in the culvert design. Improvements to fish passage at these locations will open approximately 3000 m (collectively) of stream to fish.

Outreach, communications, and education: Existing outreach initiatives, such as CVC's Your Green Yard, Greening Corporate Grounds and Frontline programs, have shown positive and far reaching effects in fostering connections between people and the environment. Tours and presentations have been delivered by Frontline volunteers with over 650 youth engaged since 2016. Continuation of such programs in the LOISS study area will engage and motivate the public to contribute to the implementation of LOISS recommendations.

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1 INTRODUCTION

Since its foundation in 1954, Credit Valley Conservation has acquired high-quality natural areas within the Credit River watershed for conservation purposes. The majority of CVC's shoreline acquisitions occurred in the 1970s, when the 1967 Metropolitan Toronto Waterfront Plan (MTWP) (Procter et al 1967) determined its purchasing strategy. The MTWP was established to provide "*guidelines for the development and redevelopment of the Lake Ontario shoreline…from Clarkson to Carruther's Creek*" and benefited from input from many sectors.

CVC was appointed by the Province of Ontario as the agency that could best manage the implementation of the ambitious acquisition program and the organization that could best maximize efficiencies from multiple funding sources, with the Province of Ontario and the City of Mississauga providing the bulk of the funding. Because of this acquisition program, CVC remains the largest single landowner of Lake Ontario shoreline in the Credit River watershed. Currently, all CVC conservation lands along the shoreline, with the exception of Rattray Marsh Conservation Area, are leased to the City of Mississauga for park, recreation and conservation purposes. In total, public lands account for approximately 43 % of the Lake Ontario shoreline within CVC's shoreline jurisdiction.

The MTWP included objectives to balance land uses with both natural amenities and public access, making it progressive for its time. However, some of the recommendations emphasized 'shore protection works', i.e. hardening the shoreline to prevent erosion. This emphasis resulted in unanticipated impacts to the ecological health of the shoreline, including reduction of sediment inputs (from shoreline erosion) to replenish substrates (cobble and gravel on the bed of the lake) used by fish in the nearshore. The implementation of recommendations from the MTWP witnessed shoreline protection measures in Mississauga skyrocket from 34 % in the mid-1970s to 81 % today.

In 1988, CVC completed a draft Lake Ontario Shoreline Management Plan (CVC 1988). It developed this plan largely in response to concerns over flooding and erosion along the shoreline and corresponded with efforts at provincial, federal and international levels. In 2005, Shoreplan Engineering Limited (SEL) completed a mapping of the hazards associated with the shoreline of Lake Ontario in CVC's jurisdiction. This hazard mapping enables CVC to enact the generic regulation under the Conservation Authorities Act (Section 28, R.S.O 1990). These reports largely focused on recreation, flooding and erosion, giving little attention to the shoreline's natural heritage features.

Credit Valley Conservation (CVC) initiated the Lake Ontario Integrated Shoreline Strategy (LOISS) in 2009 (CVC Board of Directors Resolution 78/09) in recognition of the need for an integrated approach to the restoration and management of the shoreline:

- integration of information from a range of disciplines;
- integration with local to lake-wide planning initiatives; and,
- integration of information linking inland and offshore ecosystems.

LOISS seeks to expand on the work of the MTWP, the Lake Ontario Shoreline Management Plan, and Lake Ontario Shoreline Hazards Report to identify opportunities for the protection and restoration of natural ecosystems along the shoreline, inland to the first major barrier on the Credit River and into the lake in the nearshore environment, which it defines as being from the shoreline to 20 metres in depth.

1.1 LOISS GOALS AND OBJECTIVES

LOISS's goal and objectives are intented to inform development processes by maintaining the existing healthy areas and improving, to the extent possible, the health of impaired areas, for the benefit of human beings and wildlife.

LOISS Goal:

> *A revitalized shoreline that maximizes access for people, while maintaining and restoring healthy aquatic and terrestrial habitat features and functions.*

LOISS Objectives:

- To increase accessibility to existing and new naturalized habitats by people.
- To increase habitat quality and quantity by protecting existing natural habitats and creating new ones.
- To identify and foster new and existing partnerships with municipal, provincial and federal agencies, community groups, non-government organizations, and individual and corporate stakeholders.
- To provide a basis from which to inform policies and regulations aimed at protecting, enhancing and maintaining existing and recreated natural features and functions within the study area.

LOISS aims to respond to broader lake-wide initiatives, including *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario (The Biodiversity Strategy)*, the *Great Lakes Water Quality Agreement,* the *Great Lakes Protection Act,* the *Great Lakes-Great Beaches Initiative,* the *Lake Ontario Collaborative Study to Protect Lake Ontario Drinking Water,* the *Lake Ontario Lakewide Management Plan,* and the *North American Bird Conservation Initiative (Bird Conservation Region 13).*

Many of these initiatives refer specifically to the importance of the Credit River watershed in providing important habitats and supporting species at risk. LOISS will provide guidance to local, regional, provincial, and federal governments in planning restoration initiatives, developments, and land use decisions while giving due consideration to the needs of the natural environment, including the recommendations in these broader lake-wide initiatives. Specifically, LOISS intends to further inform any updates to the City of Mississauga's Waterfront Parks Strategy or to the Credit River Parks Strategy, in addition to guiding future parkland redevelopment in the LOISS study area (CVC 2008).

1.2 LOISS: STUDY PHASES

LOISS follows the general approach to the development of subwatershed studies, including the identification and evaluation of the cumulative effects of land uses and practices on the overall health of the study area. LOISS was undertaken in three distinct phases:

1. Phase 1: Background Review and Data Gap Analysis ("Background Review"; Aquafor Beech Limited, 2011)
2. Phase 2: Characterization Report
3. Phase 3: Implementation Report

Background Review and Data Gap Analysis (2009-2011) - the collection and analysis of background information to determine historical and existing conditions within the study area. Where data gaps were identified, the Backround Review identified methods for addressing these additional data needs[1].

Characterization (2011-2017) – characterizes existing conditions of the natural features and their functions within the LOISS study area. This characterization updates the summary provided in the Background Review with findings from studies undertaken to address the data gaps it identified.to the extent feasible (considering access to survey sites and funding limitations). This phase also included the development and implementation of an extensive Communications Strategy aimed at engaging the general public and key LOISS stakeholders.

Implementation (2017- 2018) – the final phase of LOISS continues the process for public and stakeholder engagement and involvement in the identification and implementation of recommended conservation actions.

[1] Characterization reports were drafted for Sheridan and Cooksville Creeks in 2009 as part of their subwatershed studies; as such, the Background Review for LOISS focused on the remaining Lake Ontario tributaries.

1.3 LOISS: TECHNICAL STEERING COMMITTEE

LOISS is guided by a Technical Steering Committee (TSC) representing multiple levels of government, conservation authorities, non-governmental organizations and academia that provide technical advice in a range of discipline areas.

The TSC has played a key role in providing input into the refinement of the identified data gaps, in addition to ongoing reviews of the various reports. The TSC comprises representatives from the City of Mississauga, Region of Peel, Ministry of Natural Resources and Forestry (MNRF), Fisheries and Oceans Canada (DFO), and Environment and Climate Change Canada (ECCC).

Additional individual and agency representatives participated in a support capacity to the TSC, providing value-added services by providing insight to findings at key points throughout the study. Representatives supporting the TSC include individuals from the City of Mississauga, Toronto and Region Conservation Authority (TRCA), ECCC, McMaster University, Nature Conservancy of Canada, City of Toronto, University of Guelph, Conservation Halton, and Ministry of the Environment, Conservation and Parks (MECP).

Table 1-1: Technical Steering Committee Members and Support

Janette Anderson	Environment and Climate Change Canada
Tom Edge	Environment and Climate Change Canada
Dave Moore	Environment and Climate Change Canada
Sue Watson	Environment and Climate Change Canada
Ram Yerubandi	Environment and Climate Change Canada
Cindy Mitten-Wilkie	Fisheries and Oceans Canada
Marc desJardins	Ministry of Natural Resources and Forestry
Mark Heaton	Ministry of Natural Resources and Forestry
Todd Howell	Ministry of the Environment, Conservation and Parks
Janice Hatton	Region of Peel
Stefan Herceg (former)	Region of Peel
Mark Schiller	Region of Peel
Frank Buckley	City of Mississauga
Eva Kliwar	City of Mississauga
Ruth Marland	City of Mississauga
Thomas Nightingale	City of Mississauga
Jeff Smith	City of Mississauga
Ray Dewey	Modelling Surface Water Limited
Nigel Finney	Conservation Halton
Teresa Labuda	Conservation Halton
Karen Chisholme	Credit Valley Conservation
Jon Clayton	Credit Valley Conservation
Jesse DeJager	Credit Valley Conservation
Neelam Gupta	Credit Valley Conservation
Kate Hayes	Credit Valley Conservation
Bob Morris	Credit Valley Conservation
John Kinkead (retired)	Credit Valley Conservation
Tatiana Koveshnikova	Credit Valley Conservation
Jon MacMull	Credit Valley Conservation
Jon Nodwell	Credit Valley Conservation
Mike Puddister	Credit Valley Conservation
Amanjot Singh	Credit Valley Conservation
Bahar SM (former)	Credit Valley Conservation
Sherwin Watson-Leung	Credit Valley Conservation

Gary Bowen	Toronto and Region Conservation
Ken Dion	Toronto and Region Conservation
Rick Portiss	Toronto and Region Conservation
Harris Switzman (former)	Toronto and Region Conservation
Mark Stabb	Nature Conservancy of Canada
Robin Davidson-Arnott (retired)	University of Guelph
Cindy Chu	Trent University
Jeff Doucette	Geomorphic Solutions

1.4 LOISS: CHARACTERIZATION REPORT (PHASE 2)

The LOISS: Characterization Report is divided into five sections:

Section 1: Introduction – provides high level background in support of the LOISS project along with the project purpose and objectives.

Section 2: Study Approach – outlines the process followed to fulfill data gaps identified in Phase 1: Background Review. This section also identifies the study area including stream and coastal reach names, survey locations, and a list of studies completed to support the characterization of the study area.

Section 3: Characterization – divided by discipline, this section provides a summary of applicable background information identified in the Background Review and a summary of the findings from the studies undertaken to fulfill the data gaps. Each chapter concludes with a synthesis of discipline-specific recommendations

Section 4: Integration: Coastal Reaches – integrates the discipline-specific data presented in Section 4 on a coastal reach-by-coastal reach basis. The integration of discipline findings provides insights into the function of the natural heritage features in each coastal reach and further refines recommendations for future consideration.

Section 5: Conclusions and Recommendations – summarizes the overall conclusions of the LOISS Characterization exercise. The recommendations identified throughout the report are compiled in this section.

2 STUDY APPROACH

The study area for LOISS extends the length of the shoreline within the City of Mississauga within CVC's jurisdiction, stretching from the boundaries with the Town of Oakville on the west to the City of Toronto on the east, approximately 2 km inland (but 5 km up the Credit River) and 6 km into Lake Ontario (Figure 2-1). The boundaries of the inland study area are largely based on those defined by the Significant Wildlife Habitat guidelines (North-South Environmental Inc. et al 2009), while the offshore boundaries are based on the limits of CVC's jurisdiction, with an emphasis placed on the nearshore area (<20 m depth) (Lake Ontario Biodiversity Conservation Strategy Working Group 2009).

The study area was further refined through the Characterization to focus on the coastal zone (loosely defined as the area between wave breaks and landforms influenced by coastal processes), and using proposed criteria for delimiting a 'coastal riparian zone' (Figure 2-2). There is very little research focused on the structure and function of Great Lakes riparian zones. Verry et al. (2004) conducted a review of definitions for riverine riparian ecotones, and biotic (vegetation, animal and nutrients) and hydrologic (geomorphic and hydrologic processes) elements were common occurrences in over 30 years of riparian ecotone definitions and delineation.

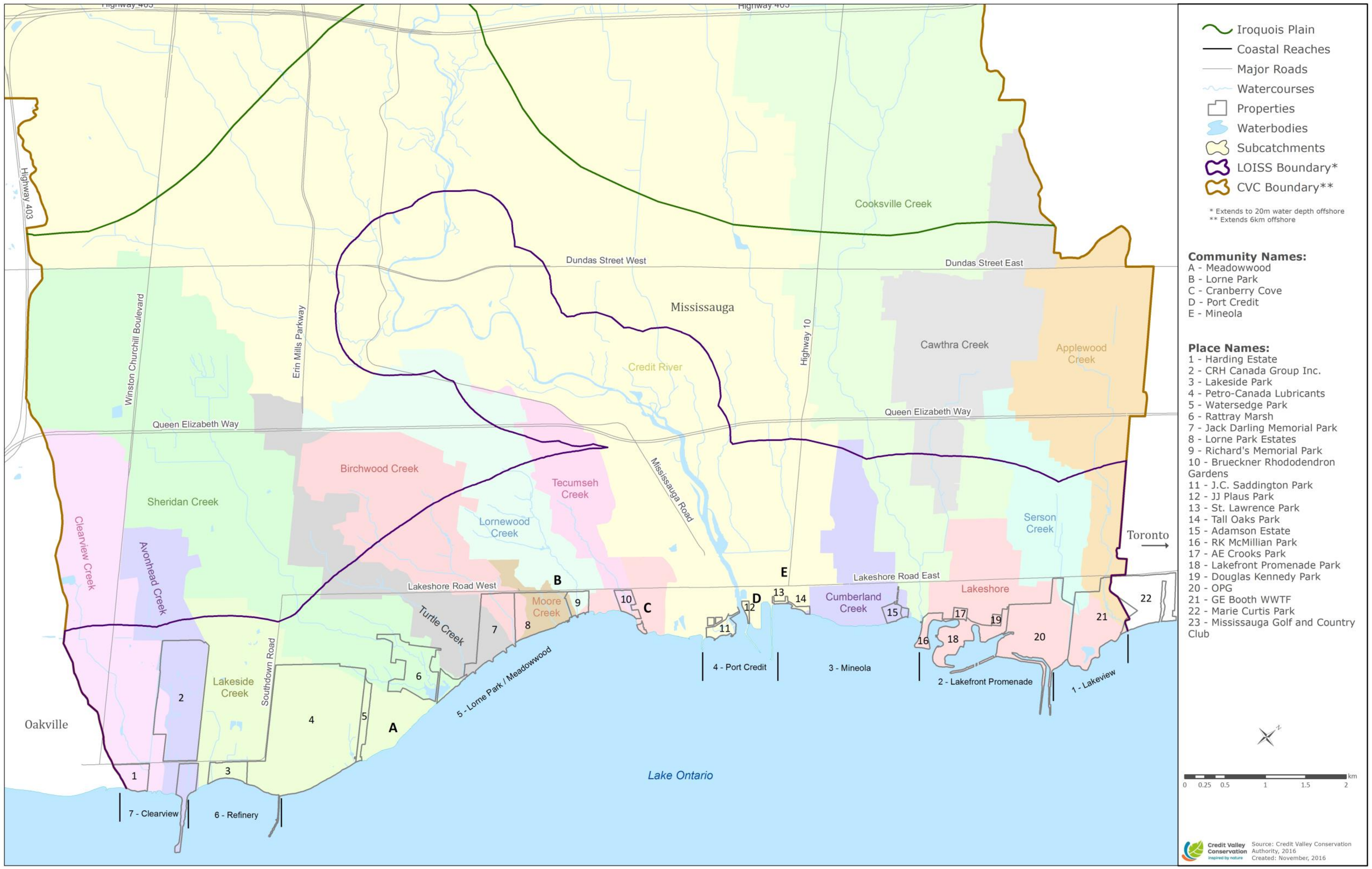

Figure 2-1: Lake Ontario Integrated Shoreline Strategy study area.

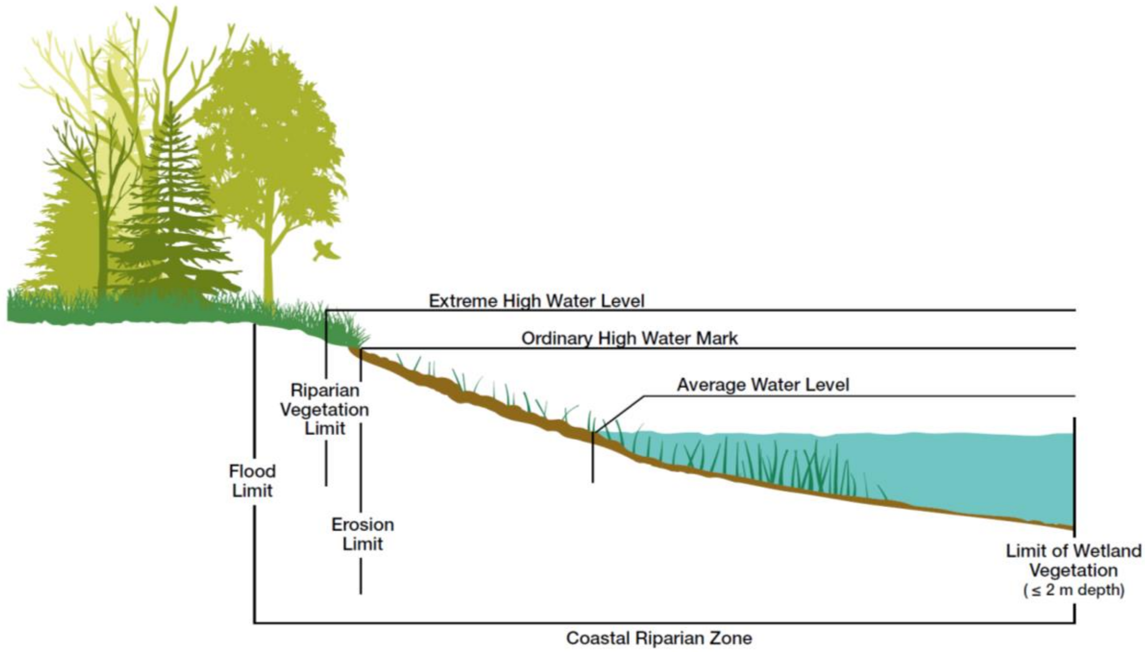

Figure 2-2: Coastal riparian zone as defined for the LOISS (Source: CVC). Note: ordinary high water mark denotes the elevation at which the presence and action of water is so usual as to influence physical characteristics of the shore such as change in soil character, erosion or shelving, limit of terrestrial vegetation, line of debris, etc.

For the purposes of LOISS, the coastal riparian zone is defined as the area along the shoreline of Lake Ontario bounded by the landward limit of natural hazard lands (flooding, erosion, wave uprush) and up to a 2-m depth contour lakeward (Figure 2-2). Based on these functions associated with lake shorelines, the following definition of 'coastal riparian zone' is proposed:

> *A three-dimensional space of interaction that includes terrestrial and aquatic ecosystems that extends down into the groundwater, up above the canopy, along the backshore that drains to the water, outward into the nearshore, and laterally into the terrestrial ecosystem.*

Delineation of the coastal riparian zone includes the following:

- limit of the erosion, flooding and dynamic beach hazards;
- limit of riparian vegetation laterally into the terrestrial ecosystem, where the interaction between groundwater and/or hydrologic disturbance events influences the type of vegetation present; and
- limit of wetland vegetation to a depth of 2 m offshore.

The limits of the coastal riparian zone are to be refined on a site basis based on the criteria above.

From east to west, LOISS includes the tributaries listed below (see also Figure 2-1); however, Sheridan and Cooksville Creeks are afforded less detailed discussion, as they are part of separate watershed studies. Details from the Sheridan Creek

Watershed Study (CVC 2010a) and Cooksville Creek Watershed Study (CVC 2010) are summarized as needed to provide context to features and functions that contribute to the LOISS study area.

1. Applewood Creek
2. Serson Creek
3. Cawthra Creek
4. Cooksville Creek
5. Cumberland Creek
6. Credit River (first 5 km upstream of the river mouth. Note: previously included tributaries of the Credit River (Kenolie Creek, Stavebank Creek, Sawmill Creek, Loyalist Creek, Mary Fix Creek) have been removed from the study area boundary as they are not major contributors to the Credit River or shoreline function)
9. Tecumseh Creek
10. Lornewood Creek
11. Turtle Creek
12. Sheridan Creek
13. Lakeside Creek
14. Avonhead Creek
15. Clearview Creek

Although this report references all tributaries, the study boundary does not necessarily capture the full catchment of all the associated watersheds. While the effects of some disciplines (e.g., coastal processes, hydrology, and water quality) extend beyond the LOISS boundary, others are fully captured within the study boundaries.

The phased approach to LOISS incorporates key findings from the Background Review into the Characterization as needed to provide context to the new data findings. The Characterization primarily summarizes the findings of those studies undertaken to fulfill identified data gaps for the following disciplines:

- Hydrogeology
- Hydrology and Hydraulics
- Fluvial Geomorphology
- Coastal Processes
- Water Quality
- Aquatic Natural Heritage
- Terrestrial Natural Heritage
- Outreach, Education and Communications

Baseline information for Conservation Lands (i.e. CVC owned properties within the study area) was summarized in the Background Review; however, no additional studies specific to this area of work has been undertaken. Similarly, studies to advance an Ecological Goods and Services assessment have not been undertaken. Conservation Lands and Ecological Goods and Services are integral to the management of the shoreline and will be advanced by CVC's Corporate Services and Watershed Knowledge departments in partnership with other organizations.

Data gaps identified through the Background Review were provided to each discipline lead (primarily comprised of CVC technical staff) for LOISS. Supplemental studies were undertaken by consultants where in-house expertise was not available (e.g. coastal processes and fluvial geomorphology). Supplemental studies are listed in Table 2-1. These studies have been referenced where applicable in this report. Each discipline lead tailored the approach to fulfilling the data gap based on suitable access to survey sites and funding limitations. Figure 2-3 and Table 2-2 summarize the locations of data collection and the type of data collected throughout LOISS study area. Discipline leads identified the appropriate protocols to follow in order to produce the data needed to characterize the study area.

Table 2-1: Studies completed through the LOISS Characterization phase

Discipline	Study Title	Author
Fluvial Geomorphology	Moore Creek: Fluvial Geomorphology Assessment	Aquafor Beech Limited
	Avonhead Creek: Fluvial Geomorphology Assessment	Ecosystem Recovery Inc.
	Sediment Movement – Applewood and Serson Creek	Parish Geomorphic
Coastal Processes	LOISS Assessment of Coastal Engineering Structures Phase 1	GHD
	LOISS Assessment of Coastal Engineering Structures Phase 2	Shoreplan Engineering Ltd
	CVC Shoreline Monitoring Program	Geomorphic Solutions
	CVC Shoreline Monitoring	GHD
	Environmental Internship – Final Report (Shoreline changes over time)	Jesse Ruthart
Water Quality	Lake Ontario Integrated Shoreline Strategy Lake Modeling	Dr. Ray Dewey
	Lake Ontario Integrated Shoreline Strategy Tributary Water Quality Modeling	EBNFLO Environmental
Aquatic Natural Heritage	The Provision of Diving Services for the Collection of Benthic Data in Support of the Lake Ontario Integrated Shoreline Strategy: Summary Field Report	Pollutech
Terrestrial Natural Heritage	Credit River Estuary: Species at Risk Research Project	CVC
Outreach, Education and Communications	Lake Ontario Shoreline Survey: Uses, Attitudes and Perceptions of Restoration Options	LURA
	Living by the Lake: Communications Strategy for LOISS (2011) LOISS Communications Roll-Out (2012; 2013; 2014)	Redbrick Communications

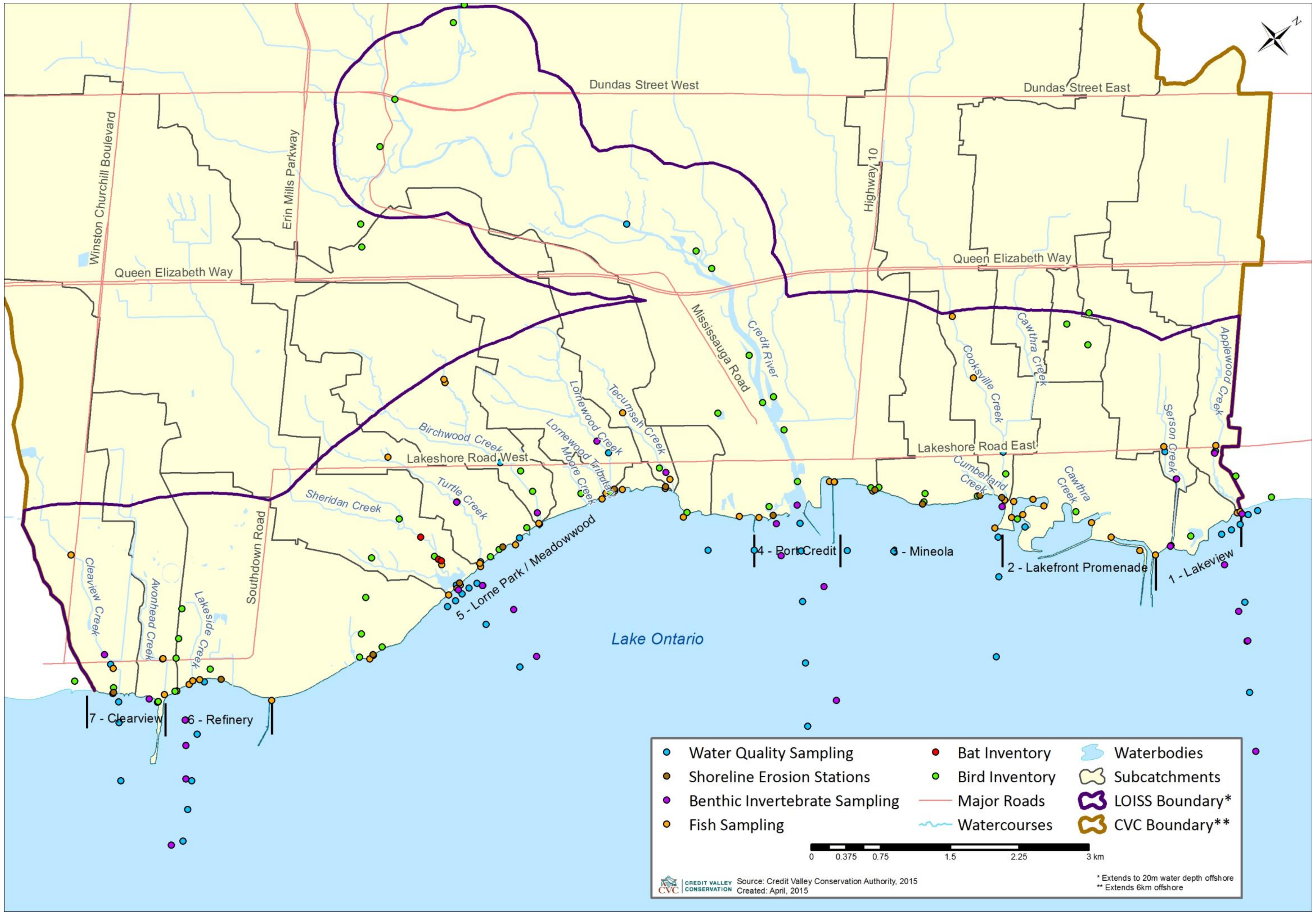

Figure 2-3: Locations of survey stations in the LOISS study area to fulfill data gaps.

Table 2-2: Studies undertaken to address data gaps (per watershed and coastal reach)

Discipline	Study	Watershed															Coastal Reach						
		Clearview	Avonhead	Lakeside	Sheridan	Turtle	Birchwood	Moore	Lornewood	Tecumseh	Credit	Cumberland	Cooksville	Cawthra	Serson	Applewood	Lakeview	2 - Lakefront Promenade	3 - Mineola	4 - Port Credit	Lorne Park/ Meadowwood	6 - Refinery	7 - Clearview
Hydrology and Hydraulics	Ice cover																X	X	X	X	X	X	
	Sediment loading				X		X		X				X		X	X							
	Drainage area	X	X		X	X	X	X	X	X	X	X	X	X	X	X							
	Flood-vulnerable structures		X					X				X											
Coastal Processes	Assessment of Public structures																	X	X	X	X	X	
	Erosion monitoring																		X	X	X	X	X
	Effects of waves on nearshore currents																X	X	X	X	X	X	X
	1-D littoral sediment transport assessment																X	X	X	X	X	X	X
	2-D littoral sediment transport assessment																X	X	X	X	X	X	X
	Baseline cross shore bathymetric data sediment composition and underwater video																X			X	X	X	
	Bathymetry analysis																X						
Water Quality	Mike 3 model																X	X	X	X	X	X	X
	Phosphorus EMC values	X	X		X	X	X		X		X		X		X	X							
	HSP-F model	X	X		X	X	X		X		X		X		X	X							
	Water quality sampling	X	X		X	X	X		X		X		X		X	X	X			X	X	X	
	Algae, Dreissenid, Round Goby																X			X	X	X	
	Temperature monitoring	X	X	X	X	X	X			X			X		X	X							
Aquatic Natural Heritage	Fisheries	X	X	X	X	X	X		X	X	X		X		X	X	X	X	X	X	X	X	X
	Benthic macroinvertebrates	X				X	X	X		X	X				X	X	X			X	X	X	
Terrestrial Natural Heritage	Unevaluated wetlands																	X		X			
	Migratory landbirds																X	X	X	X	X	X	X
	Migratory shorebirds and waterfowl																X	X	X	X	X	X	X
	Butterfly and odonate	X		X	X	X	X	X	X		X	X	X	X		X							
	Bat acoustic																X						X

Data collected by each discipline were analysed (using statistical analysis and modelling where appropriate) and interpreted.

Consistent with the broad recommendations of Zuzek et al (2013), the characterization for each discipline is integrated within each coastal reach (Section 4). Seven coastal reaches were delineated and limits defined where there were total or near total barriers to littoral sediment transport (Table 2-3 and Figure 2-1) (Shoreplan Engineering Ltd (SEL) 2011).

Table 2-3: Coastal Reaches

Coastal Reach Number	Coastal Reach Name	Associated Tributaries	Linear distance (m)
1	1 – Lakeview	Serson Creek Applewood Creek	1355
2	2 - Lakefront Promenade	Cawthra Creek	9040
3	3 – Mineola	Cumberland Creek Cooksville Creek	2334
4	4 - Port Credit	Credit River	3497
5	5 - Lorne Park/ Meadowwood	Sheridan Creek Turtle Creek Birchwood Creek Moore Creek Lornewood Creek Tecumseh Creek	6927
6	6 – Refinery	Avonhead Creek Lakeside Creek	2380
7	7 – Clearview	Clearview Creek	2270
		Total	**27802**

3 CHARACTERIZATION

This characterization describes the biotic and abiotic constituents that make up the aquatic and terrestrial habitat features and functions within the study area.

Biotic constituents are those living elements that contribute to the ecosystem. These include producers, consumers, and decomposers that affect populations of other biotic components. Biotic constituents also include human influences. Pathogens and diseases that are commonly grouped with these constituents are not discussed in this report. Abiotic factors, those non-living components that contribute to the ecosystem, include temperature, wind, waves, precipitation, water levels, light, etc. Biotic and abiotic constituents combine to create the features, functions and linkages in the study area.

This section, Characterization, is a discipline-by-discipline summary of the role the discipline plays in characterizing the LOISS environment. Each section provides an overview of the findings of the Background Review, as applicable, followed by the methods used to undertake studies to fulfill the listed data gaps. The Characteristics subsections provide an analysis of the findings and analysis from the data gap fulfillment studies. The Synthesis subsections summarize the findings presented in the section and recommendations of the discipline to be carried forward to the next phase of LOISS (Implementation).

3.1 HYDROGEOLOGY

In areas of urban development, the loss of infiltration and retention areas (e.g., wetlands and headwater streams) reduces the potential for geological materials to infiltrate, filter and discharge water into streams (Paul 2001). Lack of groundwater monitoring data for pre- and post-development makes it impossible to determine the magnitude of the loss of groundwater infiltration caused by development in the LOISS study area. Tributary flow during prolonged periods of dry weather are assumed to be comprised primarily of groundwater discharge; however, other inputs such as discharge from sewers or other infrastructure can also contribute to overall flows during otherwise low flow conditions. Therefore, baseflow can only be measured semi-quantitatively in an urbanized area. Baseflow is an important measure in determining the health of aquatic ecosystems and can have implications for watercourse use by fish and other aquatic life, water quality and temperature regulation.

A thorough characterization of the regional geology and groundwater of the LOISS study area was completed in the Background Review. The surficial geology map from the Background Review is provided in Figure 3-1 as context to the information presented below. The extensive background information led to the recommendation that further research is only required on a local site scale as it relates to a project or undertaking to confirm regional findings. The following summary of the Background Review includes updated information on baseflows (an indicator of potential groundwater inputs) and potential locations of groundwater contributions to tributaries.

3.1.1 Characteristics

The Background Review identified deep groundwater levels (>25 m depth) and shallow groundwater levels (<25 m depth) in the LOISS study area, estimated based on information from the Ministry of the Environment, Conservation and Parks (MECP) water well records from the Integrated Water Budget Report – Tier 2 Credit River Source Protection Area (Tier 2 Report) (AquaResources 2009). Both the deep and shallow groundwater levels are higher to the northwest of the study area and lower to the southeast (Figures 3-2 and 3-3). Direction of groundwater flow is perpendicular to surface contour lines. Deep and shallow groundwater surface contours suggest groundwater flows toward the interpreted buried bedrock valley just west of the Credit River valley (Figure 3-2) as well as directly to the lake.

Recharge rates from the Tier 2 Report indicate a recharge rate of about 25 to 150 mm/year across most of the study area with higher recharge rates along the northern edge coincident with bedrock or bedrock drift. This area of higher recharge also coincides with many of the headwater areas for those tributaries in the 5 - Lorne Park/Meadowwood and 6 - Refinery Coastal Reaches.

At the site scale, actual groundwater levels and flow directions could be significantly different from those estimated from MECP water well records, particularly where local fill placement or subsurface infrastructure (e.g., watermains) may influence groundwater flow directions and levels. The Background Review stated that conditions (vertical hydraulic gradient and moderate to highly permeable underlying sand and fractured Georgian Bay shale (Figure 3.1)) exist for groundwater discharge to streams in the LOISS study area however local studies are needed to confirm actual discharge (ABL 2011). Evidence of groundwater has been observed along Moore Creek (iron staining and seeps along the banks) and Birchwood Creek (presence of skunk cabbage which grows in continuously saturated soils). Close to the shore of Lake Ontario, it is expected that the lake level has a strong influence on local groundwater levels (i.e. groundwater levels are comparable to lake water levels); however, areas with hardened shorelines may limit that influence.

Baseflow (i.e., stream flow measurements after a minimum of two days without precipitation) is considered to represent groundwater contributions to streams. Previously unreported spot baseflow measurements were completed in Cooksville and Sheridan Creeks in 2008, and for the remaining 12 tributaries in July 2011 and 2013 (Table 3-1). All tributaries had measurable flow during dry summer conditions. In urban areas, the source of baseflow in streams may not be entirely from natural sources (i.e. groundwater or wetland discharge). Infrastructure leakage and discharge may also contribute to stream flow. Hence baseflow alone is not a reliable indication of groundwater presence in urban systems.

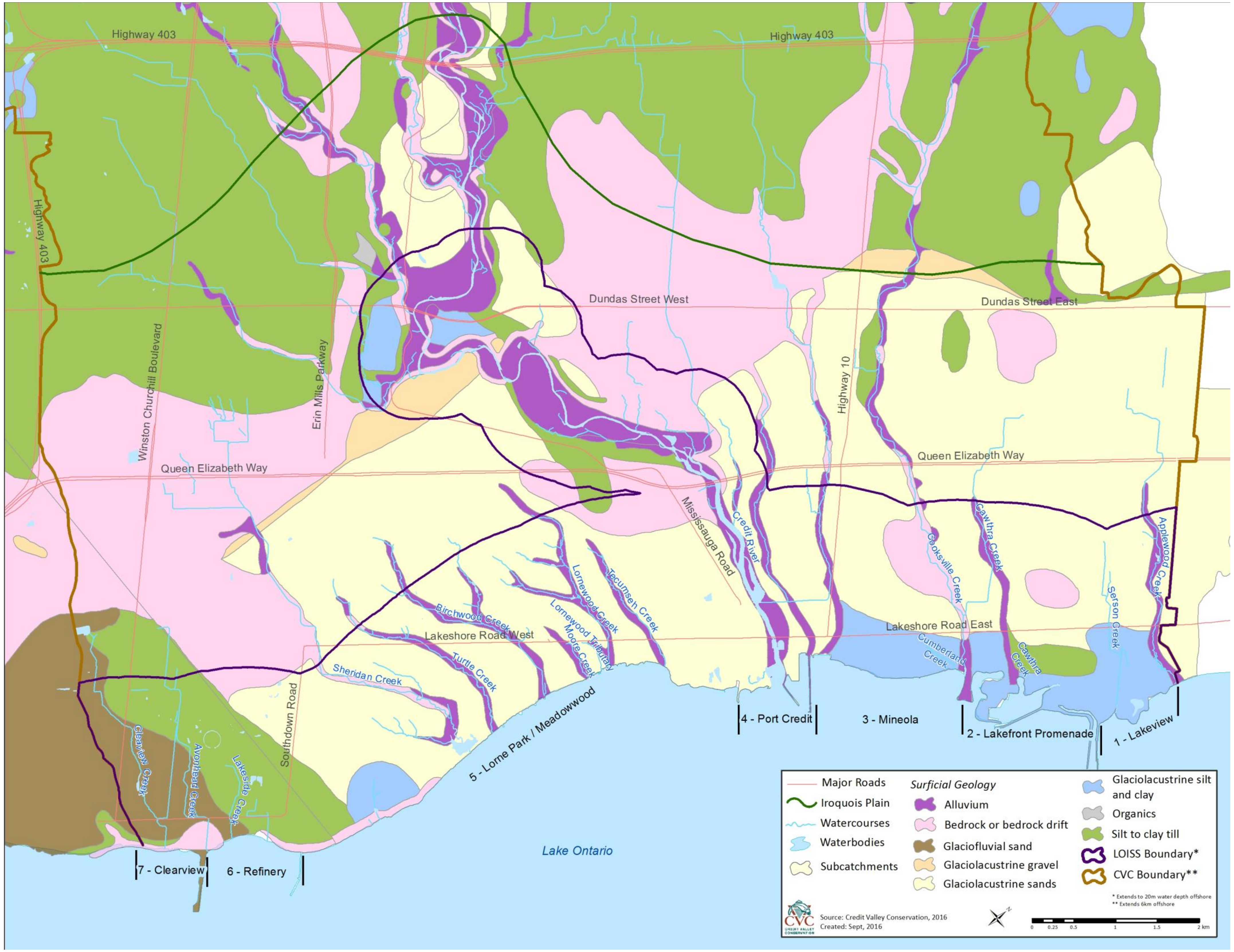

Figure 3-1: Surficial geology in southern Mississauga.

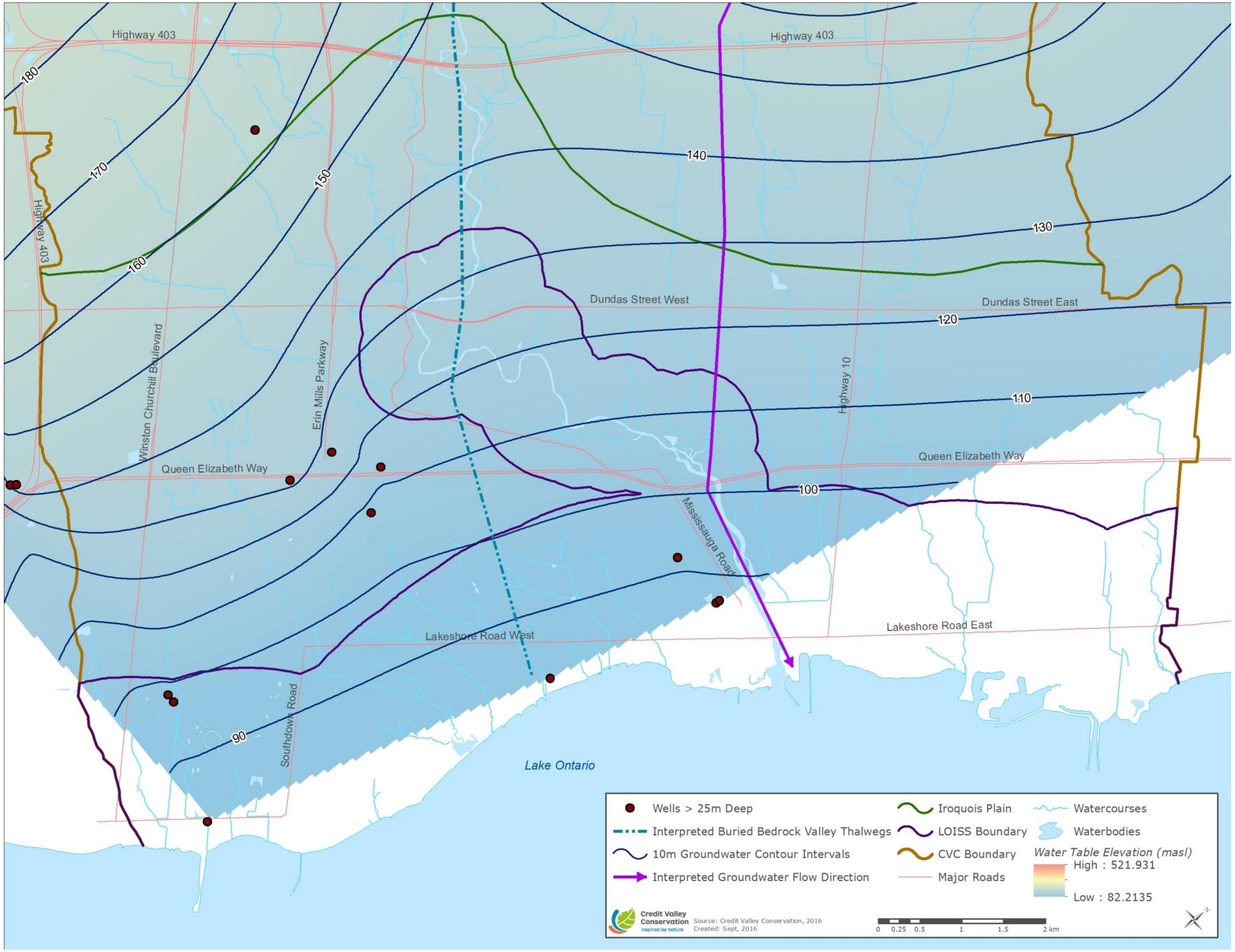

Figure 3-2: Deep groundwater surface contours showing flows directed towards interpreted buried bedrock valley west of the Credit River (Source: ABL 2011)

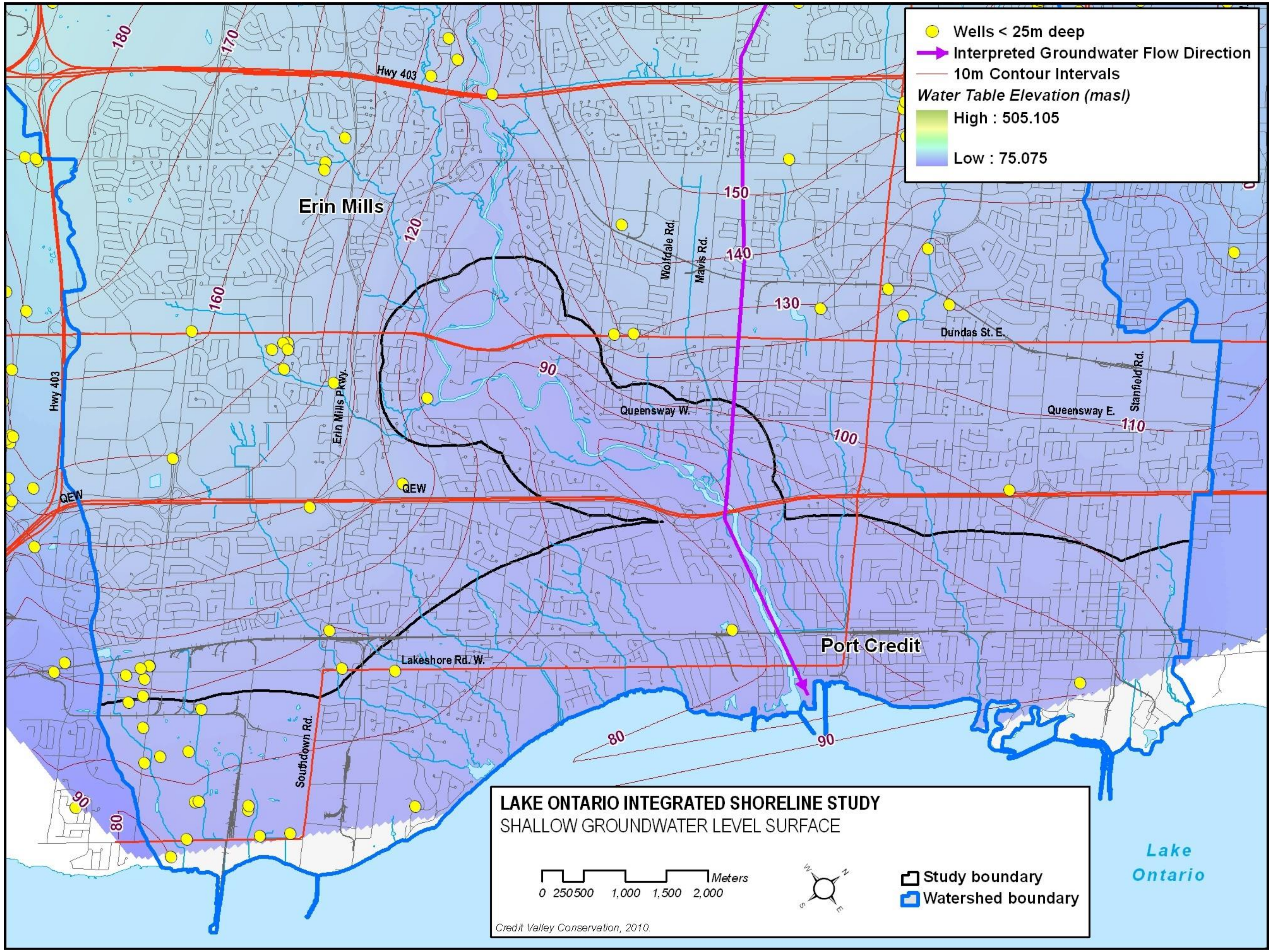

Figure 3.3: Shallow groundwater level surface (Source: ABL 2011)

Table 3-1: Approximate baseflow for tributaries in the LOISS study area.

Coastal Reach	Watershed	Drainage Area Contributing to Baseflow	Approximate Baseflow[1]		Predominant Surficial Geology Unit
			L/s*	m^3/s	
1 - Lakeview	Serson Creek	204 ha**	1	0.001	Glaciolacustrine Sand, Silt, and Clay
	Applewood Creek	597 ha**	10	0.01	Glaciolacustrine Sand
2 - Lakefront Promenade	Cawthra Creek	604 ha (diverted to Cooksville Creek)	10	0.01	Glaciolacustrine Sand, Halton Till, Glaciolacustrine Silt and Clay
3 - Mineola	Cumberland Creek	44 ha	1	0.001	Glaciolacustrine Silt and Clay
	Cooksville Creek	3200 ha (including diversion from Cawthra Creek)**	100[2]	0.1	Glaciolacustrine Sand
4 - Port Credit	Credit River	1000 ha	3000[3]	3.0	Glaciolacustrine Sand
5 - Lorne Park/Meadowwood	Sheridan Creek	1035 ha	100[4]	0.1	Bedrock and Bedrock drift and Glaciolacustrine Sand
	Turtle Creek	213 ha	1	0.001	Glaciolacustrine Sand
	Birchwood Creek	340 ha	10	0.01	Glaciolacustrine Sand
	Moore Creek	8 ha[5]	0.26	0.00026	Glaciolacustrine Sand
	Lornewood Creek	411 ha	10	0.01	Glaciolacustrine Sand
	Tecumseh Creek	167 ha	1	0.001	Glaciolacustrine Sand
6 - Refinery	Avonhead Creek	130.2 ha	1	0.001	Glaciofluvial Sand and Halton Till
	Lakeside Creek	250 ha	4.3[2]	0.0043	Glaciolacustrine Sand and Halton Till
7 - Clearview	Clearview Creek	414 ha	1	0.001	Glaciofluvial Sand

* Baseflows were measured at various points in each stream. These values represent an order of magnitude for comparison purposes.
[1] source: Aquafor Beech Ltd. 2011 except where noted
[2]source: Cooksville Creek Watershed Study. CVC 2010
[3]source: CVC data
[4]source: Sheridan Creek Watershed Study, CVC 2010a
[5]Moore Creek existing drainage area (2008). Diversion of 8 to 13 ha into storm sewers discharging to Lornewood Creek in 1986 (source: T. Nightingale City of Mississauga)

Depending on the depth below ground surface, groundwater temperatures are typically consistent in the 8 to 12°C range; therefore, stream temperature may be an indicator of groundwater contributions to flow under some conditions (i.e., thermal influences of groundwater discharge are most apparent during warmer or colder months). Groundwater helps to regulate water temperatures in the winter and summer by moderating extreme highs and lows. CVC conducted stream temperature surveys in the summer of 2011 (Table 3-2) to inform the characterization of the LOISS streams. Continuous range temperature readings were collected in July and August in 2011 using HOBO thermal loggers in 11 streams. Hobo temperature loggers were placed in pools at road crossings closest to the mouth of each stream. Temperature data was collected every 15 minutes for most streams (30 minutes for Cooksville and Sheridan Creeks).

Table 3-2: Summer (July 1 to end of August 31) Instream Temperature

Coastal Reach	Tributary	2011 continuous temperature (°C) [3] July 1 – August 31 Avg. Air Temp (23°C)*
		Water
1 – Lakeview	Serson Creek	Avg: 20 Max: 26 Min: 14
	Applewood Creek	Avg: 21 Max: 27 Min: 16
2 - Lakefront Promenade	Cawthra Creek	n/a
3 – Mineola	Cumberland Creek	n/a
	Cooksville Creek	Avg: 22 Max: 29 Min: 17
4 - Port Credit	Credit River	Avg: 24 Max: 32 Min: 17
5 - Lorne Park/Meadowwood	Sheridan Creek	Avg: 21 Max: 37 Min: 17
	Turtle Creek	Avg: 19 Max: 23 Min: 15
	Birchwood Creek	Avg: 20 Max: 25 Min: 15
	Moore Creek	n/a
	Lornewood Creek	n/a
	Tecumseh Creek	Avg: 15 Max: 20 Min: 12
6 – Refinery	Avonhead Creek	Avg: 21 Max: 26 Min: 17
	Lakeside Creek	Avg: 17 Max: 27 Min: 14
7 – Clearview	Clearview Creek	Avg: 21 Max: 25 Min: 17

Source: CVC unpublished data (note: June data not included due to incomplete dataset)
* average air temperature at Credit River (Mississauga Golf and Country Club) and Cawthra Climate Stations, including night time temperatures.

As with baseflow, urban development (culverts and pipes) can influence stream water temperature by shielding them from thermal inputs or mitigating thermal inputs by conveying colder underground temperatures. Generally, streams with water temperatures rarely higher than 20^{o}C likely have significant groundwater contributions. For the LOISS study area, these conditions were observed in the following streams:

- Serson Creek
- Turtle Creek
- Birchwood Creek
- Tecumseh Creek
- Lakeside Creek

It should be noted that Lakeside Creek and Tecumseh Creek flow through long pipes just upstream of the sampling location. These pipes likely influence water temperature in these streams.

Temperature results from 2011 data are similar to results reported through modelling completed in the Tier 2 Report which identified the following tributaries with potential groundwater contributions:

- Cooksville Creek
- Credit River
- Lornewood Creek
- Birchwood Creek
- Turtle Creek
- Sheridan Creek
- Lakeside Creek
- Avonhead Creek

Additional studies are needed to confirm baseflow of these streams include groundwater sources.

Groundwater discharge quantity was modeled in the Tier 2 Report. The model estimates that 10,000 m^3/day (115 L/s) discharges to LOISS streams (excluding the Credit River). This equates to 1 L/s per kilometer of stream or 2 to 3 L/s for most streams in the study area. Estimates of groundwater discharge directly to Lake Ontario is about 17,000 m^3/day based on modeling. Evidence of groundwater (seeps) was observed by CVC staff in 2012 along the bluff at Lorne Park estates (5- Lorne Park/Meadowwood)

Groundwater quality sampling has not been undertaken as part of the LOISS.

3.1.2 Synthesis of Hydrogeology

While it is generally accepted that development reduces infiltration, reduces groundwater discharge, and reduces the regulation of stream water temperature and baseflow (Paul 2001), the impact of these changes on the ecosystem cannot be determined without an understanding of the pre-development condition.

Many factors control groundwater contribution to natural heritage features. Catchment size appears to be the most important factor in determining groundwater contributions to stream flows since there are similar discharge contributions for sand and shale units (Georgian Bay Formation) (ABL 2011). The influence of anthropogenic contributions to baseflows (e.g., via pipes and sewers) are difficult to quantify but are important qualifiers for data interpretation.

Water temperature data and baseflow measurements were analyzed to compare to the findings of the Tier 2 Report model which identified potential groundwater inputs to the LOISS tributaries. These data on their own are insufficient to identify potential groundwater contributions to tributaries. While it is recommended that additional baseflow and temperature surveys be undertaken to further refine the understanding of potential groundwater contributions to stream flows, based on the available data, the tributaries listed in Table 3-3 may have groundwater input since they have measureable flow and temperatures rarely exceed 20^{o}C during the summer months. Moore Creek is also included on this list due to the observed groundwater indicators (iron staining and seeps). No temperature data is available for Moore Creek.

Table 3-3: Potential Groundwater Contributions

Coastal Reach	Tributary
1 - Lakeview	Serson Creek
5 - Lorne Park/Meadowwood	Turtle Creek
	Birchwood Creek
	Moore Creek
	Tecumseh Creek
6 – Refinery	Lakeside Creek

Baseflow and temperature data do not support the modeling results presented in the Tier 2 Report that also identifies Cooksville Creek, Credit River, Lornewood Creek, Sheridan Creek, and Avonhead Creek as potentially receiving groundwater discharge. Perhaps not surprising, Sheridan Creek, Turtle Creek, Birchwood Creek, Lornewood Creek and Tecumseh Creek show up on these lists of streams with potential groundwater contribution since the shallow groundwater mapping (Figure 3.3) identified the headwaters of this streams as being in an area where groundwater is generally high. Still, further studies should be considered on a project by project basis in all LOISS stream watersheds due to uncertainty of anthropogenic influences.

No further efforts have been made to quantify direct groundwater discharges into Lake Ontario in the LOISS study area beyond the modeling completed through the Tier 2 Report, although discharges along the bluff habitat within Lorne Park Estates (5 - Lorne Park/Meadowwood Coastal Reach) have been observed. This may warrant closer examination of potential nearshore restoration opportunities as well as slope stability in future studies.

A number of data gaps (e.g. groundwater quality, artificial contributions to baseflow, discharge to the lake and stream mouths, etc.) still exist for hydrogeology, and are best suited to being addressed at the site scale (Table 3-4). Groundwater studies for individual projects will also be necessary to confirm the findings of the regional groundwater studies.

Table 3-4: Summary of Hydrogeology Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Studies to be completed on a project-by-project basis			

3.2 HYDROLOGY AND HYDRAULICS

Increases in the frequency of overland flow, frequency of erosive flow, magnitude of high flow, rise and fall of storm hydrograph, and a decrease in lag time to peak flow are consistent hydrologic responses among urban tributaries (Walsh et al., 2005). In urban tributaries, such as those in the study area, the hydrograph is typically compressed, reflecting the stream's quick response cycle (peak to recovery) to storm events (i.e. flashiness) due to a reduction in infiltration and attenuation in headwaters, limited access to floodplains and lack of diversity in channel morphology to reduce velocities. Increases in peak rates and volumes due to runoff, increases the erosive force of uncontrolled discharge over a shorter duration, which can cause geomorphic changes to downstream reaches including widening and downcutting. Further, piped (enclosed in culverts or other engineered structures) headwaters detached from their floodplains increase the risk of flooding downstream due to reduced attenuation of flows in these upstream areas. The variability and stability of flows are needed to maintain morphology, fish production and habitat suitability, invertebrate production and habitat suitability, with other flow conditions necessary to achieve certain water quality parameters and to relieve flooding.

Flow data, overtopped structures and imperviousness were identified as data gaps in the Background Review for some LOISS tributaries (Table 3-5). Hydraulic modelling for the LOISS streams will be updated in 2018. This section summarizes the flows, flooded structures and diversions in the LOISS tributaries detailed in the Background Review.

Table 3-5: Status of Hydrology and Hydraulics Data Gaps

Data Gap	2017 Status
Avonhead Creek flows: 2-25 year North of Lakeshore Road – Existing	In Progress
Avonhead Creek flows: 2-25 year Western portion of watershed – Post-development	In Progress
List of overtopped structures and flooded buildings (Avonhead Creek, Cumberland Creek, Moore Creek)	In Progress
% Imperviousness (Avonhead Creek, Cumberland Creek, Moore Creek)	To be completed in 2018
% Imperviousness (Credit River)	Not being pursued
Credit River flows: Regional Upstream of Highway 5	In Progress
Credit River flows: Regional Upstream of Queen Elizabeth Way (QEW)	In Progress
Credit River flows: Regional CN Rail Line	In Progress
Cumberland Creek flows: All	In Progress
Cumberland Creek drainage area	Complete
Cumberland Creek Hydrologic model	In Progress
Cumberland Creek Hydraulic model	In Progress
Cumberland Creek flood hazard mapping	In Progress
Moore Creek flows: All	In Progress
Moore Creek drainage area	Complete
Moore Creek hydrologic model	In Progress
Moore Creek hydraulic model	In Progress
Moore Creek flood hazard mapping	In Progress

3.2.1 Characteristics

With the exception of refined drainage areas for Cumberland Creek and Moore Creek and updates to the list of flooded structures, updated hydrology and hydraulics studies are not yet complete. Below is a summary of findings from the Background Review including related updates not previously identified that are important to carry forward to ensure a comprehensive understanding of stream function. These findings will be integrated with other disciplines and carried forward as recommendations, where appropriate.

3.2.1.1 Flows

Various return period peak flows (Table 3-6) for tributaries within the study area were compiled from previous floodplain mapping studies by CVC based on hydrology models. Significant gaps exist in the monitored flows for the Lake Ontario tributaries particularly for larger return periods. Examination of existing return period peak flow model data at the outlets of the Lake Ontario tributaries (Table 3-6) (excluding the Credit River) revealed that Lakeside Creek has the smallest 2-year return period flow of 1.8 m^3/s, and Cooksville Creek (80 m^3/s) the largest 2-year return period peak flow. The tributaries follow a similar order for higher flows (100-year and Regional flows). Of interest is the comparison of the 2-year return period peak flow for Cooksville Creek to that of the Credit River. The Credit River drainage area is 26 times larger than the Cooksville Creek drainage area yet the 2-year return period peak flow of the Credit River are only 1.5 times greater than that of Cooksville Creek. The higher 2-year return period flow in Cooksville Creek relative to its small drainage area as compared to the Credit River demonstrates the flashiness of the flows in Cooksville Creek during frequent storm event.

Table 3-6: Summary of Return Period Peak Flow by Subwatershed at the furthest downstream location. All flows are for the mouth of the stream except where identified (Source: CVC floodplain modelling).

Watercourse	Drainage Area (km^2)*	Flow (m3/s)						
		2-year	5-year	10-year	25-year	50-year	100-year	Regional
Applewood Creek	5.97	9.57	13.77	18.48	22.72	26.77	31.31	50.20
Serson Creek	2.04	4.1	6.7	9.8	12.4	14.9	18.2	23.4
Cawthra Creek[5]	6.04	0.0	0.0	0.0	7.2	14.0	22.1	30.5
Cooksville Creek	33.9	80	100	115	140	160	180	315
Cumberland Creek	0.44	-	-	-	-	-	-	-
Credit River[4]	900	126	231.22	293.51	395.31	477.57	550.24	-
Tecumseh Creek	1.67	3.1	5.5	8.0	10.7	12.8	15.7	19.1
Lornewood Creek[3]	4.11	3.6	5.08	6.48	7.69	10.35	11.77	12.03
Moore Creek	0.08	-	-	-	-	-	-	-
Birchwood Creek	3.4	6.7/ 8.9	8.2/11	9.5/12	12/15	14/18	16/20	35/35
Turtle Creek	2.13	4.2	6.3	9.0	11.5	14.0	17.0	25.5
Sheridan Creek	10.35	27.78	43.17	47.23	66.88	78.08	89.12	108.02
Lakeside Creek	2.5	1.8	3.3	5.0	6.7	8.3	10.1	13.3

Watercourse	Drainage Area (km^2)*	Flow (m3/s)						
		2-year	5-year	10-year	25-year	50-year	100-year	Regional
Avonhead Creek [2]	0.85*	-	-	-	-	15.67	28.20	28.82
Clearview Creek [1]	4.14	-	-	-	-	40.13	48.61	55.63

1. South of Lakeshore Road
2. North of Lakeshore Road
3. QEW
4. CN Rail Line
5. South of Lakeshore Road

* Drainage areas are subject to change associated with diversions
- indicates flows are not available

A number of factors influence stream flows including imperviousness, land use, and stream slope, and drainage area. Notably, in urban tributaries, channel-forming flows are typically the 1.2-year return flow not the 1.4-1.6-year return flow in natural tributaries (Rosgen 1996). Meaning, channel-forming flow are experienced more frequently in urban land uses than rural.

The above information is based on existing condition models and do not reflect the potential changes associated with climate change. As the climate changes it is expected that the potential for flooding will increase due to increased imperviousness and the extend of flooding will increase due to increased volumes of runoff (Dickinson, 2018). Predictive models can be used to better inform infrastructure design today to address potential conditions in the future.

Real Time Monitoring Stations
CVC now has five real-time flow stations within the LOISS study area:

- Applewood Creek (installed December 2013)
- Serson Creek (installed December 2012)
- Cooksville Creek (installed June 2009)
- Turtle Creek (installed December 2012)
- Sheridan Creek (installed December 2013),

one real-time climate station:

- Cawthra Woods (installed January 2011),

and one real-time rainfall station

- Jack Darling Park (installed December 2013),

The data collected at these stations will be used to inform various studies including hydraulic modelling updates. CVC's real-time data can be accessed at www.creditvalleyca.ca/watershed-science/watershed-monitoring/real-time-monitoring.

Tributary Flow and Lake Ontario
The complex interactions between stream flows and lake waters influence water levels, thermal structure, circulation, water inflow and ice in the lake. Depending on the magnitude of discharge, water entering Lake Ontario from streams and other outlets can influence the currents in the lake, locally and potentially basin-wide as the Niagara River demonstrates (Section 3.4.1.3). The measured stream flows

provide a relative basis to determine their potential influence on nearshore processes.

The substantially higher discharge from the Credit River than the other urban tributaries has the greatest impact on nearshore processes. Cooksville Creek and Sheridan Creek have the similar magnitude flows with potential to influence the lake waters but to a lesser degree than the Credit River. However, flows in Sheridan Creek discharge to the lake through Rattray Marsh, which attenuates flows likely decreasing the local effect of the discharge to Lake Ontario. The remaining LOISS tributaries experience flows of similar magnitude to each other and do not significantly influence local lake currents and nearshore processes.

Similarly, the greater the flow, the more influence the stream waters have on whether waters enter the lake as interflow, overflow or underflow (Section 3.4.1.3). These interactions are important in developing a complete understanding of how the hydrologic and hydraulic processes can affect other disciplines, both temporally and spatially. A range of flows needs to be considered when determining the effect hydrology has on the biologic health of the tributaries and Lake Ontario.

3.2.1.2 Flooded Structures

Flooding of structures (culverts and buildings) is of paramount concern to CVC and member municipalities due to the potential impacts to life and property. Flooding of structures can occur due to their location in proximity to floodways associated with tributaries or the lake or due to under capacity culverts or pipes that restrict flow access to floodplains. Undersized crossing structures and pipes of buried streams may restrict flow conveyance causing backwater effect and flooding. Lack of overland flood routes exacerbate flooding in low-lying areas.

In the long term, undersized openings may result in the watercourse channel migrating into the crossing and road or rail infrastructure including footings, piers or embankments, thereby requiring maintenance and added costs. Further, encroachment into to floodplain and interruption of natural stream processes (e.g., the creation of backwater areas, exacerbated erosion, lack of access to the floodplain, etc.) degrades the overall health of aquatic habitats in both the stream and littoral areas of the lake.

Many of the tributaries have clusters of structures in the floodplain just upstream of the rail line that traverses the study area. These clusters of at-risk structures are in part due to the damming effect of the raised rail bed. While some flows are conveyed through the culverts, higher flows are backed up behind the raised rail bed and potentially undersized culverts causing the floodplain upstream of the rail line to widen. This damming effect also occurs at many road crossings; however, most roads today are designed to eliminate offsite-flooding impacts.

A list of flood-vulnerable structures within the study area and the return period in which they are flooded (ABL 2011 and subsequently updated by CVC in 2012) was compiled in the Background Review. Table 3-7 shows that the majority of structures are flooded at return periods greater than 10 years, a few such as Turtle Creek, Serson Creek, and Cooksville Creek are flooded at 2-year and 5-year events. Overall, Cooksville Creek has the highest number of buildings (133 buildings) vulnerable to flooding. Updates to floodplain mapping and to the associated number of structures that are flood vulnerable is being completed by CVC in 2018.

Table 3-7: Number of Flood-Vulnerable Structures by Return Period* (Source: ABL 2011 and subsequently updated by CVC in 2012)

Coastal Reach	Watercourse	Number of Flood-Vulnerable Buildings by Return Period							
		Total	Regional	100-Yr	50-Yr	25-Yr	10-Yr	5-Yr	2-Yr
1 – Lakeview	Serson Creek	106	106	106	106	106	86	6	1
	Applewood Creek	17	17						
2 – Lakefront Pomenade	Cawthra Creek	5	5	5	5	5	5	0	0
3 – Mineola	Cooksville Creek	133	133	39	25	17	13	5	0
	Cumberland Creek								
4 – Port Credit	Credit River	0	0	0	0	0	0	0	0
5 – Lorne Park/Meadowwood	Sheridan Creek								
	Turtle Creek	58	58	58	58	58	56	56	4
	Moore Creek								
	Birchwood Creek	5	5	1	0	0	0	0	0
	Lornewood Creek	10	10						
	Tecumseh Creek	8	8	0	0	0	0	0	0
6 – Refinery	Avonhead Creek								
	Lakeside Creek	0	0	0	0	0	0	0	0
7 – Clearview	Clearview Creek								

*data currently being updated

Data unavailable

3.2.1.3 Diversions

As in many urbanized areas, numerous historic alterations such as diversions and enclosures (i.e., piped sections of streams) have been made to the tributaries found within the study area. Many of the headwater drainage features within the City of Mississauga are now contained within storm sewers, with the associated network in some instances encompassing the natural catchment area of these urban tributaries. Hence, the sewershed is the most accurate delineation of the catchment for many of these tributaries.

Diversion of flows or portions of catchments to neighbouring tributaries has been used in the past to alleviate flooding downstream. It should be noted that the diversions identified in Figure 3-5 may contribute to increased flooding upstream of the diversion structure under a climate change scenario. This is due to potentially insufficient capacity within existing diversion structures to accommodate the increase in flows expected as climate changes. Hydraulic modeling using flows representative of climate change scenarios is recommended to determine the resiliency of existing diversion infrastructure and infrastructure downstream of the diversion on receiving streams.

The study area contains the following known diversions; however, others are likely and will be documented as additional information becomes available (Figure 3-4):

Avonhead Creek

A drainage area of 148.88 ha has been diverted from Avonhead Creek to Clearview Creek (Totten Sims Hubicki and Harington and Hoyle 2000). As a result of the diversion, only baseflows remain in Avonhead Creek between Orr Road and the piped section of Avonhead Creek at Avonhead Road. Flows increase significantly in the pipe downstream of Lakeshore Road with the addition of stormwater and non-contact processing water from CRH Canada Inc.

Moore Creek

Approximately 8–13 ha of drainage area have been diverted from Moore Creek to the stormsewer, resulting in a remaining drainage area of 8 ha.

Cawthra Creek

Flows from Cawthra Creek are diverted to Cooksville Creek at Dellwood Park (Atwater Ave. and Cawthra Road). The diversion structure has a capacity of approximately 20 m^3/s. The remaining stream is piped under existing development and discharges directly to Lake Ontario at Lakefront Promenade Park.

Serson Creek

Serson Creek flows are not diverted to another watershed; however, the flood flows have been separated from lower flows by the installation of a diversion channel. The low flows (less than 2-year flow) for Serson Creek are piped under the G.E. Booth Wastewater Treatment Facility (WWTF), while the less frequent higher flows travel south through a ditch located between the Ontario Power Generation (OPG) and G.E. Booth WWTF sites and discharge to Lake Ontario. This diversion will change through the implementation of the Lakeview Waterfront Connection[2] project (currently under construction) that will direct low flows down the diversion channel to re-establish fish passage into Serson Creek.

Little Etobicoke Creek

Recent analysis identified significant portions of flow from Little Etobicoke Creek (TRCA watershed) that spill into CVC's watershed jurisdiction during larger storm events. Further examination is needed to determine the pathway and distribution of flows into adjacent watersheds (Serson, Applewood, and Cooksville Creeks). The City of Mississauga (in partnership with CVC and TRCA) is initiating a flood evaluation study for the Little Etobicoke Creek watershed to evaluate various urban and riverine flooding mitigation measures.

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[2] Lakeview Waterfront Connection will be renamed in the future as this project transitions into one of Credit Valley Conservation's Conservation Areas.

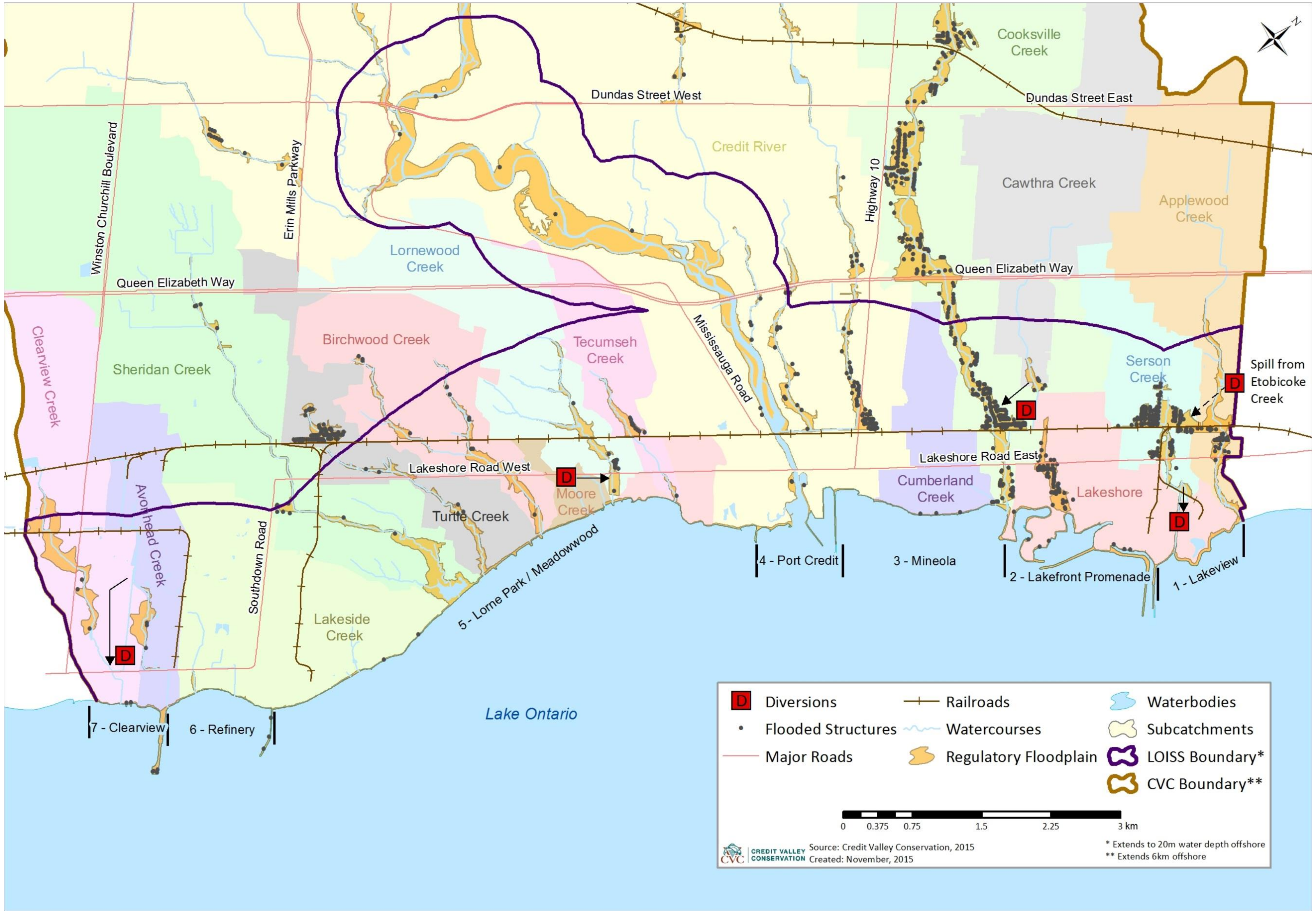


Figure 3-4: Location of flow diversions (D) and flooded structures.

3.2.2 Synthesis of Hydrology and Hydraulic

The enclosure of many stream headwaters in pipes within the study area and limited stormwater control has created flashy (rapid increase in flows during storm events) systems typical of urban tributaries. Further, floodplains have been built on, removed, or confined by development resulting in increased risk of flooding to structures. Methods to mitigate stormwater impacts (e.g. flashiness and increased risk of flooding) are recommended.

Turtle, Serson, and Cooksville Creeks have the greatest number of structures in the floodplain and face the highest risk of associated damages. CVC is updating the floodplain mapping for the LOISS tributaries in 2018 and subsequently the flooded structures mapping will be updated. Feasibility studies are recommended at a site level to determine if stream modifications, including crossing upgrades, will reduce (or remove) flooding of structures.

With the exception of the Serson Creek diversion, existing diversions are considered permanent due to the downstream constraints; hence, diversion of flows back to their original tributaries is very unlikely. However, an assessment of how the existing diversion structures perform under climate change scenarios should be undertaken and appropriate mitigation measures implemented to ensure these structures are climate change-ready.

Next steps and recommendations regarding Hydrology and Hydraulics are identified in Table 3-8.

Table 3-8: Summary of Hydrology and Hydraulics Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Study of techniques to mitigate stormwater impacts	All tributaries except Lakeside Creek, Moore Creek and Cumberland Creek*	High	CVC
Feasibility studies to reduce or remove risk of flooding of structures	All tributaries except Lakeside Creek, Moore Creek and Cumberland Creek and shoreline – Priority to Cooksville, Turtle, Serson Creeks.	High	CVC and City of Mississauga
Assessment of capacity of structures associated with diversions to perform under climate change scenarios	Clearview Creek/Avonhead Creek Lornewood Creek Cooksville Creek Applewood Creek Serson Creek	High	CVC and City of Mississauga

Action	Location	Priority (High, Medium Low)	Lead Agency
Update floodplain modelling to include climate change	All tributaries	Medium	CVC and City of Mississauga
Development of flood forecasting model	All Tributaries	Medium	CVC (currently underway)
Remove tributaries from underground pipes	All tributaries	Medium	CVC and City of Mississauga

*the majority of Lakeside Creek, Moore Creek and Cumberland Creek is contained in pipes with limited opportunities for daylighting hence impacts of stormwater on these streams in considered a low priority.

3.3 FLUVIAL GEOMORPHOLOGY

Fluvial geomorphology is the study of the form and function of tributaries and the interaction between tributaries and the landscape around them. Tributary channel form is a product of the flow regime and the availability and type of sediment found within the stream corridor. Headwater tributaries have been classified as 'production zones' as they supply much of the water and sediment to the downstream system (Schumm 1981). Sediment is then transported through the 'transfer zone' or mid-reaches and deposited in the 'deposition zone' or the river mouth. Sediment deposition in this area can be caused by barrier bars and wave action that slow down flows causing sediment to fall out of suspension.

Headwaters in urban areas are often piped or modified to allow for the addition of infrastructure and development, which is consistent with the condition of many of the tributaries found throughout the study area. These landscape scale changes result in a modified hydrologic regime and tributaries that are largely disconnected from their sediment supply. These changes often result in a period of rapid stream adjustment, which is evident through erosion and indicators of channel instability. Common signs of instability include: slumping and undercut banks, incised/entrenched channel (i.e. not well connected to the floodplain), and abrupt vertical drops (e.g. knickpoint, headcut) in the bed of the stream. Further, universal symptoms of the "Urban Stream Syndrome" (Walsh et al. 2005) are reductions in channel complexity and instream habitat caused by channelization and armouring of streambed and banks typically required to mitigate or repair damage due to erosion.

This section provides an overview of the data presented in the Background Review with updates where noted. The status of data gaps identified in the Background Review are found in Table 3-9.

Table 3-9: Fluvial geomorphology data gaps identified in the Background Review

Data Gap	2017 Status
Rapid Stream Assessment Technique (RSAT) evaluation for reaches of the Credit River	Not pursued
Documentation for the mouth of Serson Creek	Complete
Geomorphological data for Moore Creek	Rapid Geomorphic Assessment complete (RGA). RSAT incomplete
Sediment loads to Lake Ontario for all watercourses in the study area except the Credit River	Completed for Moore Creek

3.3.1 Characteristics

3.3.1.1 Fluvial Geomorphology Assessments

As part of the Background Review, AquaforBeech Ltd. delineated stream reaches (up to one reach above the first fish movement barrier or one reach upstream of the historical lake effect) and assessed most of the tributaries within the study area using a combination of the Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT) (Figure 3-6a,b).

The RGA uses indicators of channel instability to develop an overall stability index (or score) and identify the primary mode of adjustment within the reach. This adjustment could be in the form of aggradation, degradation, widening or planimetric form adjustment.

The RSAT evaluates stream morphology by allotting points based on specific characteristics observed in the stream. RSAT considers channel stability, channel scouring/deposition, physical instream habitat, water quality, riparian habitat conditions and biological indicators, with the following classifications representing the total points scored in all categories:

- Excellent (42–50 points)
- Good (30–41 points)
- Fair (16–29 points)
- Poor (<16 points)

Table 3-10 and Figure 3-5a,b depict the delineated stream reaches and summarize the results of the RGA and RSAT studies (including Sheridan Creek (CVC 2010a), the Credit River (ABL 2005), Cooksville Creek (CVC 2010), Avonhead Creek (Ecosystem Recovery Inc 2015) (and additional updates undertaken in 2012, 2013 and 2014 for Serson, Applewood, and Moore Creeks). Based on this analysis, the following are the results for the 59 delineated stream reaches:

RSAT

- 2 reaches are good overall
- 40 reaches are fair overall
- 6 reaches are poor overall
- 11 reaches where data are not available or the study did not apply

RGA

- 9 reaches are stable
- 33 reaches are moderately stable
- 8 reaches are unstable
- 9 reaches where data are not available or the study did not apply

Examining the results of the overall RGA scores and the dominant process identified (Table 3-10), the stream reaches downstream of piped sections of creek are unstable or moderately stable and the most common dominant processes are degradation or widening. This is reflective of the expected increase in erosion in receiving waters identified by Waters (1995).

As previously noted, reduction in channel complexity is common in urban systems. The instream habitat component of RSAT can be used a surrogate for channel complexity (formation of riffles, pools, point bars, etc.) based on the definition used to evaluate instream habitat:

> "Relates to the ability of the stream to meet basic physical requirements necessary for the support of a well-balanced aquatic community (e.g. depth of flow, water velocity, water temperature, substrate types, etc.)" (Galli 1996)

The findings of the instream habitat component of RSAT for the 59 delineated stream reaches are summarized as follows and as shown on Table 3-10:

- 5 reaches are good
- 11 reaches are fair
- 6 reaches are poor
- 37 reaches where data not available or the study did not apply

In general, instream habitat for reaches where data is available can be described as being dominated by riffles and runs with few pools, with low velocity flows and shallow water depth.

Overall, the stream reaches in most need of attention due to being classified as poor under RSAT or unstable under RGA are as follows:

- Applewood Creek: Reach 1
- Serson Creek: Reach 2, Reach 3
- Cooksville Creek: Reach 4
- Sheridan Creek: Reach 5, Reach 13
- Avonhead Creek: Reach 5, Reach 6
- Clearview Creek: Reach 2

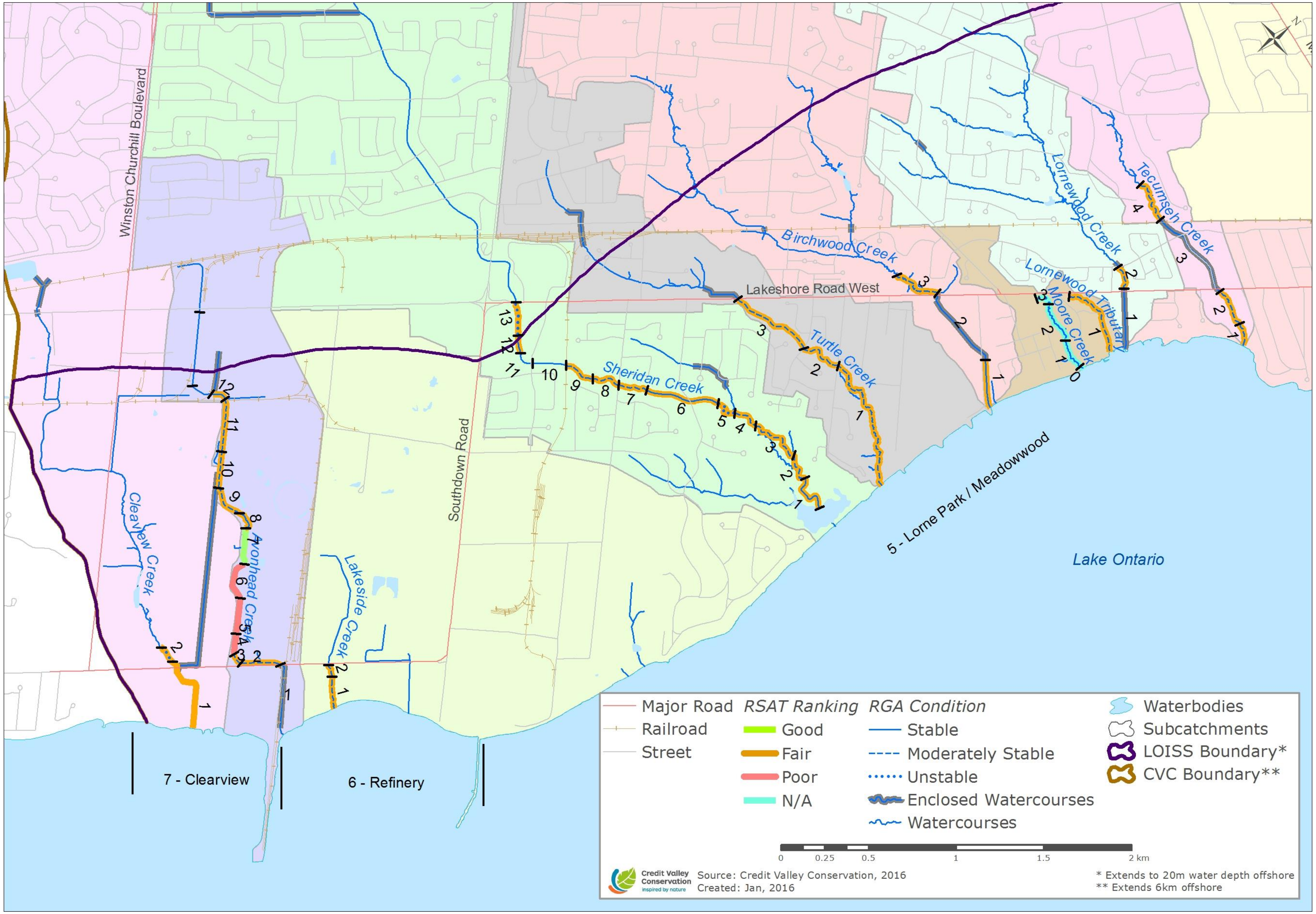


Figure 3-5a: Summary of RSAT and RGA Results by stream reach (west) (Source: Sheridan Creek (CVC 2010a), Credit River (ABL 2005), Cooksville Creek (CVC 2010), Avonhead Creek (Ecosystem Recovery Inc 2015), Applewood Creek and Serson Creek (Parish 2013), Moore Creek (ABL 2014)

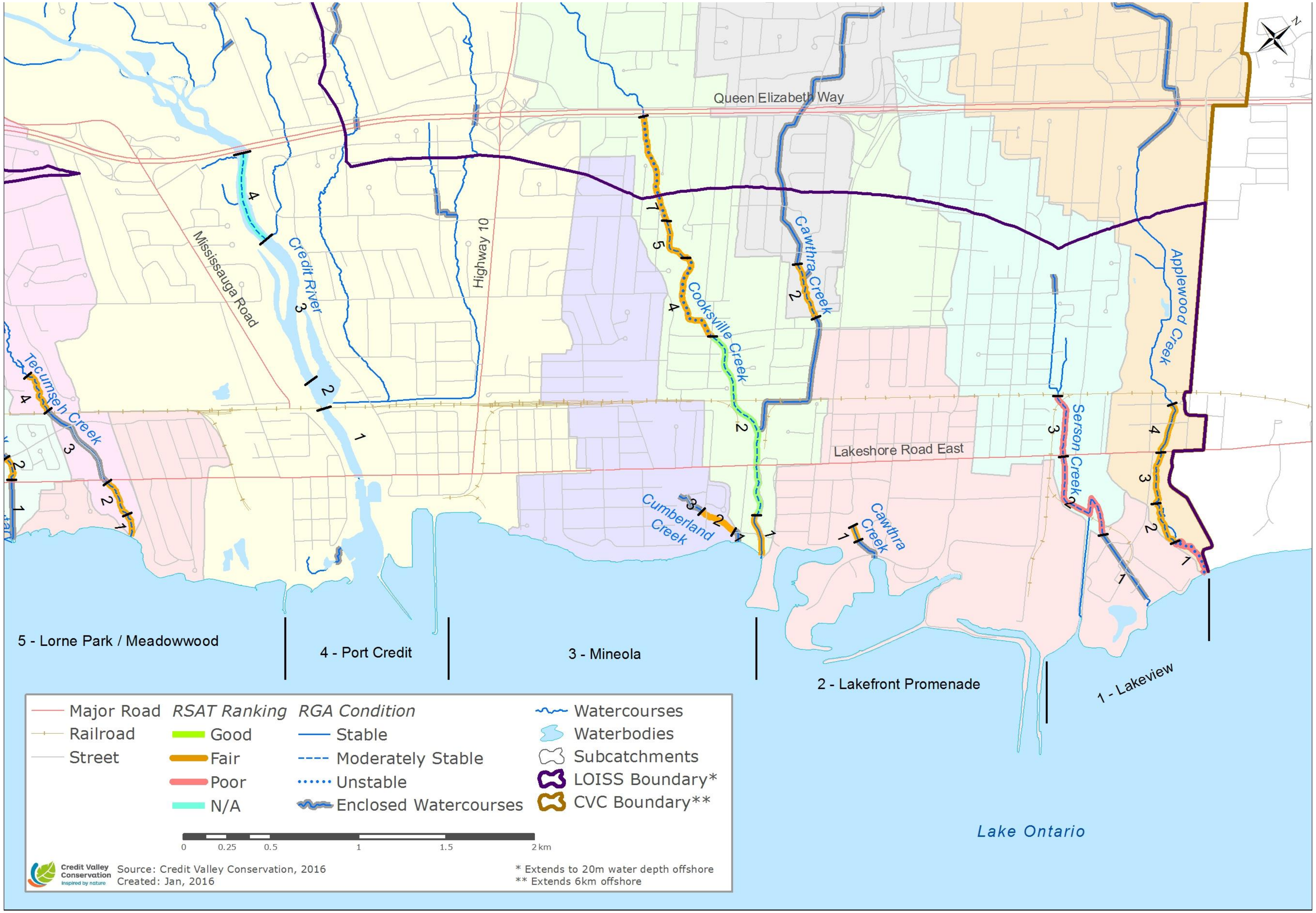


Figure 3-5b: Summary of RSAT and RGA Results by stream reach (east) (Source: Sheridan Creek (CVC 2010a), Credit River (ABL 2005), Cooksville Creek (CVC 2010), Avonhead Creek (Ecosystem Recovery Inc 2015), Applewood Creek and Serson Creek (Parish 2013), Moore Creek (ABL 2014)

Table 3-10: RSAT and RGA Results (Source: ABL 2011 except where noted)

Coastal Reach	Tributary	Fish Barriers	Tributary Reach	Mean Slope (m/m)[1]	Average Bankfull Width (m)	Riparian Vegetation	RGA Stability Index	RGA Condition[2]	Dominant Process[3]	RSAT Score	RSAT Condition	RSAT Instream Habitat Condition
1 – Lakeview	Serson Creek	TR1 piped under GE Booth wastewater treatment facility Perched culvert at Lakeshore Rd	TR2	N/A	4	Tree, shrub, some grass	0.46	MS	P	12	Poor	Poor
			TR3	0.0039	1.75	Shrub, grass	0.35	MS	P	10	Poor	Poor
	Applewood Creek		TR1	N/A	7	Tree, shrub, grass	0.64	U	W/A	15	Poor	Fair
			TR2	N/A	5	Tree, shrub, grass	0.42	MS	P	23	Fair	Good
			TR3	N/A	6	Tree, shrub, grass	0.48	MS	D	17	Fair	Fair
			TR4	0.0110	3.3	Tree, shrub	0.11	S	A	23	Fair	Fair
2 – Lakefront Promenade	Cawthra Tributary 1	Perched pipe at the lake	TR1	N/A	1	Some trees, shrub, grass	0.07	S	P	18	Fair	Poor
	Cawthra Creek	Piped downstream	TR2	N/A	7	Trees, shrubs, grass	0.40	MS	A/W	17	Fair	Fair
3 – Mineola	Cumberland Creek	Perched pipe at the lake. TR1 piped under subdivision. TR3 piped under subdivision	TR2	N/A	5	Trees, shrubs, herbs	0.33	MS	W	16	Fair	Poor
	Cooksville Creek***		CC01	N/A	N/A	Trees, shrubs. Manicured lawn	.20	S	A	29.5	Fair	N/A
			CC02	N/A	N/A	Trees, shrubs, herbs, grasses	.29	MS	A	30	Good	N/A
			CC04	0.0076	11.4	Trees, shrubs, groundcover	.47	U	W	17.5	Fair	N/A
			CC05	N/A	N/A	N/A	.25	MS	W	21	Fair	N/A
			CC07	N/A	N/A	Trees, grasses, manicured lawn	.63	U	D	23	Fair	N/A
4 – Port Credit	Credit River **		R1	0.0004	53 +/- 7	Emergent wetland species, shrubs, trees	N/A	N/A	A	N/A	N/A	N/A
			R2	0.0017	41 +/- 7	Herbs, shrubs, trees	N/A	N/A	A/P	N/A	N/A	N/A
			R3	0.0024	26 +/- 3	Bare banks, herbs, shrubs, trees	N/A	N/A	D/W	N/A	N/A	N/A
			R4	0.0044	29+/-8	Herbs, shrubs, trees	N/A	MS	P/A	N/A	N/A	N/A
			R5	0.0052	28+/-7	Herbs, shrubs, trees	N/A	MS	W	N/A	N/A	N/A
5 - Lorne Park/ Meadowwood	Sheridan Creek*	Dynamic cobble beach	SC01	0.0088	8-10	Dense cattails	0.19	S	A	20	Fair	N/A
			SC02	0.0046	6-12	Mature dense hardwoods, shrubs, grasses	0.34	MS	N/A	21	Fair	N/A
			SC03	0.0059	6	Mature dense hardwoods, shrubs, grasses	0.36	MS	N/A	20	Fair	N/A
			SC04	0.0113	10	Mature dense hardwoods, shrubs, grasses	0.28	MS	N/A	24.5	Fair	N/A
			SC05	0.0152	25	Large trees, short grasses	0.41	U	A	22.522.5	Fair	N/A
			SC06	0.0125	12	Sparse trees, discontinuous shrubs, short grasses	0.19	S	N/A	15	Fair	N/A
			SC07	0.0134	8-9	Dense large trees	0.35	MS	N/A	20.5	Fair	N/A
			SC08	0.0086	14	Long over hanging trees	0.36	MS	N/A	20.5	Fair	N/A
			SC09	0.0287	8	Large trees with mixes short grasses	0.38	MS	N/A	19	Fair	N/A
			SC10	0.0090	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			SC11	0.0041	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			SC12	0.0019	8-10	Tall grasses, low lying shrubs	0.18	S	W	22	Fair	N/A
	Turtle Creek	Piped upstream of TR3	TR1	0.0100	1.75	Shrub, herb	0.31	MS	A	22	Fair	Poor

			TR2	0.0028	2.1	Tree, shrub	0.32	MS	A	26	Fair	Good
			TR3	0.005	2.9	Tree, grass	0.25	MS	W	22	Fair	Fair
	Birchwood Creek	TR2 piped	TR1	N/A	2.25	Tree, shrub, grass	0.18	S	A	24	Fair	Fair
			TR3	N/A	2.5	Shrub, grass	0.25	MS	A	23	Fair	Fair
	Moore Creek****		TR0	N/A	N/A	N/A	0.37	MS	D	N/A	N/A	N/A
			TR1	N/A	4.8	N/A	0.47	U	A	N/A	N/A	N/A
			TR2	N/A	2.8	N/A	0.46	U	A	N/A	N/A	N/A
			TR3	N/A	N/A	N/A	0.60	U	D	N/A	N/A	N/A
	Lornewood Creek Tributary (aka Orient Creek)		TR1	0.004	2.5	Shrub, grass	0.21	MS	A	29	Fair	Fair
	Lornewood Creek	TR1 piped	TR2	N/A	0.75	Tree, shrub, grass	0.28	MS	W	19	Fair	Poor
	Tecumseh Creek	TR3 piped under subdivision	TR1	0.0060	3	Tree, shrub	0.33	MS	D	25	Fair	Good
			TR2	0.0270	2.5	Tree, shrub	0.22	MS	A	23	Fair	Fair
			TR4	0.0085	1	Shrub, grass, some trees	0.26	MS	A	25	Fair	Fair
6 – Refinery	Lakeside Creek	Perched culvert at waterfront trail (between TR1 and TR2)	TR1	0.0213	2.5	Tree, shrub	0.42	MS	A	21	Fair	Fair
			TR2	0.0044	3	Tree, shrub	0.29	MS	D	19	Fair	Good
7 – Clearview	Clearview Creek	Concrete spillway (TR1)	TR2	0.0119	3.5	Tree, shrub	0.52	U	D	19	Fair	Good
	Avonhead Creek*****	TR1 piped	TR2	N/A	0.8-2.4	Grass	0.23	MS	W/P	20	Fair	N/A
			TR3	N/A	2.14-3.05	Marsh	0.34	MS	W	21	Fair	N/A
			TR4	N/A	N/A	Shrub	N/A	N/A	N/A	7	Poor	N/A
			TR5	N/A	N/A	Grass/shrub	N/A	N/A	N/A	9	Poor	N/A
			TR6	N/A	N/A	Grass/shrub	N/A	N/A	N/A	7	Poor	N/A
			TR7	N/A	7.3-10	Forest	N/A	N/A	N/A	30	Good	N/A
			TR8	N/A	2.45	Marsh	0.20	S	A/P	24	Fair	N/A
			TR9	N/A	2.2-2.65	Forest	0.23	MS	A	23	Fair	N/A
			TR10	N/A	2.3	Marsh	0.23	MS	A	19	Fair	N/A
			TR11	N/A	N/A	Forest	0.24	MS	W/A	24	Fair	N/A
			TR12	N/A	1.4-2.2	Mix	0.16	S	A	21	Fair	N/A

1: N/A – slope not available due to limited topographic contour spacing or unavailability of contours.
2: Stability: S-Stable, MS-Moderately Stable, U-Unstable.
3: Dominant Process: A: Aggradation; D: Degradation; W: Widening; P: Planimetric Form Adjustment.
* Source: Sheridan Creek Watershed Study and Impact Monitoring. Draft Characterization Report 2009.
**Source: Credit River Adaptive Management Strategy: Development of a Rehabilitation Plan.
***Source: Cooksville Creek Watershed Study and Impact Monitoring, Draft Characterization Report 2009.
****Source: Lake Ontario Integrated Shoreline Strategy Moore Creek: Fluvial Geomorphology Assessment, Aquafor Beech Ltd. 2014.
*****Source: Lake Ontario Integrated Shoreline Strategy Avonhead Creek: Fluvial Geomorphology Assessment, Ecosystem Recovery Inc. 2015

Aggradation is noted as being the most common dominant process in the first reach of the studied tributaries. This is consistent with Schumm's (1981) findings that identify lower stream reaches as deposition zones.

3.3.1.2 Backwater Influences

The manner in which tributaries meet Lake Ontario at their mouths can significantly influence the lower reaches of the stream. Backwater influence occurs where the mouth of the stream is lower than the normal water level of the lake, thereby dictating the water depth in the stream. Lake backwater can also occur where wave action deposits sediment and other materials at the mouth of the stream (barrier bars). The accumulated material, which holds back flows from the stream, causes water levels in the streams to rise.

Five of the following streams were identified in the Background Review as having backwater influences at the mouths (ABL 2011). A description of backwater in the Credit River has been added as an update in this report.

Lakeside Creek

The location of the mouth of Lakeside Creek is determined by the beach formation along the waterfront. The beach consists of cobbles and weathered terra cotta clay pipes. The wave action from the lake continuously moves the cobble and terra cotta pipes, thereby shifting the location and manner in which the stream discharges to the lake. At the time of the ABL study, flows from the stream were percolating through the beach material. The backwater effect on this stream is limited and affects only about 10 m upstream of the beach.

Sheridan Creek

Sheridan Creek flows through Rattray Marsh before discharging into Lake Ontario. The outlet of the stream is formed through a sand and cobble beach. The waves from the lake push the beach substrate from the nearshore back onto the beach causing the stream outlet to close. Large storm flows in Sheridan Creek burst through the barrier beach restoring the stream outlet. The dynamic stream mouth influences the water depth in Rattray Marsh.

Turtle Creek

Turtle Creek flows through a wetland and over a sand and cobble beach before discharging to the lake. The sand and cobble beach at the shoreline is somewhat protected from the wave action from the east by a small concrete pier but is subjected to minor waves from the west. The extent of the backwater effect on Turtle Creek is approximately 200 m upstream of the beach to the middle of the wetland upstream. It is likely that the water depth within the wetland is controlled by the formation of the mouth of the stream and the degree to which the channel is open to the lake. Under closed mouth conditions, the water is impounded within the wetland causing the depth to increase. Under open mouth conditions the water depth in the wetland is lower. Water depth directly influences the type and amount of wetland vegetation is present in the wetland.

Credit River

The maximum extent of backwater in the Credit River has not been delineated. Under conditions where the lake levels are higher than the flows in the Credit River, water from the lake will backwater up the mouth of the Credit River. This process results in some wave uprush in the mouth of the Credit River as well as the deposition of larger suspended sediment as flows slow down upon meeting the lentic lake waters. Gravels and sands drop out of suspension closer to the open waters of the lake where river flows have less power.

Cooksville Creek

Cooksville Creek experiences backwater influence from Lake Ontario up to the top of the first stream reach (CC01) at the pedestrian bridge downstream of Lakeshore Road. Extensive gabion baskets line the banks and bed of this reach. Aggradation is the dominant process in this reach due to the slower moving lake waters that cause deposition resulting in poorly sorted bed material, the formation of point bars and siltation in pools (CVC 2010).

Applewood Creek

Applewood Creek flows through a small riverine wetland prior to discharging to the lake over a sand and cobble beach. There is also a treed beach ridge located on both sides of Applewood Creek near the mouth. This feature is gradually succeeding to a more forested feature, particularly on the west side, where it is now only rarely subjected to wave actions due to water level regulations in Lake Ontario.

The flow path through the beach depends on sediment deposition from the stream and wave action from the lake. At the time of the field survey, a pool had formed on the beach redirecting the flows eastward and creating a bar, prior to connecting to the lake. The extent of the backwater effect is approximately 100 m upstream of the beach.

3.3.1.3 Sediment Loadings and Quality

Many factors must be considered when estimating sediment load. Although no direct relationship exists between watershed size and sediment supply, it can be inferred that the Credit River yields the greatest amount of sediment supply to Lake Ontario in the study area, as the overall size of the Credit River basin is almost three times greater than the next largest basin. The Credit River Adaptive Management Study (ABL 2005) estimated that the total sediment yield from the Credit River to Lake Ontario is over 174,000 tonnes per year, and primarily composed of medium sized sand particles.

CVC commissioned a geomorphic study, including sediment movement analysis, on Moore Creek (ABL 2014) to inform future management of this tributary and fulfill an identified datagap in the Backgound Review. The study estimated the total sediment load (suspended and bedload sediment) to the lake for Moore Creek (watershed area = 8 ha) to be approximately 9 tonnes per year or 40 t/yr*km^2. This is within sediment yield range for Lake Ontario tributaries (ABL 2014).

Environment and Climate Change Canada (2003) completed a screening-level survey of sediment quality in the Lake Ontario tributaries. This information has been added to this report to provide more insight into the health of the LOISS tributaries. The survey followed the Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (1995). Federal Probable Effect Level exceedances (i.e., the chemical concentration above which adverse biological effects frequently occur) are summarized in Table 3-11 for the study area tributaries.

Table 3-11: Sediment Quality for tributaries in the LOISS study area (source: Environment Canada and Climate Change 2003)

Coastal Reach	Tributary	Federal Probable Effect Level (PEL)* Exceedances	Typical Origin
1 – Lakeview	Serson Creek	No PEL exceedances	
	Applewood Creek	Total DDE, Acenaphthalene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Lead	Agricultural Fossil fuels/automobile exhaust
2 – Lakefront Promenade	Cawthra Creek	Not in study	
3 – Mineola	Cumberland Creek	Not in study	
	Cooksville Creek	Total DDE, Phenanthrene, Pyrene, Benz(a)anthracene	Agricultural Fossil fuels/automobile exhaust
4 – Port Credit	Credit River	Total DDE	Agricultural
5 - Lorne Park/ Meadowwood	Sheridan Creek	Total DDE, Phenanthrene, Pyrene, Benz(a)anthracene	Fossil fuels/automobile exhaust
	Turtle Creek	Total DDE, Total DDD	Agricultural
	Birchwood Creek	Total DDE	
	Moore Creek	No PEL exceedances	
	Lornewood Creek	Total DDE, Total DDT	Agricultural
	Tecumseh Creek	Total DDD, Total DDE, Phenanthrene, Pyrene, Benz(a)anthracene, Chrysene, Zinc	Agricultural Fossil fuels/automobile exhaust
6 – Refinery	Avonhead Creek	Lindane	Agricultural
	Lakeside Creek	Not in study	
7 – Clearview	Clearview Creek	Total DDE, Total DDD, Total DDT	Agricultural

* Adverse biological effects on aquatic life are usually or always observed.

The sources of these chemicals are unknown; however, their origins in agricultural practices and automotive and fossil fuels speak to the development transitions from agriculture to industrial, commercial and residential land uses that have occurred in the study area over the last 100 years. While exceedances are expected to have adverse biological effects, the presence of these chemicals is not considered to prevent fish and other aquatic life from using and occupying these tributaries.

3.3.2 Synthesis of Fluvial Geomorphology

The morphology of the studied reaches generally reflects the predicted characteristics of tributaries under urban influence. Using the RSAT Instream Habitat parameter as a surrogate for channel complexity, the studied stream reaches have an average Instream Habitat Condition of "Fair". This reflects a general trend towards a more homogeneous channel form including shallower pools, dominance of riffles and runs, small riffle substrate and a general lack of cobble (Galli 1996), all consistent with the Urban Stream Syndrome (Walsh et al. 2005). Indicators (degradation, widening) of high erosion downstream of piped headwater features are common throughout the study area. The influence of the urban matrix on tributary flows will be a limiting factor in the consideration of restoration, enhancement and rehabilitation initiatives.

As evidenced by aggradation being the most common process in Tributary Reach 1 near the mouth of the studied tributaries, larger material (coarse sands, gravel, cobble) is likely deposited prior to flows entering the lake, except under larger storm events. This process applies particularly to those tributaries that experience the backwater effect from the lake. Most sediment that reaches the lake consists of finer silts that are easily transported along the shoreline and out into the lake. Infrequent larger storm events carry larger material into the lake providing some replenishment to the nearshore. Where piers and other protrusions exist along the shoreline, the larger entrained sediment is typically trapped on the up-drift side of the structure, whereas finer sediment follows the flow around the structure and is typically pushed further out into the lake (see Section 3.5.1.1).

While the amount of sediment being released to the lake from most of the tributaries is unknown (except for the Credit River and Moore Creek), it appears that, based on the Environment and Climate Change Canada screening level survey (2003) (Table 3-11), any sediment flushed into the lake is generally of fair quality (i.e. overall 13 of the 38 tested species were found to have probable effects exceedances in the study area).

No additional data gaps in Fluvial Geomorphology were identified through the Characterization phase. Further Fluvial Geomorphology studies are to be completed on a project-by-project basis (Table 3-12).

Table 3-12: Summary of Geomorphology Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Further studies to be completed on a project-by-project basis			

3.4 COASTAL PROCESSES

Coastal processes, those natural processes in Lake Ontario that influence the physical characteristics of the shoreline, are an important part of characterizing the LOISS study area. Urban influences on coastal processes, such as erosion protection measures, can alter natural functions along the shoreline. In the study area, these influences include armoured shorelines and lake filling (e.g. piers), stonehooking (removal of nearshore substrates) and removal of coastal wetlands. These influences can alter nearshore sediment dynamics, change water depths and wave power, and interactions between tributaries and the lake.

Winds generate waves that drive much of the coastal processes. Long-term wind data from Toronto Island airport are used to model coastal processes along the western end of Lake Ontario. Along with wind, waves in the nearshore are dependent on water depth and bathymetry.

Waves in the nearshore of Lake Ontario are considered depth dependent. That is, the water depth determines the wave height in the nearshore; wave height increases with water depth. Bathymetry influences wave transformation in the nearshore including changes in wave direction. The Background Review identified that the majority of offshore wave energy in the study area is from the east. Further analysis is needed on a site-specific basis to determine the changes in waves under local conditions (e.g., water depth, bathymetry, etc.).

Data gaps identified in the Background Review are summarized in Table 3-13, as well as the current status of those studies:

Table 3-13: Status of data gaps for coastal processes identified in the Background Review (ABL 2011)

Data gap	2017 Status
Shoreline recession rates	Erosion monitoring stations installed in 2012
Condition and extent of shoreline protection structures (public lands)	Phase 1 of shoreline structures assessment completed in 2014. Phase 2 completed in 2017.
Effects of waves on nearshore currents at a specific location	To be completed on case-by-case basis
Influence of proposed shoreline modifications on littoral sediment regime	To be completed on case-by-case basis
Influence of proposed shoreline modifications on sub-littoral sediment regime	To be completed on case-by-case basis
Condition and extent of shoreline protection structures (private lands)	Some private lands included in Phase 2 of shoreline structures assessment (2017)

3.4.1 Characterization

The Background Review identified coastal processes within the study area. This section provides updates to this information. Where noted, a summary of information from the Background Review is provided as context in support of findings from other disciplines.

3.4.1.1 Water levels

As noted in the Background Review, the International Joint Commission (IJC) began regulating long-term Lake Ontario water levels at the Moses-Saunders Dam in Cornwall, Ontario in 1960 with target water levels ranging from 74.15 to 75.37 m International Great Lakes Datum (IGLD) 1985. In 2014, the IJC proposed changes to the regulation of water levels (Plan 2014) that will more closely match the natural hydrologic regime (prior to regulation) of Lake Ontario (IJC 2014).

Since the Background Review, Plan 2014 was approved by both the Canadian and American governments (December 2016) for implementation in January 2017, with regulated mean water levels ranging from 73.56–75.73 m IGLD 1985. This new regulated range in water levels is actually closer to the measured monthly levels in the existing regulatory regime (IJC 2014) hence minimal noticeable change is expected. It should be noted that seasonal changes to water levels occur as a result of the annual hydrologic cycle in the Lake Ontario basin. Water levels generally peak in the summer (June) and are lowest in the winter (December), with short-term fluctuations resulting from local meteorological conditions (ABL 2011).

Lake water levels are summarized in Table 3.14. The lake water levels in the study area tend to range between 74 and 75.5 m IGLD 1985 with an average annual fluctuation of 0.5 m (SEL 2014). The lowest water level recorded is 73.8 m IGLD 1985 prior to water level regulation. Prior to spring 2017 the highest level recorded was 75.82 m IGLD 1985 in 100 years of records (SEL 2014). Snow melt and rainfall in spring 2017 resulted in a new record high of 75.88 m, with expectations that the water levels may continue to rise. Water depth at the shoreline in the LOISS study area is up to (approximately) 2 m where infilling (land creation) has taken place.

Table 3-14: Lake Ontario water levels (m IGLD 1985)

Record Low Water Level (m IGLD 1985)	Record High Water Level (prior to 2017) (m IGLD 1985)	Regulated Mean Water Level Range (Plan 2014) (m IGLD 1985)	Datum (m IGLD)
73.8	75.82	73.56 - 75.73	74.2

3.4.1.2 Bathymetry

The Background Review provided a coarse overview of bathymetry for the LOISS study area based on lake-wide bathymetry data. The coarse scale bathymetric mapping available through the National Oceanic and Atmospheric Administration (NOAA), is noted in the Background Review as having inaccuracy issues (ABL 2011). Complete bathymetric analysis on a local scale has not been obtained for the entire study area; however, some site-specific investigations have been undertaken through other programs and projects. The following is a summary of those findings.

Lakeview Waterfront Connection

A detailed bathymetric study (side scan sonar) was conducted by Toronto and Region Conservation Authority (TRCA) in 2011 for the area in front of the G.E. Booth Waste Water Treatment Facility (WWTF) and Marie Curtis Park (1 – Lakeview Coastal Reach, Figure 3-6) as part of the Lakeview Waterfront Connection initiative. Analysis of the bathymetric information identified variable topography including a shallow shelf immediately in front of the WWTF with a deep drowned valley in front of the beach to the east. A steep drop exists at the end of the OPG intake piers.

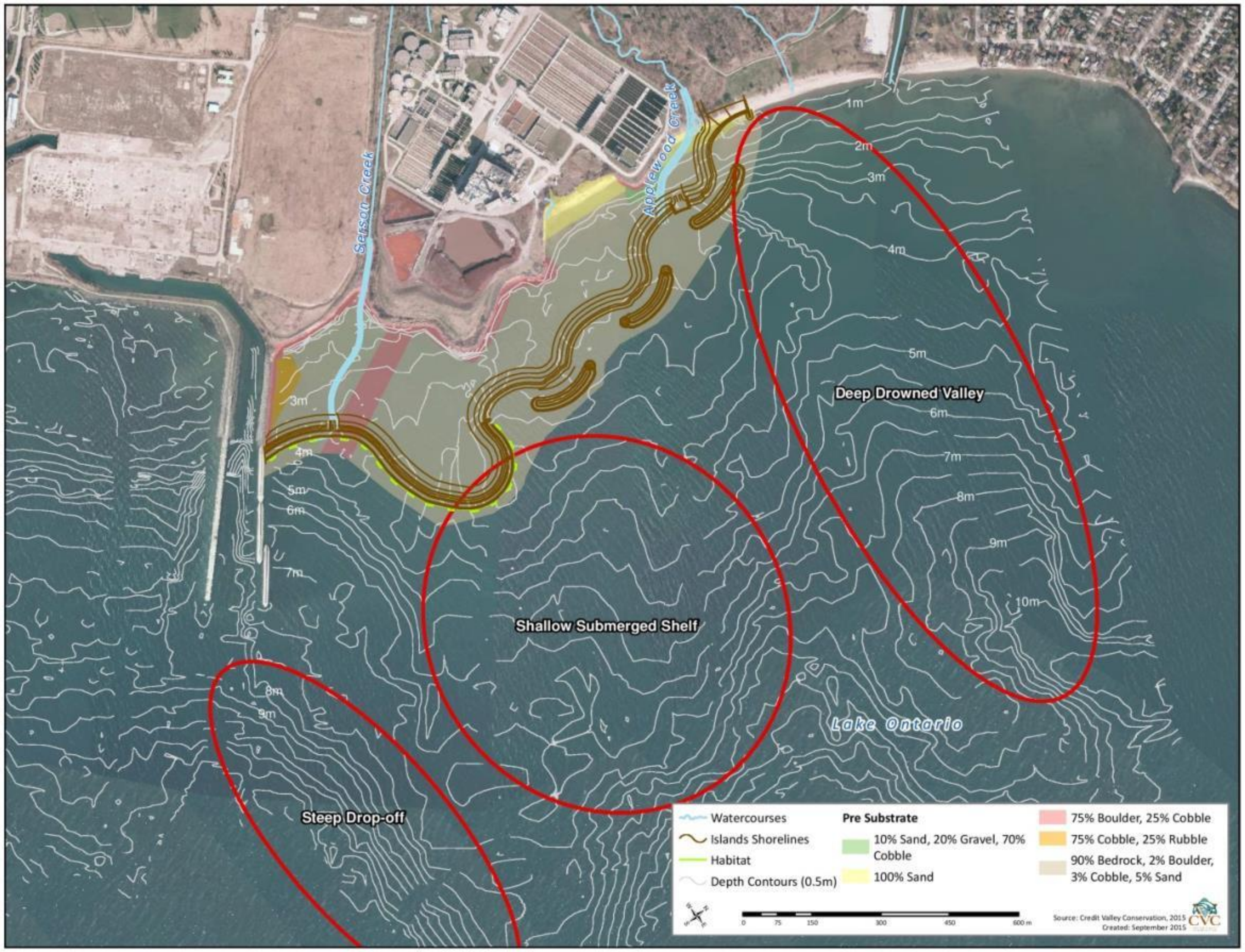


Figure 3-6: Interpretation of side scan sonar bathymetry for the 1 – Lakeview Coastal Reach (Source: TRCA)

Lakefront Promenade

Bathymetry was completed for portions of Lakefront Promenade Park embayment in 2016 (Figure 3-7). The embayment is relatively shallow with a maximum depth of 2.75 m at the mouth of the embayment. Depths rise again outside the basin then gradually drop off in front of RK McMillan Park.

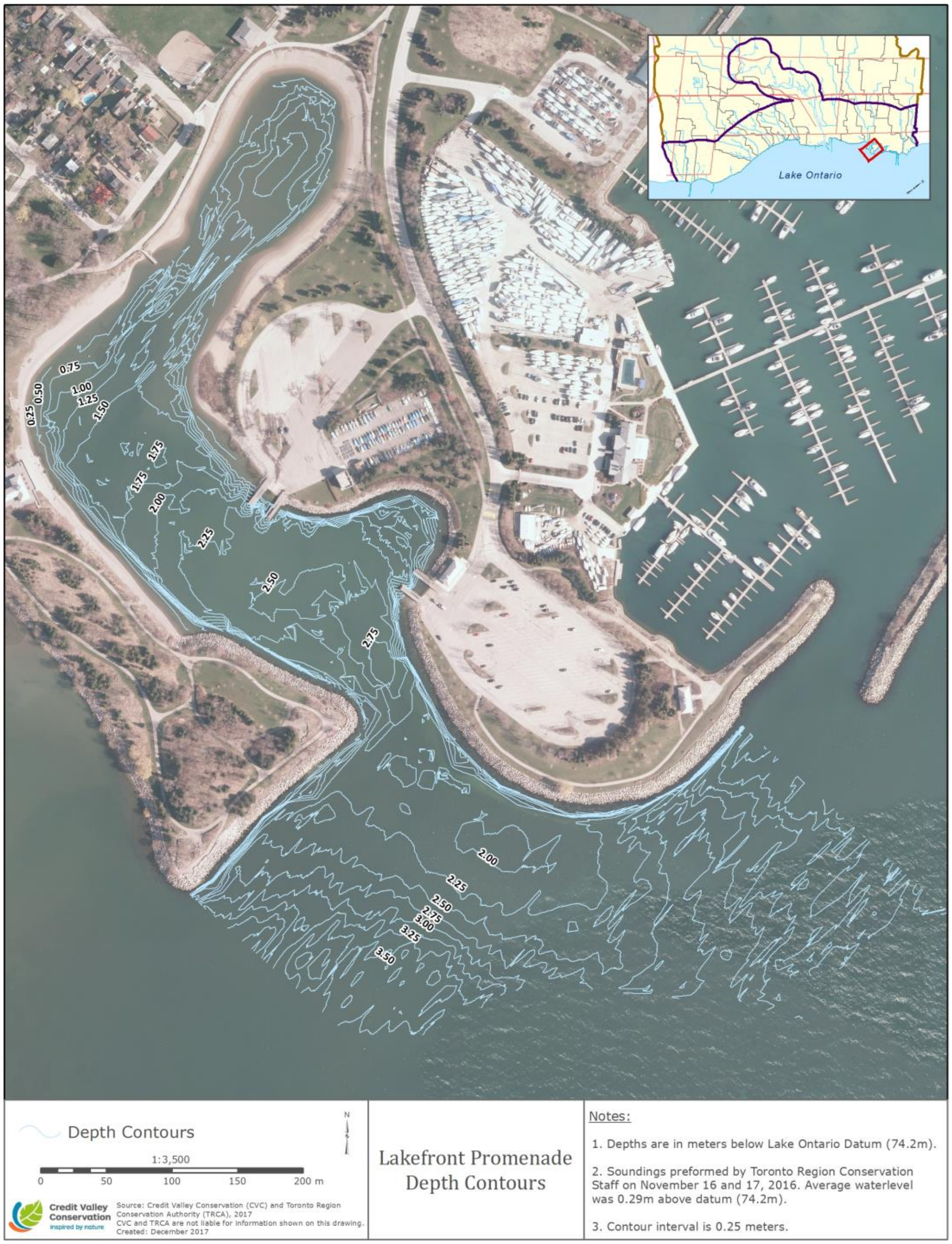


Figure 3-7: Lakefront Promenade Park side scan sonar bathymetry (source: CVC)

Credit River Harbour Sedimentation Study

A sedimentation study including bathymetric sounding was completed for the Port Credit Marina, River Channel, Outer Harbour and Harbour Mouth (Geomorphic Solutions 2012b). A comparison with data sets from 1989, 1995, 1996, 2010 and 2011 identified areas of sediment loss and gain, and revealed that the marina and outer harbour are experiencing continuous sedimentation. In 2014, the City of Mississauga completed a project to restore the navigability of the Port Credit harbour by removing excess sediment in the mouth of the Credit River (4 – Port Credit Coastal Reach, Figure 3-8)

The deposition in the outer harbour is a natural function of decreasing flow velocity as the river mouth widens and, historically, these conditions supported a large coastal wetland in this area. Wave action likely also influences deposition in this area. The thalweg also appears to be deflected to the west in the outer harbour and the narrower river channel appears to be in equilibrium. Sedimentation likely occurs during low flows with higher discharges periodically flushing the sediment to the outer harbour.

GHD (2011) completed bathymetric transects at 12 locations across the shoreline to support the establishment of shoreline erosion monitoring stations. These transects show fairly uniform slopes extending out to up to 980 m into Lake Ontario. In general, the bathymetry in the LOISS study area is flat with gradual slopes.

Figure 3-8: Bathymetry at the mouth of the Credit River in 2012. (source: Geomorphic Solutions 2012b)

3.4.1.3 Circulation

Water circulation in Lake Ontario is strongly influenced by wind and water temperature changes. Currents, waves, and upwelling/downwelling events generated and controlled by wind and water temperature govern the water circulation patterns in the lake and the manner in which discharge to the lake enters the water column. Below is a summary of findings from the Background Review and is provided for continued context and support of processes related to other disciplines.

Currents

Seasonal thermal stratification occurring in late May/early June (spring turnover) to October (fall turnover) influences circulation and current patterns both offshore and in the nearshore. Currents are caused by wind, changes in atmospheric pressure, horizontal density gradients and influxes of water into the lake (Wetzel, 1983). When surface waters begin to warm in the spring warmer, less dense surface water creates a distinct upper layer (epilimnion) over a colder, denser water layer (hypolimnion) with a middle (metalimnion) dividing layer (Figure 3-9).

Thermal bars are created when shallow nearshore waters heat faster than open water (Figure 3-10). A near vertical thermal bar is created when the nearshore becomes stratified and the open water remains mixed at 4^{o}C. Thermal density differences cause a downward current along the thermal bar creating a counter-clockwise coastal current inside the bar (see downwelling below). The thermal bar slowly moves across the basin creating stratified layers (Wetzel 1983). Temperature ranges under stratification are 15–20^{o}C for the upper 5–15 m of water above the thermocline, 5–6^{o}C in the thermocline, and isothermal conditions of 4^{o}C below the thermocline (Beletsky et al. 1999).

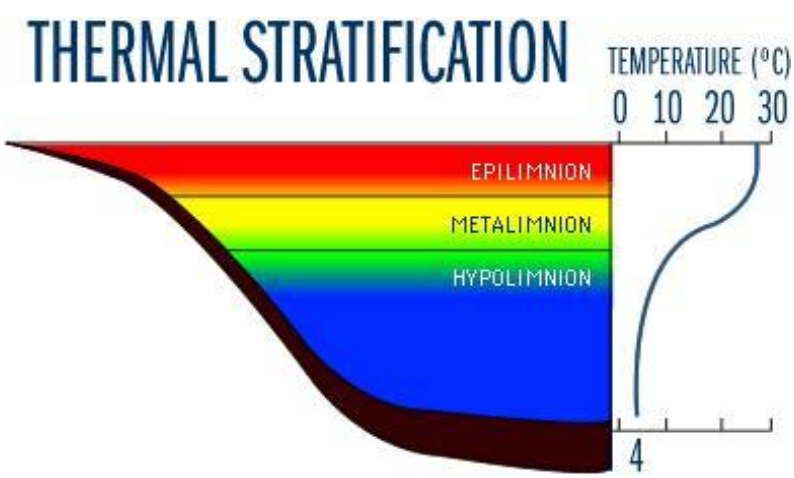


Figure 3-9: Thermal stratification.
Source (University of Minnesota-Duluth 2014. Used with permission)

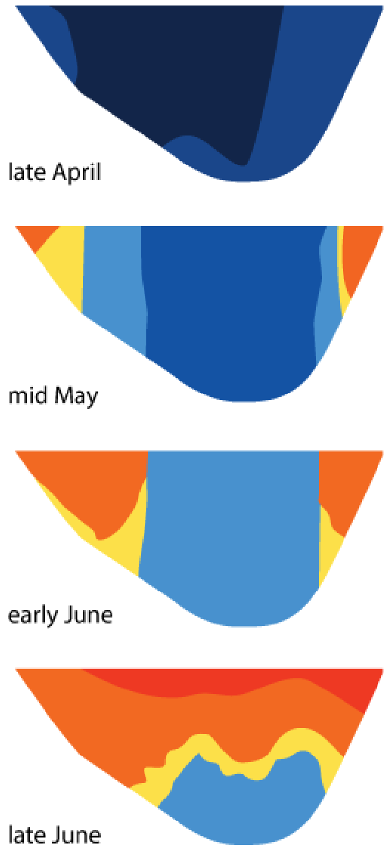


Figure 3-10 Thermal bar formation

While storm induced shoreline currents are quite strong, average currents are relatively weak through most seasons of the year (Figure 3-11). In the winter, currents are barometric (affected by atmospheric pressure) and almost entirely wind-driven, with little variation in depth due to the absence of thermal stratification Summer currents have more vertical variation making them more complex; however, annual circulation patterns follow the stronger winter circulation patterns. The strongest winter current recorded is 9.5 cm/s in the Lake Ontario Eastern Basin (Beletsky 1999), which generally follows in a counter-clockwise direction. Figure 3-12 shows a larger circulation pattern in the western Lake Ontario basin in the winter than the summer. The direction of shoreline current changes between winter and summer in the central north shore area of Lake Ontario.

The thermocline prevents nearshore waters from mixing with deeper water during spring and fall stratification as the current travels east to west through the study area. This is an important function that may influence water quality (Section 3.5.1.1)

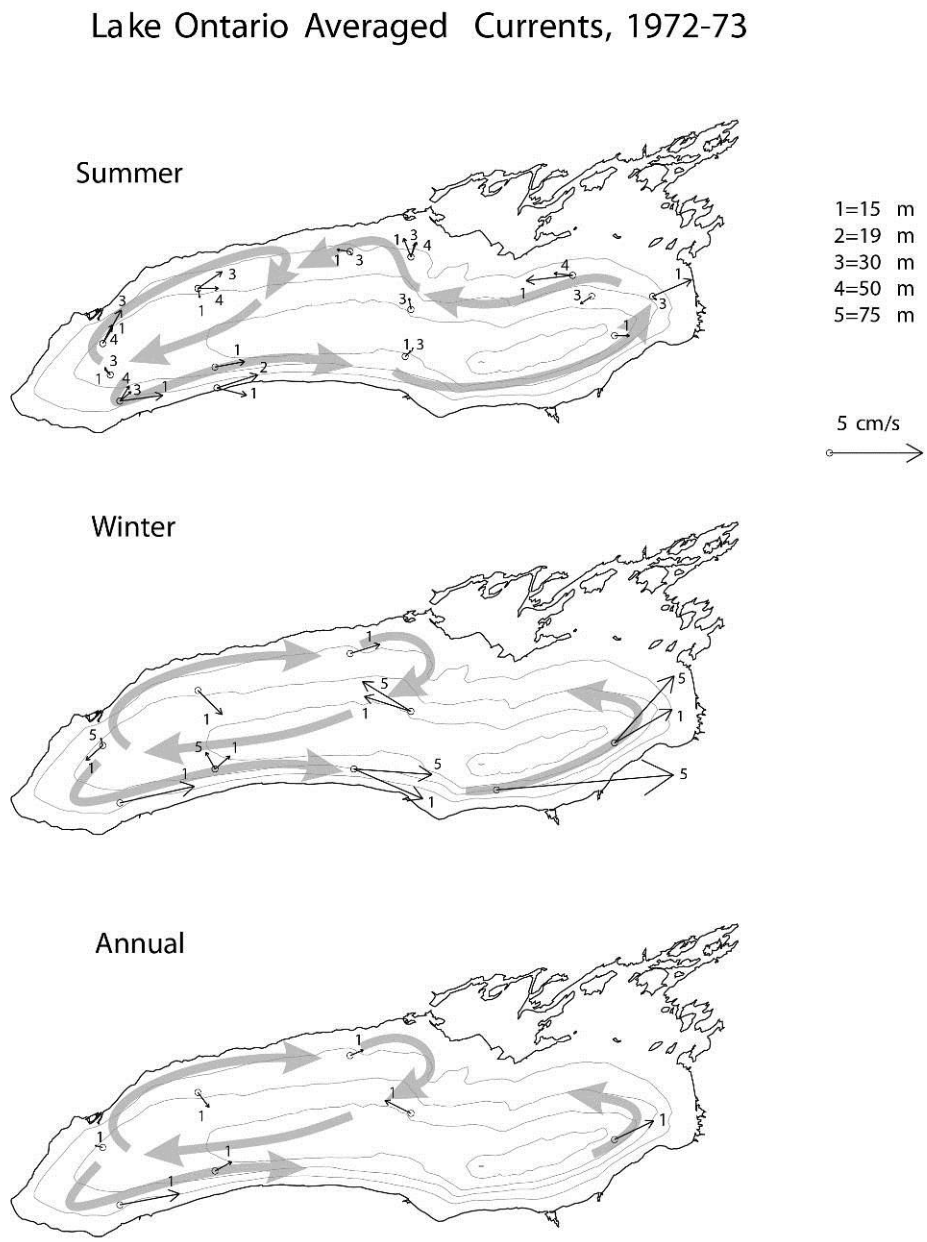


Figure 3-11: Lake Ontario Gyres (currents).
Source (Beletsky 1999, used with permission).

Waves
Approximately 70% of the total offshore wave energy comes from the east; 30% is from the southwest (SEL 2011) in the LOISS study area. Shoreplan Engineering Limited interpreted offshore (deep water) wave data using a combination of a wave transformation model and nearshore bathymetry to determine the effect of bathymetry on waves moving into the shallower nearshore in the 1 – Lakeview Coastal Reach. This model determined that 90% of the nearshore wave energy comes from the easterly direction due to the relatively little refraction experienced by these waves than those from the southwest (SEL 2011).

Kelvin waves, generated when the Coriolis force (as a result of the earth's rotation) is constrained by the thermocline, create a wave-induced thermocline in the nearshore. Confined to the nearshore, Kelvin waves progress cyclonically in a counter-clockwise direction along the coast (Beletsky et al. 1997). Kelvin waves travel a full cycle back and forth along Lake Ontario over a period of 14 days; however, new wind events and storms often interrupt the waves on larger lakes (Hall 2008). Coastally trapped waves prevent circulation with waters in deeper areas of the lake while water trapped in the thermal bar are well mixed.

Upwellings/Downwellings
Upwellings occur in the wake of Kelvin waves and when prolonged west winds move surface water away from shore and are replaced by colder water from deeper in the lake. Upwellings can result in temperature changes of >10°C within a 24-hour period. Upwellings occur when dense, nutrient rich water from the bottom of the water column offshore replaces nutrient depleted surface water in the nearshore (Figure 3-12). The distance from shore usually affected by upwellings depends on wind stress and nearshore bathymetry, but it is typically 5–10 km (Beletsky et al. 1997).

Downwellings occur when denser water moves towards the shore and forces the existing water to sink to deeper waters (Figure 3-13).

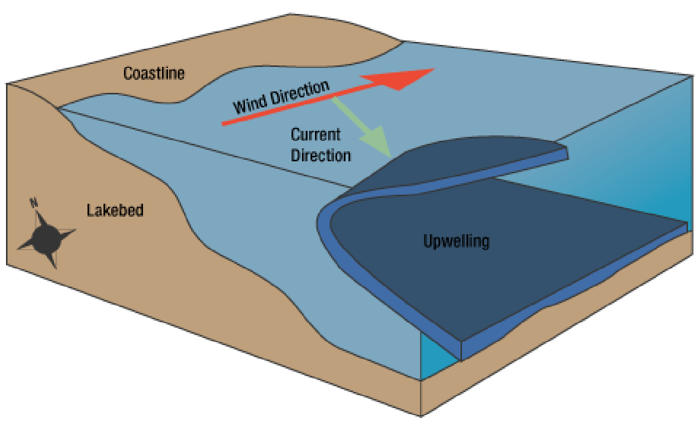


Figure 3-12: Upwelling Example

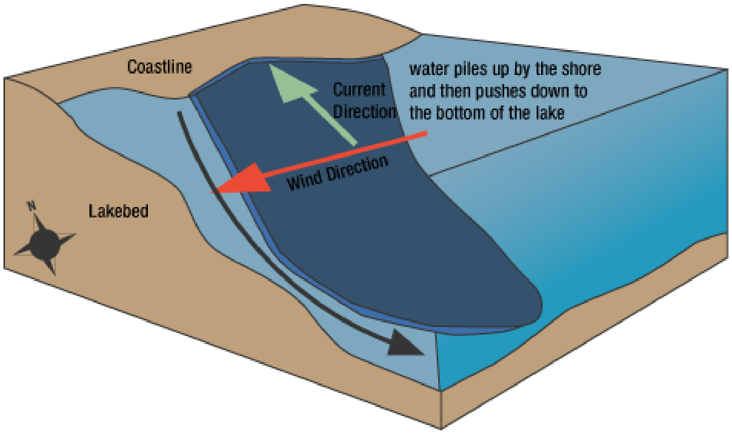


Figure 3-13: Downwelling Example

Figure 3-14 shows an example of upwelling (cool water (shown in green) on north shore of Lake Ontario) and downwelling (warmer water (shown in red) events on the south shore of Lake Ontario) (September 7, 2013).

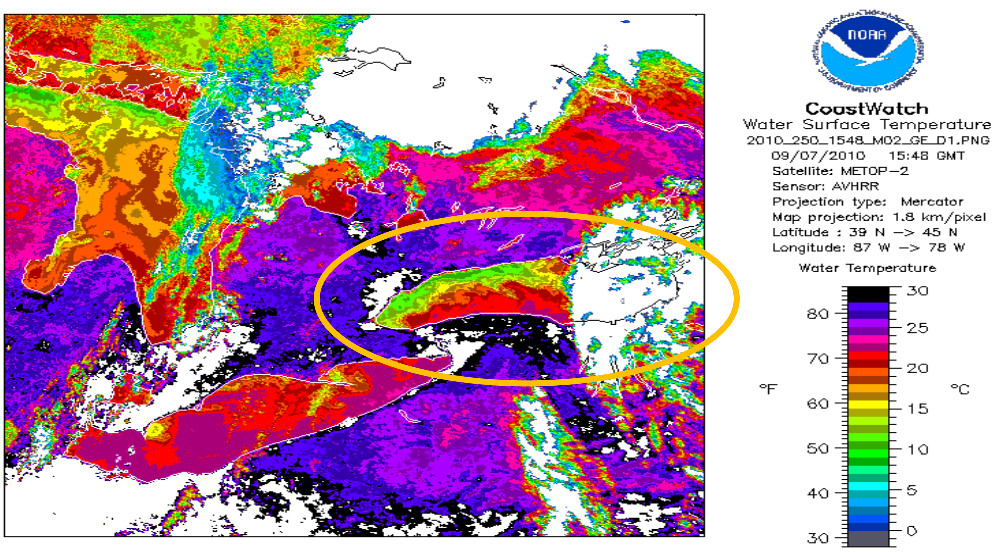


Figure 3-14: Example of upwelling (green) on the north shore of Lake Ontario and downwelling (red) on the south shore of Lake Ontario (Source: NOAA Sept 7, 2013)

Downwelling at the thermal bar creates a counter-clockwise current that travels in the same direction around the lake. Upwellings resulting from coastally trapped waves can interrupt the stratification in the nearshore.

Contributing flows from tributaries

Flows discharged from tributaries enter Lake Ontario in the layer most similar to its own density (Wetzel 1983), with three key types of inflow: interflow, overflow and underflow as depicted in Figure 3-15.

- Overflow occurs when the inflow water density is less than the lake water density (i.e., river waters float)

- Underflow occurs when inflow water density is greater than lake water density (i.e., river waters float)
- Interflow occurs when inflow water density is greater than the epilimnion density but less than the metalimnion, and flow enters in a plume at an intermediate depth (i.e., river and lake waters are mixed)

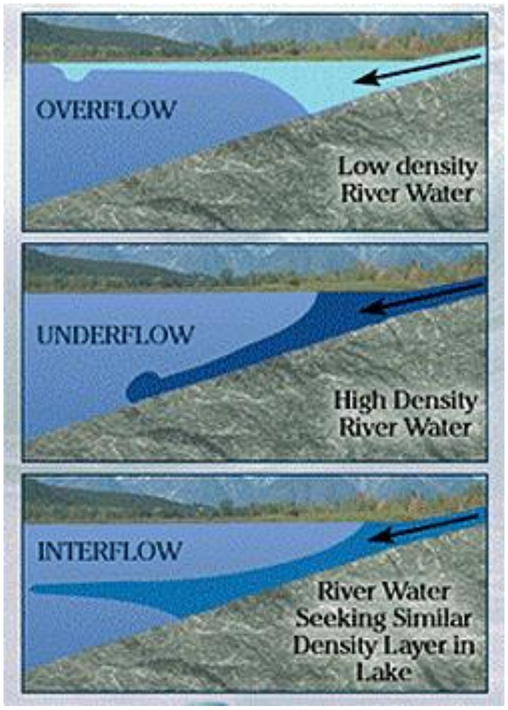


Figure 3-15: Overflow, Underflow and Interflow
(Source: http://www.aquatic.uoguelph.ca/lakes/currents/curntfrm.htm)

The extent of the plume and current generated by the inflow is a function of discharge volume of the river in relation to the volume of the lake (Wetzel 1983). Dispersion of inflows along the coast is determined by the prevailing current. Annual, winter, and upwelling currents travel in a counter-clockwise direction around the lake. Occasionally, winds from the west can change the direction of the current. Under conditions of a coastally trapped wave or thermal bar, inflow water can be trapped close to the shore at varying depths. This function is essential for understanding water quality in the nearshore (See Section 3.5).

Under stratified conditions (typically achieved by mid-summer), overflow tends to dominate (inflow water above lake water) or interflow (inflow water between the epilimnion and metalimnion). Under isotherm (i.e. not stratified) conditions, stream flow temperature is typically higher or equal to lake water temperatures. Considering temperature alone, inflows will be introduced as interflow, or well-mixed with lake water (Figure 3-15).

While all stream flows entering the study area influence the current in the nearshore, the Credit River (followed by Cooksville Creek) has the most impact due to its volume of flow. However, the flow volume is not substantial enough to cause major disruption of current direction with only local changes in current pattern and mixing of lake and stream waters occurring.

Effects on circulation
Stratification can confine currents and waves to the nearshore through the development of thermal bars. The thermal bar can also create upwellings and downwellings in the nearshore. Current, waves, and upwellings can influence circulation in the lake. When not confined by thermal bars the manner in which flows discharging to the lake influence circulation (mixing) is dependent on flow volume and water temperature of both inflows and receiving waters.

3.4.1.4 Ice Cover

Ice cover was not previously discussed in the Background Review. Ice cover has been included in this report as it plays an important role in nearshore functions including ecology and sediment movement. Impacts of less ice coverage on lake ecology include:

- reduced reproduction success for some fish due to lack of protection of fall spawned eggs from waves and wind afforded by shore ice as well as higher water temperature and reduced flows in spring that some fish use as signals to move into spawning ground (Magnuson et al. 1997),
- increases in phosphorus concentrations (Nicholls 1998), and
- changes in winter zooplankton activity (Vanderploeg et al. 1992).
- protection against shore erosion during winter storms.

Ice cover and winter mean ice cover on Lake Ontario has been declining since the early 1970s (Wang et al 2012), and this is attributed to increasing surface water temperatures. Increases in air temperature are generally coincident with increases in water temperature, with the greatest warming and associated reductions in dissolved oxygen anticipated in the nearshore area.

The potential for extensive ice formation on Lake Ontario is small given the mean depth of Lake Ontario (86m), the depth configuration and the relatively mild winter temperatures (Assel et al. 2003). For the period 1972–2013, Environment Canada and Climate Change recorded the highest percent ice coverage on Lake Ontario in 1979 at 86.91%, and the lowest percent in 2002 at 3.02%. Maximum ice coverage for Lake Ontario usually occurs in the first half of February. In severe winters, ice coverage is typically about 17%, while milder winters have coverage closer to 10%. The earliest formation of ice is around the third week of November, and the latest break up occurs in the last week of April (Environment Canada and Climate Change 2012).

The greatest percentage of the surface of the lake covered by ice each winter is sometimes referred to as Annual Maximum Ice Concentration (AMIC) (Assel et al. 2003). Eleven percent of Lake Ontario's surface area comprises waters less than 5 m deep (including coastal wetlands and embayments). Low heat storage and small percentage of lake surface area cause these areas to be the most susceptible to ice formation and have been observed to be ice-covered consistently in years with the lowest AMICs (Assel et al. 2003).

CVC conducted ice monitoring along the LOISS shoreline in February 2014 and found that ice accumulation was greatest in protected areas (with complete coverage in the Credit River upstream of Lakeshore Road and in Lakefront Promenade Park embayment and marina) and areas of shallower depth (e.g., Rattray Marsh beach, Watersedge Park), supporting Assel's findings above. While air temperatures in the Greater Toronto Area in winter 2014 were the coldest in 20 years (Environment

Canada and Climate Change 2015), ice formation is the result of the combination of air temperature and wind; hence, higher ice coverage does not necessarily follow suit. Notably, elevated chloride levels can affect the formation of ice. Chloride reduces the freezing point of water thereby reducing the duration of ice-in conditions. These conditions were observed in spring of 2013 and 2014 in the Credit River where density of water increased with high chloride levels (see Section 3.5.1.1), increasing the freezing point of water.

3.4.1.5 Sediment Transport

Shoreline natural hazards (i.e. erosion, flooding, dynamic beaches) are a major concern to those who live and own property along the shoreline. Erosion hazard limits, flood hazards limits and dynamic beach limits were identified by SEL (2005).

Generally, sediment transport along the Mississauga shoreline is from northeast to southwest (left to right when facing offshore). The shoreline between Toronto and Burlington is known as a 'non-drift zone' based on the lack of littoral sediment (i.e., sediment found in the very near shore that are affected by waves and longshore currents) (SEL 2011). Littoral sediment have been greatly reduced due to shoreline erosion protection structures, lack of nearshore substrates, and installation of groynes and piers.

Permanent erosion monitoring stations were established in 2011 and monitored again in 2012 by GHD (2012) to fulfill the data gaps identified in the Background Review. An additional erosion monitoring station was established at Marie Curtis Park beach in 2015 by SEL. The summary results are included in Table 3-15. Generally, erosion rates in the LOISS study area are considered moderate (approximately 0.30 m/year). GHD (2012) recommended short-term monitoring continue on a seasonal (spring, summer, fall) basis to develop a range for baseline conditions. At minimum, long term monitoring of these stations should continue on an annual basis. Monitoring recession (i.e. erosion) along the shoreline and the function and stability of erosion protection structures help determine areas that may be vulnerable to future instability.

Table 3-15: Coastal Reach Shoreline Characteristics

Coastal Reach	Length * (m)	Associated Creek(s)	Nearshore substrate[2]	Shoreline type	Erosion Rate (m/yr)[1]	Dynamic Beach	Infilling
1 – Lakeview	1355	Serson Creek Applewood Creek	Bedrock, sand/silt veneer	Rock armouring, sand/cobble beach	0.33 (moderate)	No	- Infilling associated with expansion of GE Booth Waste Water Treatment Facility
2 – Lakefront Promenade	9040	Cawthra Creek	Sand in depths >2.5m; cobbles, boulders, bedrock >2.5m; aquatic vegetation in embayments	Rock armouring, small areas of natural/sand	n/a	No	- Lakefront Promenade headland - Lakefront Promenade Marina breakwaters - Ontario Power Generation pier (640 m)
3 – Mineola	2334	Cumberland Creek Cooksville Creek,	Cobbles	Rock armouring	Considered stable (after 1954) due to shoreline armouring	Cooksville Creek beach shoreline acts like dynamic beach but does not meet formal definition (constrained by bluff)	- R.K. McMillan headland
4 – Port Credit	3497	Credit River	Medium silt to medium sand	Rock armouring	n/a	No	- Credit Harbour Marina headland and breakwater (675 m)
5 - Lorne Park/ Meadowwood	6927	Sheridan Creek Turtle Creek Birchwood Creek Moore Creek Lornewood Creek Tecumseh Creek	West – bedrock with sand veneer Mid-reach – cobble East – cobble transitioning to sand veneer at depth >1.3m	Rock armouring, cobble beach, natural/sand	0.07 (low) (excludes unprotected shoreline at Lorne Park Estates)	PetroCan Lubricants Energy Richard Memorial Jack Darling Rattray Marsh Lorne Park Estates	- 7 small headlands - 2 groynes
6 – Refinery	2380	Avonhead Creek Lakeside Creek	Bedrock dominated with sand and silt veneer	Rock, boulders/broken brick	0.31 (moderate)	Lakeside Park	- PetroCan Lubricants Refinery pier (540m)
7 – Clearview	2270	Clearview Creek	Bedrock dominated with sand and silt veneer	Small cohesive bluff at west end, cobble beach, boulders, rock armouring	0.31 (moderate)	Harding Estates	- 2 headlands protecting radio towers - CRH Canada pier (700 m)

[1] Source: Geomorphic Solutions 2012a.
[2] Source: GHD 2011
* calculated (source: CVC)

Approximately 81% of the shoreline within the study area has been hardened with erosion protection structures (i.e., armourstone, steel sheetpile, or other material with low erodibility placed along the shoreline to prevent loss of land by erosion from coastal processes) (Table 3-16 and Figure 3-16). Shoreline structures reduce or eliminate the contribution of source sediment to Lake Ontario and increase erosion rates of adjacent unprotected natural shorelines. The remaining unhardened shoreline consists of sand and cobble beach and bluff.

Table 3-16: Shoreline Treatments (source: CVC)

Treatments	Coastal Reach: Shoreline Treatment* (m)							Subtotal (m)	Percent
	1 – Lakeview	2 – Lakefront Promenade	3 – Mineola	4 – Port Credit	5 - Lorne Park/ Meadowwood	6 – Refinery	7 – Clearview		
Armourstone	986	5454	1813	2749	3917	186	744	15983	57.00%
Boulder, Broken Rock		198		658			146	1002	3.60%
Broken Brick						657		657	2.36%
Broken Concrete					175	69	405	649	2.33%
Concrete Wall			177		61	1131	738	2107	7.58%
Old Barge		718						718	2.58%
Retaining Wall		324						324	1.17%
Sheet Pile Wall		1032	128	49				1209	4.35%
Sand Beach		923	127		1277			2327	8.37%
Natural		391				243		634	2.28%
Bluff							103	103	0.37%
Cobble	368		89	40	1497	94	133	2221	7.99%
TOTAL	**1355**	**9040**	**2334**	**3497**	**6927**	**2380**	**2270**	**27803**	**100.00%**

An assessment of shoreline erosion protection structures on CVC owned properties was completed by GHD in 2014. A subsequent assessment was completed on municipally and privately owned structures in 2015 by Shoreplan Engineering Ltd. These assessments included:

- an inspection of existing erosion protection structures for risk of damage or structure failure,
- personal safety,
- material condition,
- structures effectiveness and performance, and
- environmental factors and impacts.

It should be noted that no structures in 1 – Lakeview Coastal Reach were assessed as part of this study since at the time of writing this report this coastal reach is undergoing restoration including the creation of a new shoreline (i.e., Lakeview Waterfront Connection). The structures in 1 – Lakeview Coastal Reach were assessed in detail through the development of the Lakeview Waterfront Connection Environmental Assessment.

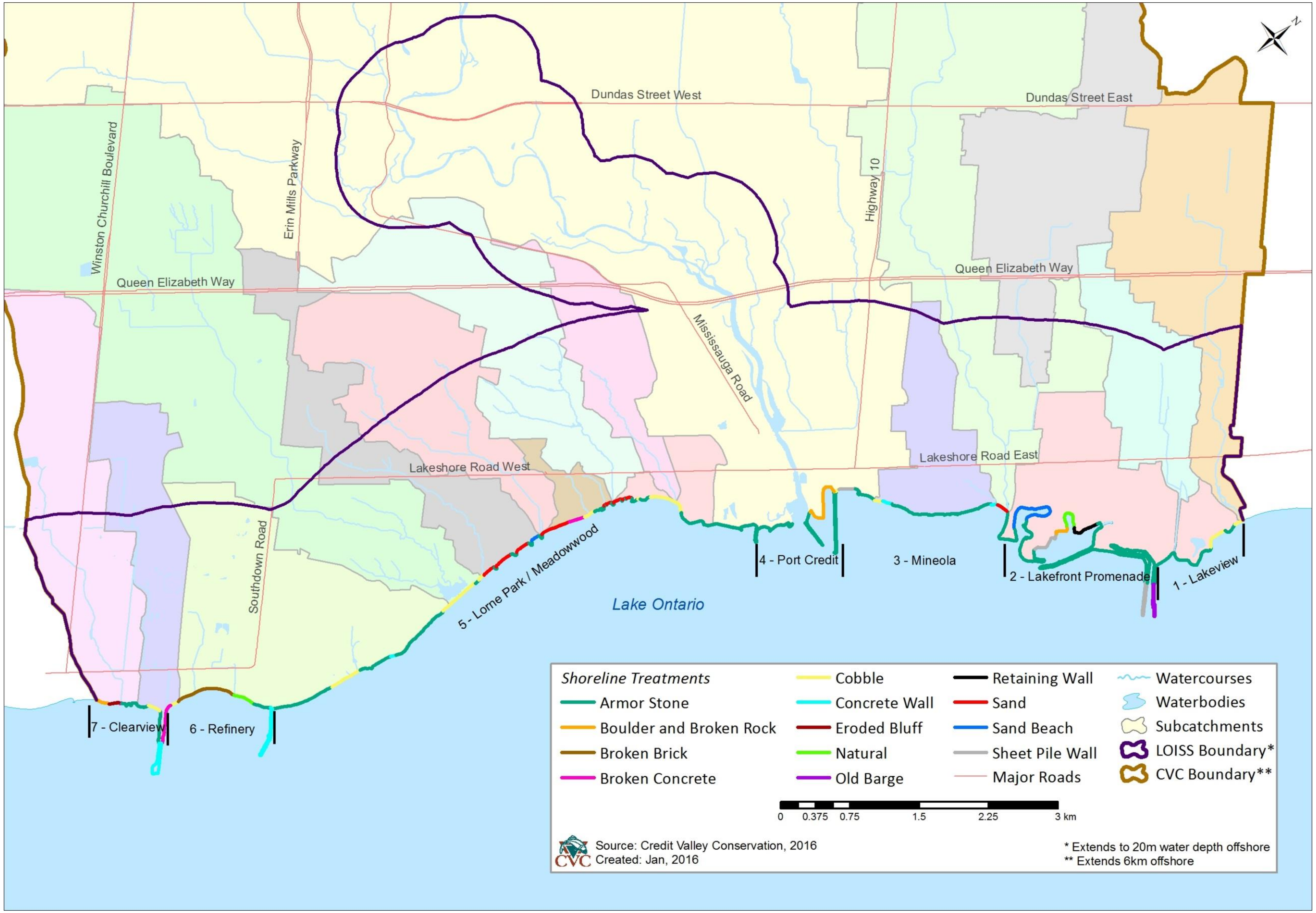


Figure 3-16: Shoreline Treatments in the LOISS study area. (Source: CVC)

Sixteen priority structures were identified in the LOISS study area (Table 3-17) that will need maintenance, repairs or replacement as soon as financially feasible. Of these, sections of Lakefront Promenade, JC Saddington, and the mouth of Cooksville Creek shoreline are of highest priority for work. The headland (i.e., point of land extending out into the water) of RK McMillan (2 – Lakefront Promenade Coastal Reach and 3 – Mineola Coastal Reach) appears several times on the priority list. This location is particularly vulnerable to damage since it is exposed to strong waves from both the east and west.

Table 3-17: Top 16 priority erosion protection structures that require maintenance, repair or replacement. (Source GHD 2014, SEL 2017)

Coastal Reach	General Location	Site Number	Existing Structure Type	Potential Work Needed
2 – Lakefront Promenade	Lakefront Promenade	3E.2, 3F.1	Western breakwater and central headland shore protection	Repair and replacement of missing stones
4 – Port Credit	JC Saddington	7A.6 to 7A.10	Groyne off the headland, south shore revetments, west armourstone groyne, east headland and groyne	Cobble beach per Port Credit Harbour West Parks report
3 – Mineola	Cooksville Creek mouth	4.1	Failed gabions	Remove and repair failed gabion
6 – Refinery	Lakeside Park	18D.1	Steep clay pipe bank	Headland beach system
6 – Refinery	Lakeside Park	18D.2	Steep clay pipe bank	
7 – Clearview	Harding Estates	21F	Till bluff	Headland beach system
7 – Clearview	Harding Estates	21G	Randomly placed armourstone	
2 – Lakefront Promenade	RK McMillan headland	3J	Headland shore protection	Replacement and reinforcement of stones
5 – Lorne Park/Meadowwood	Turtle Creek west side of mouth	14A.1	Bank treatment	Repair of failed bank treatment
2 – Lakefront Promenade	RK McMillan headland (southeast corner of headland	3I	Headland shore protection	Replacement and reinforcement of stones
3 – Mineola	RK McMillan headland (west side)	3K	Headland shore protection	Replacement and reinforcement of stones
2 – Lakefront Promenade	Lakefront Promenade	3B.1	Broken concrete and rubble	Repair/replacement of stones
5 – Lorne Park/Meadowwood	Rattray Marsh old pump station	14A.3	Armourstone	Remove concrete structure and repair shoreline
2 – Lakefront Promenade	Lakefront Promenade	3G.2	Rip rap revetment	Repair and reinforce revetment

Coastal Reach	General Location	Site Number	Existing Structure Type	Potential Work Needed
5 – Lorne Park/Meadowwood	Ben Machree Park East	7G and 7H.1	Randomly placed concrete rubble and armourstone	Shore protection structure upgrades
5 – Lorne Park/Meadwood	Ben Machree Park West	7I.1 and 7I.2	Randomly placed concrete rubble and armourstone	

Beyond shoreline hardening, a number of deliberate land creation initiatives have been implemented along the shoreline for reasons ranging from the creation of parkland to industrial development. While groynes and piers provide some protection from erosion to adjacent areas of the shoreline, they also disrupt natural erosion and littoral sediment transport. It is estimated that the impact of structures protruding into the lake (piers, groynes, etc.) greater than 400 m in length may extend as much as 6–10 times the overall length of the structure along the shoreline (Meadows et al. 2005). As a result, littoral sediment inputs from the Toronto shoreline into the study area and output sediment from the study area to Oakville are limited.

Major modifications to the shoreline (since 1859) are captured in a coarse manner in Figure 3-17 and summarized further in Table 3-14. Areas where erosion has occurred within the same period cannot be accurately identified due to the discrepancies in the projection of the aerial photographs. It is estimated that 170 acres of land creation has occurred in the LOISS study area between 1859 and 2012, to facilitate development (e.g. marinas) and protect again erosion. An additional 26 ha of land creation will be added through the Lakeview Waterfront Connection initiative in 1-Lakeview coastal reach to facilitate creation of natural heritage features including wetlands, meadows, forests and beaches, and provide access to the water for people which have previously been reduced due to development.

Five large structures extend more than 400 m into the lake in the LOISS study area: 2 – Lakefront Promenade Coastal Reach (OPG piers), 3 – Mineola Coastal Reach (R.K. McMillan Park), 4 – Port Credit Coastal Reach (Port Credit Village Marina), 6 – Refinery Coastal Reach (PetroCan Lubricants) and 7 – Clearview Coastal Reach (CRH Canada). Based on the findings by Meadows et al. (2005) described above, the structures within the LOISS study area may influence coastal processes across the entire length of the study area. Although no attempt has been made to distinguish between the relative up – vs down – drift impacts of the individual protruding structures, typically, on the downdrift side of the structures, the shoreline appears to be afforded some protection from the erosive, dominant waves from the east, as evidenced in part by the circulation of finer substrates on the downdrift side of RK McMillan headland (2 – Lakefront Promenade Coastal Reach) and Cranberry Cove headland (5 – Lorne Park/Meadowwood Coastal Reach), which replenish the beaches and alter the bathymetry at the mouth of Cooksville Creek and Tecumseh Creek, respectively (Davidson-Arnott, pers. comm. 2012). With the exception of the OPG piers, all of these structures are actively used. The OPG piers are included in the visioning of the redevelopment of the OPG lands. Their future use is yet to be determined.

Figure 3-17: Coarse-Level Shoreline Modifications (1859 vs 2012) (Ruthart 2012)

Where filling has occurred, the waves break closer to the shore and, in some instances, on the engineered erosion protection structures. The erosive force on the bed of the lake at the shoreline can lead to downcutting, thus increasing water depth. Rock and gravel in the nearshore help to dissipate energy in waves thereby protecting against lake bed and shoreline erosion. Historically, stonehooking, the process of mining rock and gravels from the lakebed, has removed substantial quantities of substrate from the nearshore.

Stonehooking was prevalent from the Mississauga waterfront to Burlington Bay from the 1830s to just after World War I when concrete became more readily available and materials began to be sourced from the Niagara Escarpment and the Oak Ridges Moraine. An estimated 3,900,000 tonnes of rock was removed from the nearshore (depths of approximately 6 m) during almost 100 years of stonehooking within the nearshore of the LOISS study area (Collins pers. com. 2012). Bradley (1966) refers to stonehooking of Lake Ontario in the 1800s leading to 'the lake being pitted with holes where the stone was taken with grappling irons'.

The tributaries in the study area are unlikely to be a primary source of large substrates (e.g., cobbles) in the nearshore. While existing data are insufficient to characterize current nearshore sediment particle size, depth to bedrock, abundance, etc., some general characterizations can be made based on qualitative data collected through various studies (Table 3-14). In general, the nearshore substrates consist of shallow finer grained materials (sands, silts) with small areas of cobble and erratic boulders. However, the dominant controlling substrate (shale bedrock) in the lake is the most important factor influencing physical processes at the land/water interface. While bedrock is less erodible than tills and clay, shale is prone to fractures and chipping, particularly with frequent exposure to air. As stated above, the dominance of shale on the lake bed likely contributes to shoreline erosion.

3.4.2 Synthesis of Coastal Processes

Wind, water level and bathymetry are underlying factors that influence the processes of circulation, ice formation and sediment transportation in the nearshore environment.

Circulation is both enhanced and constrained by currents, waves, and upwellings/downwellings. Stratification and thermal bar formation restrict mixing of nearshore waters with deeper offshore waters, confining waves and currents to shallower waters. Littoral nutrients and sediment are well mixed within the thermal bars by waves, currents, and upwellings/downwellings. Waters discharging to the lake within the study area have little influence on these larger lake processes (waves, currents, upwellings/downwellings) due to low relative flow volumes. However, local mixing and circulation patterns may be affected by these discharge waters as they enter the water column as overflow, underflow or interflow. Dominant wave direction assists in predicting the direction of plumes (sediment and pollutants) associated with stream inputs.

In the Study Area dominant waves from the east push littoral sediment along shore toward the west. The many shoreline protrusions (e.g., headlands, piers, breakwaters) limit the movement of sediment and pollutants along the shore and interrupt dilution. Generally, sediment accumulating on the updrift side of the protrusions is protected from erosive waves on the downdrift side. Currently, the OPG piers are the only protrusions into the lake that are not actively being used. Further study on the function of these piers in shoreline processes is needed to determine if removal or modification of these piers are expected to improve sediment transportation or other nearshore functions.

Ice cover in the nearshore can protect natural shorelines from erosion caused by winter storms. Generally ice forms in sheltered areas (river mouths, embayments) in the LOISS study area and very shallow areas of the open coast.

Erosion is a natural process that serves to replenish substrates in the nearshore that diffuse wave energy thereby reducing shoreline erosion. These eroded materials provide habitats for fish and benthic macroinvertebrates. Prevailing wind and wave action from the east subjects the shoreline to strong erosive forces and this, coupled with historic stonehooking, has contributed to the gradual hardening of much of the shoreline to protect life and property. Opportunities to soften the shoreline need to be identified on a case-by-case basis and incorporated into shoreline modification designs where appropriate.

Bathymetry also plays a key role in determining appropriate erosion protection treatments along the shore. Waves breaking further from the shore are less erosive than those that break closer to shore. Where filling has occurred, waves break on the shoreline rather than out in the lake requiring non-erosive (hard engineered) protection structures along the shore. These hard structures reduce erosion along the shore and transfer the erosive energy to the bed of the lake exacerbating erosion and increasing water depth. Higher water levels experienced in spring of 2017 resulted in damage to areas with erosion protection structures in the LOISS study area. This damage is largely due to high-energy waves breaking on or behind the shoreline protection structures requiring restoration of the structure and/or adjacent lands. Going forward, the design of shoreline protection structures will need to consider the effects of higher lake levels.

Assessment of the erosion protection structures on public and private lands identified 16 structures (Table 3-16) in need of maintenance, repair or replacement as soon as financially possible (GHD 2014, SEL 2017). Where appropriate, hardened shorelines should be replaced with softer elements such as cobble or sand beaches or vegetated riparian zones.

Shoreline erosion monitoring stations at 13 locations established by GHD and SEL should be monitored annually to identify changes in erosion rates (GHD 2011, SEL 2015).

This general understanding of coastal processes are helpful in focussing further study efforts in the LOISS study area. Next steps and recommendations are summarized in Table 3-18.

Table 3-18: Summary of Coastal Processes Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Establish a formal annual shoreline erosion monitoring program at established stations	Harding Estates, Lakeside Park, Watersedge Park, Rattray Marsh Conservation Area, Jack Darling Park, Richards Memorial Park, Brueckner Rhododendron Gardens, JC Saddington Park, Tall Oaks Park, Hiawatha Park, The Adamson Estate, RK McMillan, Marie Curtis Park	High	CVC
Create guidance document on best management practices for development adjacent to shorelines		Medium	CVC
Repair/maintenance of shoreline erosion protection structures and concurrent efforts to restore nearshore substrate	See Table 3-16	High	CVC/City of Mississauga

3.5 WATER QUALITY

Rainfall and snowmelt run off surfaces rapidly and in unnaturally large amounts in areas of high urban density. This runoff gathers speed and erosional power and takes up contaminants as they travel into receiving waters. Urbanization increases the variety and amount of pollutants carried into streams, rivers, and lakes. The pollutants include: sediment, oil, grease, pesticides and nutrients from lawns and gardens; viruses, bacteria, and nutrients from pet waste and failing septic systems; road salts; heavy metals from roof shingles, motor vehicles, and other sources; and thermal pollution from dark impervious surfaces such as streets and rooftops. Additional pollutants from upstream agricultural areas also contribute. These pollutants can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe and unpleasant (https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf).

The Background Review identified that the largest watercourse within the LOISS Study Area, the Credit River (Figure 3-18) has the greatest effect on most water quality parameters. The Credit River contributes more than two times the combined phosphorus load of the Clarkson and Lakeview Wastewater Treatment Plants to Lake Ontario. As well, it contributes 86% of the suspended solids, 66% of the nitrates, and 80% of the heavy metals entering Lake Ontario from within the study area (ABL 2011). The study concluded that while historical data exist relating to concentrations of water quality parameters from storm sewer outfalls and within watercourses, water quality data along the waterfront are limited. Therefore, it was recommended that an assessment be completed as to how flows, sediment, and pollutants move and circulate along the nearshore. Additionally, the report identified lake and watershed modeling, instream and nearshore water quality sampling of key parameters, and nearshore water temperature monitoring as some of the tasks required to characterize water quality of the LOISS study area. The identified water quality gaps and their current status is presented in Table 3-19.

Figure 3-18: The sediment plume from Credit River entering Lake Ontario (Photo Credit: Aquafor Beech Ltd 1990)

Table 3-19: Status of water quality data gaps

Data Gap	2017 Status
Instream and nearshore water quality sampling	Completed in 2011-2013 2011 (June-Oct) 2012 (July-November) 2013 (April-August)
Nearshore water quality/circulation modeling	Mike 3 Model completed in 2011
Improved understanding of the role of sediment as it relates to contaminants	Not being pursued
Watershed modeling to estimate delivery of contaminants to the lake	HSP-F model completed in 2011
Nearshore Thermal monitoring	Completed in 2011 (May-Oct 2011)

3.5.1 Characteristics

In 2011, CVC began monitoring and modelling water quality of the watercourses (Figure 2-1) draining directly into Lake Ontario and the nearshore area of the lake (up to 20 m depth) within CVC's jurisdiction. The objectives of monitoring and modelling were to characterize the study watercourses, estimate nutrient, sediment, and *E. coli* loadings to the lake, and understand in-lake pollutant dynamics. Dry (baseflow) and wet (storm event) samples were collected from nine streams (Applewood, Serson, Cooksville, Lornewood, Birchwood, Turtle, Sheridan, Avonhead and Clearview), the Credit River, three beaches (Lakefront Promenade, Richard's Memorial and Jack Darling) and six lake transects (Figure 2-1). Watershed modeling was accomplished using the Hydrologic Simulation Program – Fortran (HSP-F) model and lake modeling was conducted using MIKE-3 model. The watershed model was used to estimate contaminant loadings from the contributing watersheds to the lake while the lake model was used to simulate in-lake fate of the water quality parameters of concern.

3.5.1.1 Water Quality Parameters of Concern

Seven water quality parameters; temperature, total suspended solids (TSS), nutrients (total phosphorus (TP), nitrate-nitrogen (NO_3-N)), *E. coli*, specific conductivity (SC), and chloride, were identified as parameters of concern (POC) that could significantly impact the beneficial use of the lake for drinking, recreation (swimming and fishing), and aesthetics. The section below discusses the results of LOISS (both watercourses and lake) water quality monitoring and modeling for the identified POC. Where available, the 75th percentile[3] statistics of each parameter of concern is compared to its Provincial Water Quality Objective (PWQO) or Canadian Water Quality Guidelines (CWQG). A description of high for these parameters is in reference to the monitored or modeled levels as being higher than the PWQO or CWQG.

[3] 75th percentile is the statistical value that is used to compare against the PWQOs.

Temperature

Temperature helps to answer many key water quality questions. It exerts a major influence on biological activities, aquatic organism growth, and how quickly a contaminant will decay. Temperature also influences whether the contaminants delivered by the river will enter a lake as overflow (floating at the surface), interflow (intermediate depth), or underflow (close to the lake bed) (Section 3.4.1.3). Periods of lake stratification, upwelling, downwelling, and fall turnover can also be determined by monitoring temperature. These periods are important for in-lake contaminant mixing, organic matter decomposition, and temperature regulation of aquatic biota. During upwellings, nutrient rich lake bottom water replaces nutrient depleted surface water and provides food to phytoplankton and other nearshore organisms. During downwellings, oxygen rich denser surface water sinks to the lake bottom providing healthy conditions for biological activities at the lake bed. Lake stratification has a two-sided role. During summer the heat exchange between a lake and the atmosphere happens in the shallow surface layer which divides the lake water column into three layers: the epilimnion layer at the surface where all the heat transfer takes place, the metalimnion layer further down, which experiences maximum rate of temperature decrease with respect to depth (sometimes referred to as the thermocline), and the hypolimnion layer at the bottom, which is minimally impacted by atmospheric changes. The temperature in the hypolimnion layer remains relatively stable over time. The hypolimnion layer is shielded from atmospheric heat and dissolved matter until cooler fall and winter temperatures force circulation to deep waters. This natural shielding protects aquatic life. In winters lake surface icing, could stratify a lake when a layer of low density water cooler than 4 ^{o}C but warmer than 0 ^{o}C forms just under the ice. Below this water the remaining lake water is usually near 4 ^{o}C. At this point, a lake is said to be in winter stagnation.

Water temperature in the study area was monitored in collaboration with Environment and Climate Change Canada from April 19-October 28, 2011 at six different locations in the lake, two at 19m depth and four at 9m depth at a 10-minute interval. Each location was monitored using a mooring with temperature probes installed at one metre depth intervals throughout the water column. The Credit River temperature was monitored close to its mouth from June 10-October 28 (Figure 2-1), at a 15-minute interval.

Figure 3-19 shows the time-series profile of lake temperature recorded at 9 m (9 thermistors (i.e. thermal resistors) installed at 1 m intervals from surface to lake bed) and 19 m (19 thermistors, surface to lake bed at 1 m interval) lake depth contours for comparison. Figure 3-20 (b) shows that during late spring and early summer (day 109-140) the lake temperature profiles do not show much variation and hover around 5 ^{o}C. Early in the monitoring period surface temperature was lower than the bottom temperature by 2.02 ^{o}C (April 26th, day 116). However, as the weather warmed up, the lake started to stratify. The maximum temperature difference recorded between the surface and bottom lake layers at 19m depth during one of the stratification periods was 18.02^{o}C (July 24th, day 205). At the 19m depth monitoring location the minimum and maximum temperatures at the lake surface were 3.4 ^{o}C and 24 ^{o}C, respectively, and at the bottom 3.14 ^{o}C and 21.15 ^{o}C, respectively. The wide range of temperatures at both the lake surface and lake bottom are due to temperature changes associated with stratification.

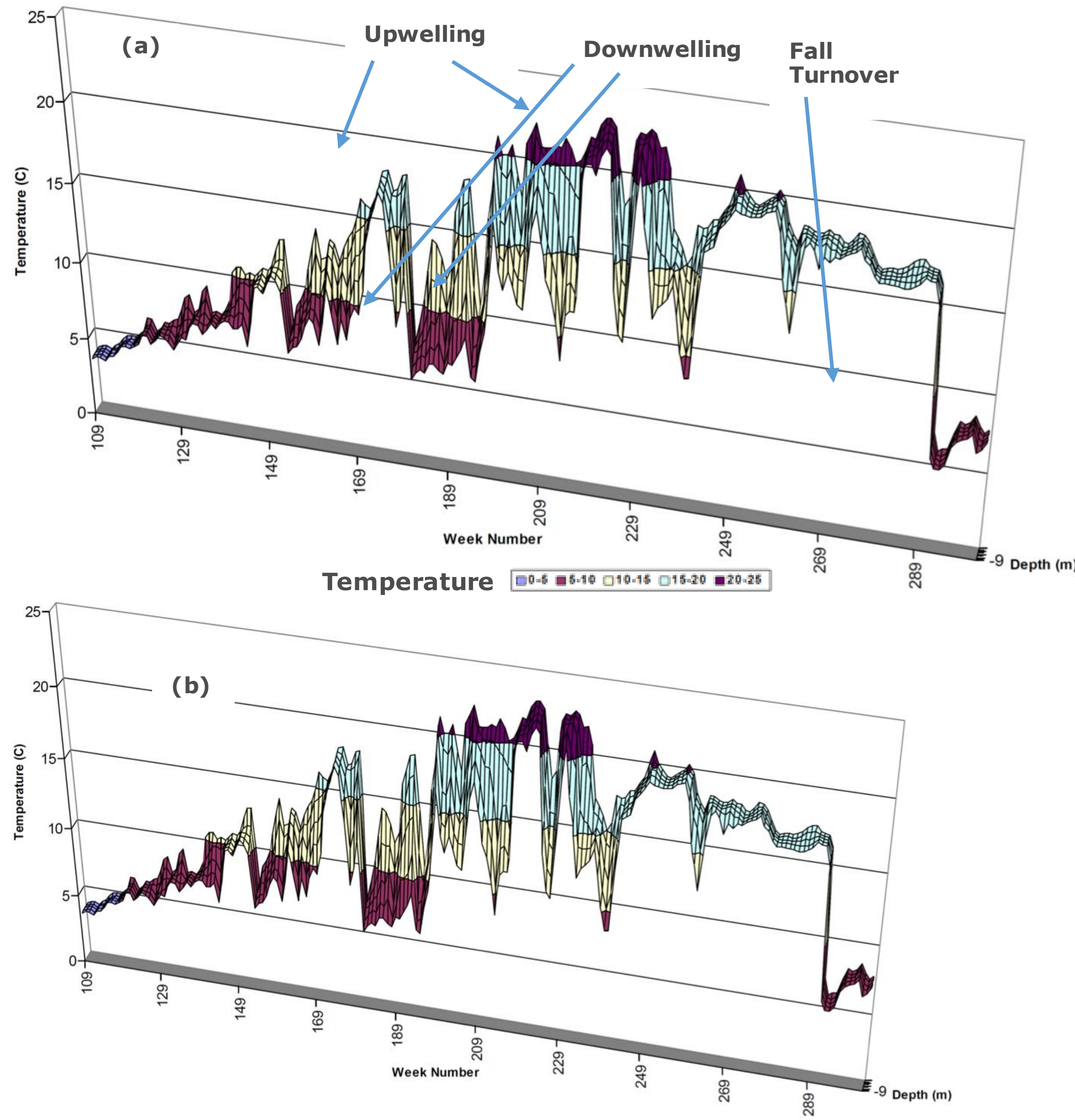


Figure 3-19: Lake water temperature time series recorded in 2011 (May – October) at one meter interval from surface to bottom at (a) 9m lake depth and (b) surface to 19m lake depth (Source: Environment and Climate Change Canada water temperature data 2011)

The upwelling and downwelling events are noted in Figure 3-19. However, these events are also presented in Figure 3-20 by calculating large changes in surface and bottom lake temperature within a 24-hour period. If the bottom temperature increased by 4 °C or more then it is an downwelling event, and if the surface temperature deceased by 4 °C or more, then it is an upwelling event. During the monitoring period eight downwelling and five upwelling events were observed. There is no guideline on how many upwelling or downwelling events are ideal, however, the changing climate could change the frequency of these events. Therefore, a long term analysis of upwelling and downwelling events is necessary in order to understand how changes in their frequency may impact nutrient redistribution and oxygenation of the lower layer of the lake.

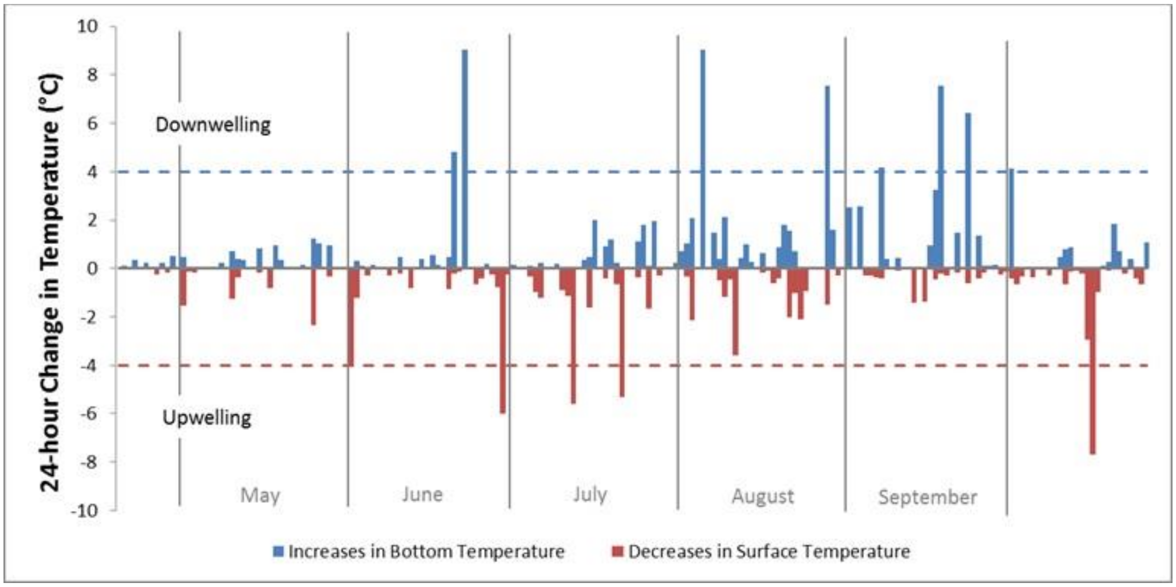
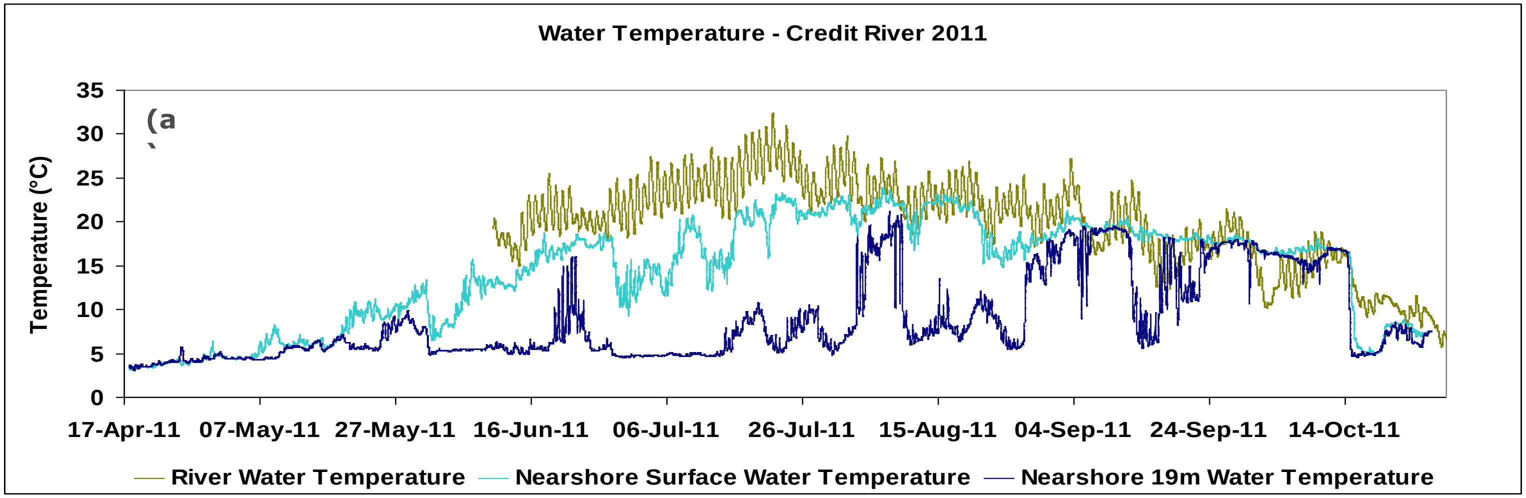


Figure 3-20: Observed lake upwelling (4°C decrease in lake bottom temperature in 24 hours) and downwelling (4°C increase in lake surface temperature in 24 hours) events at 19m depth offshore from April 19th to October 27th, 2011 (Source: Environment and Climate Change Canada water temperature data 2011)

Figure 3-21(a) shows the time series of surface and bottom temperature at the 19 m depth monitoring station along with Credit River temperature. The Credit River temperatures are higher than the lake temperature (surface and bottom) in spring and summer; however, in the fall the river temperature is either lower than lake surface temperature or lower than both the surface and bottom temperatures. Figure 3-21(b) presents lake and river densities as functions of temperature. The densities guide whether the Credit River plume will enter the lake as overflow, interflow, or underflow. This influences where the contaminants delivered by the river will get distributed in the lake. For example, in the case of overflow, the contaminants will float over the lake surface, however, in case of underflow, they will sink down to the bed of the lake. The lake modeling conducted for this study confirmed the effect of density on contaminant distribution in the lake. Figure 3-23(a) shows overflow (floating) of the total phosphorus plume delivered by the Credit River to the lake during a storm event in May. Figure 3-22(b) shows the underflow (sinking) of the total phosphorus plume during a storm event in October. The findings reiterate that long-term monitoring of both river and lake temperatures are critical in light of the changing climate since the changes in temperatures could have an impact on the distribution of contaminants in the lake, which could affect algae resurgence and aquatic life.

The effect of temperature on contaminant decay was not studied, however, it is recommended as a future initiative since decay of contaminants and decomposition of organic matter has a potential impact on lake oxygen levels in the hypolimnion layer.



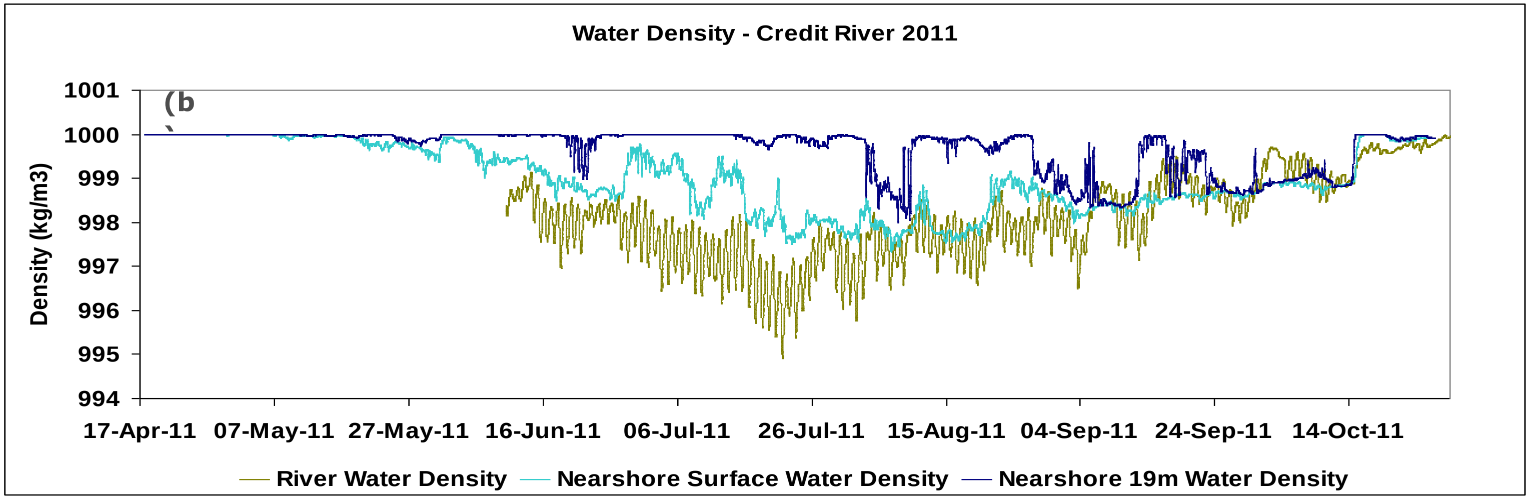


Figure 3-21: Continuous (a) water temperature recorded and (b) water density calculated in 2011 (May – October) at the mouth of Credit River, the lake surface, and the lake at 19m depth (Source: Environment and Climate Change Canada and CVC water temperature data 2011

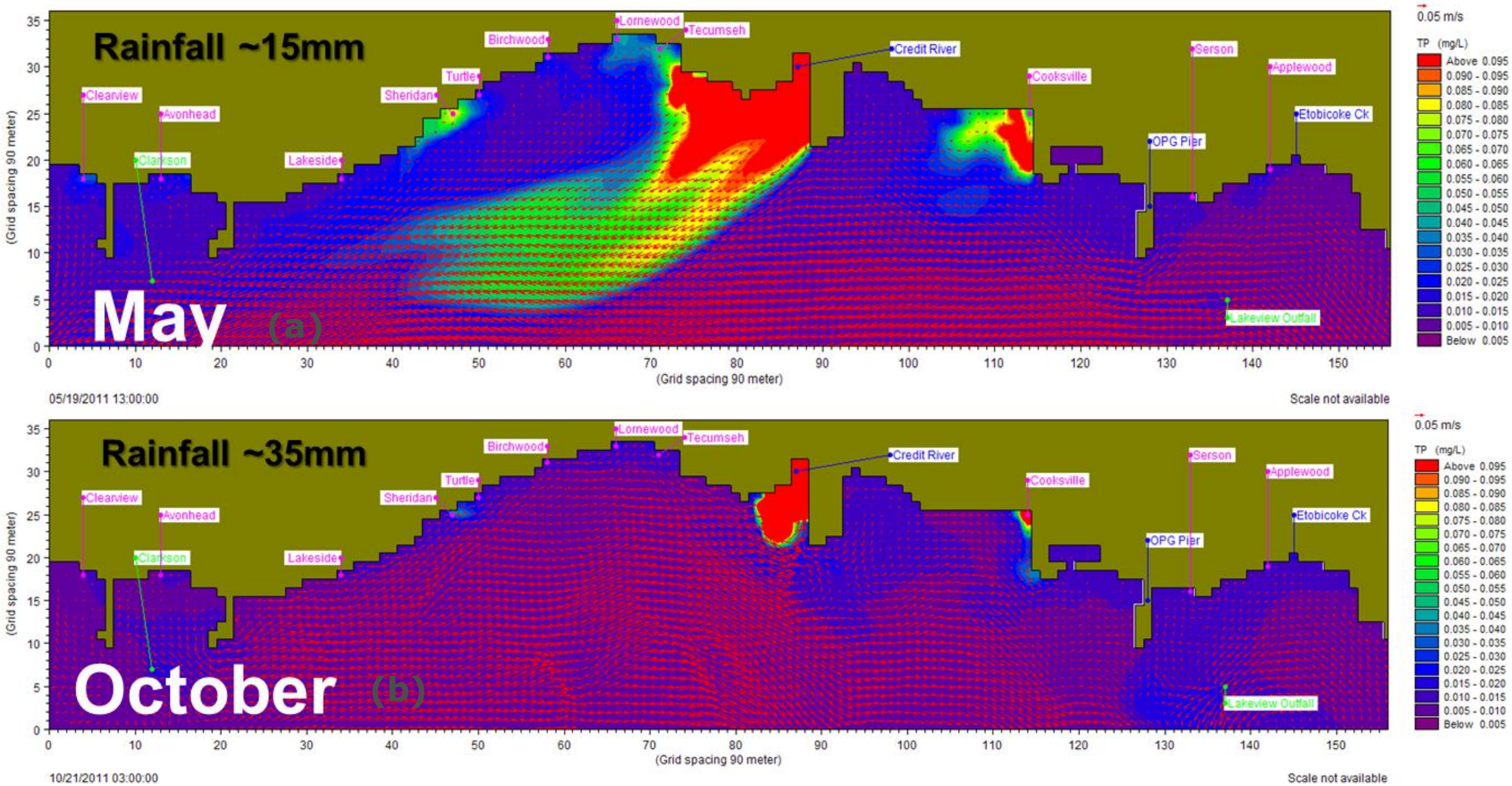


Figure 3-22: Modelled total phosphorus plumes entering Lake Ontario during a storm event (a) in spring showing overflow condition and (b) in fall showing underflow condition. (Source: Lake study CVC, 2011)

Total Suspended Solids

Total suspended solids (TSS) are particles found in the water column that are larger than two microns. These solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. TSS is a surrogate for particle-adsorbed contaminants such as phosphorus, *E. coli* and metals. There is no PWQO for TSS; however, the CWQG for TSS in fresh water is 25 mg/L. TSS is also indicative of water clarity which relates to the amount of sunlight that can penetrate deeper into a water column. More light in a lake means a greater opportunity for plant photosynthesis.

The monitored instream TSS concentration (75th percentile of all samples) ranged from 6.5 mg/L for Applewood Creek to 38 mg/L for the Credit River with the Credit River and Sheridan Creek exceeding the CWQG limits (Table 3-20). The nearshore monitored TSS concentrations (75th percentile) were very low ranging from non-detect to 6.75 mg/L with highest levels observed at the Credit River transect close to the shore (Figure 3-23). Since the monitored TSS concentrations near the two water treatment intakes were close to zero, TSS likely did not have an impact on the treatment facilities at the time the samples were taken. However, it is highly likely that TSS peaks during extreme events were missed as samples were not collected due to health and safety reasons. Therefore, continuous in-lake turbidity monitoring is strongly recommended to capture the whole spectrum which includes dry and wet weather conditions. Further, instream sampling of wet events was also very difficult because of the rapid response of streams in the study area. Most of the streams respond within half an hour of a rain event and the timing is difficult to predict. Some of these streams are now being continuously monitored for turbidity, a surrogate for TSS; therefore, better information on the dry and wet weather conditions will be available in the future.

The TSS loads delivered by the streams in the LOISS study area were simulated by the HSP-F model in 2011. The model estimated that the highest contribution came from the Credit River at approximately 226,676 tonnes annually followed by Cooksville Creek's contribution of 3,422 tonnes annually (Figure 3-24). Smaller watercourse contributions ranged from 0.2 tonnes annually for Serson Creek to 213 tonnes annually for Sheridan Creek. The GE Booth and Clarkson WWTP contributed 1,273 and 223 tonnes annually of TSS, respectively, in 2011 (Figure 3-24).

Table 3-20: Summary of Monitored Instream and Beach Water Quality Results (75th percentile[4]). The shaded cells indicate exceedances of parameters when compared to its objective or guideline (Source: CVC monitored data, 2011-2013)

Coastal Reach	Tributary	Conductivity (µS/cm)	Total Suspended Solids (mg/L)	Total Phosphorus (mg/L)	Dissolved Phosphorus (mg/L)	*E. coli* (cfu/100mL)	Nitrate-Nitrogen (mg/L)
	Provincial Water Quality Objective /Canadian Water Quality Guideline	**n/a**	**25**	**0.03**	**n/a**	**n/a**	**3.0**
1 – Lakeview	Serson Creek	1790	9	0.109	0.083	3800	3.47
	Applewood Creek	3333	6.5	0.062	0.019	2300	1.47
2 – Lakefront Promenade	Lakefront Promenade Park Beach (Thumb Basin)	350	3	0.036	0.003	24.75	0.5
3 – Mineola	Cooksville Creek	2403	7.75	0.062	0.011	1100	1.85
4 – Port Credit	Credit River	806	38	0.051	0.003	152	1.82
5 – Lorne Park/ Meadowwood	Sheridan Creek	1555	29.5	0.109	0.021	475	0.65
	Turtle Creek	2340	13	0.188	0.066	800	1.06
	Birchwood Creek	1720	6	0.082	0.026	1300	2.38
	Jack Darling Beach	371	28	0.057	0.003	272.5	0.52
	Lornewood Creek	1900	16	0.148	0.102	5400	2.54
	Richard's Memorial Beach	1074	26.75	0.09	0.015	2500	1.14
6 – Refinery	Avonhead Creek	1725	16.5	0.182	0.05	1500	0.913
7 – Clearview	Clearview Creek	2945	15.25	0.105	0.029	268.5	2.07

4 75th percentile is the statistic that is used to compare against PWQOs

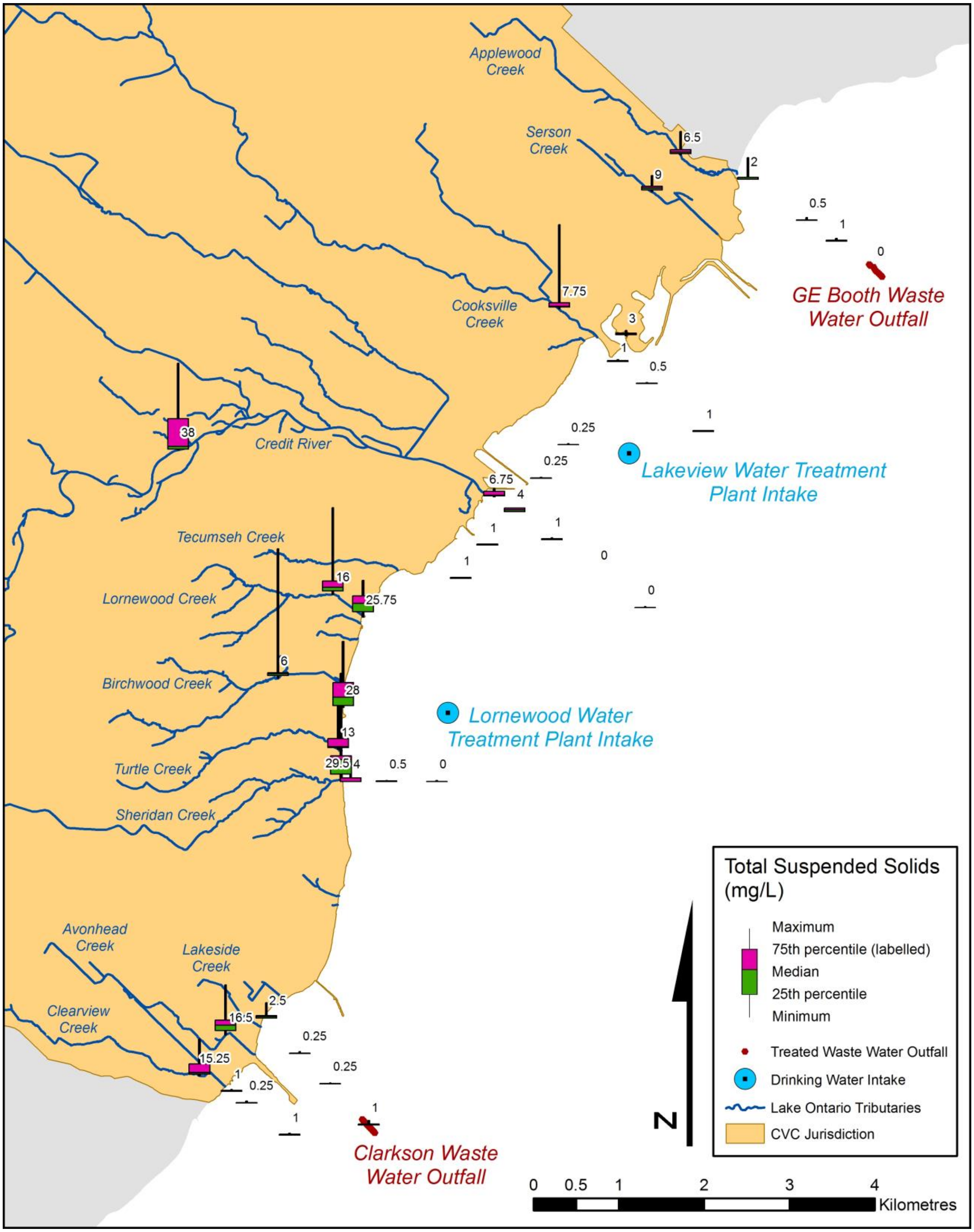


Figure 3-23: Instream and nearshore monitored Total Suspended Solid concentration from 2011-2013 (Source: CVC monitoring data 2011-2013)

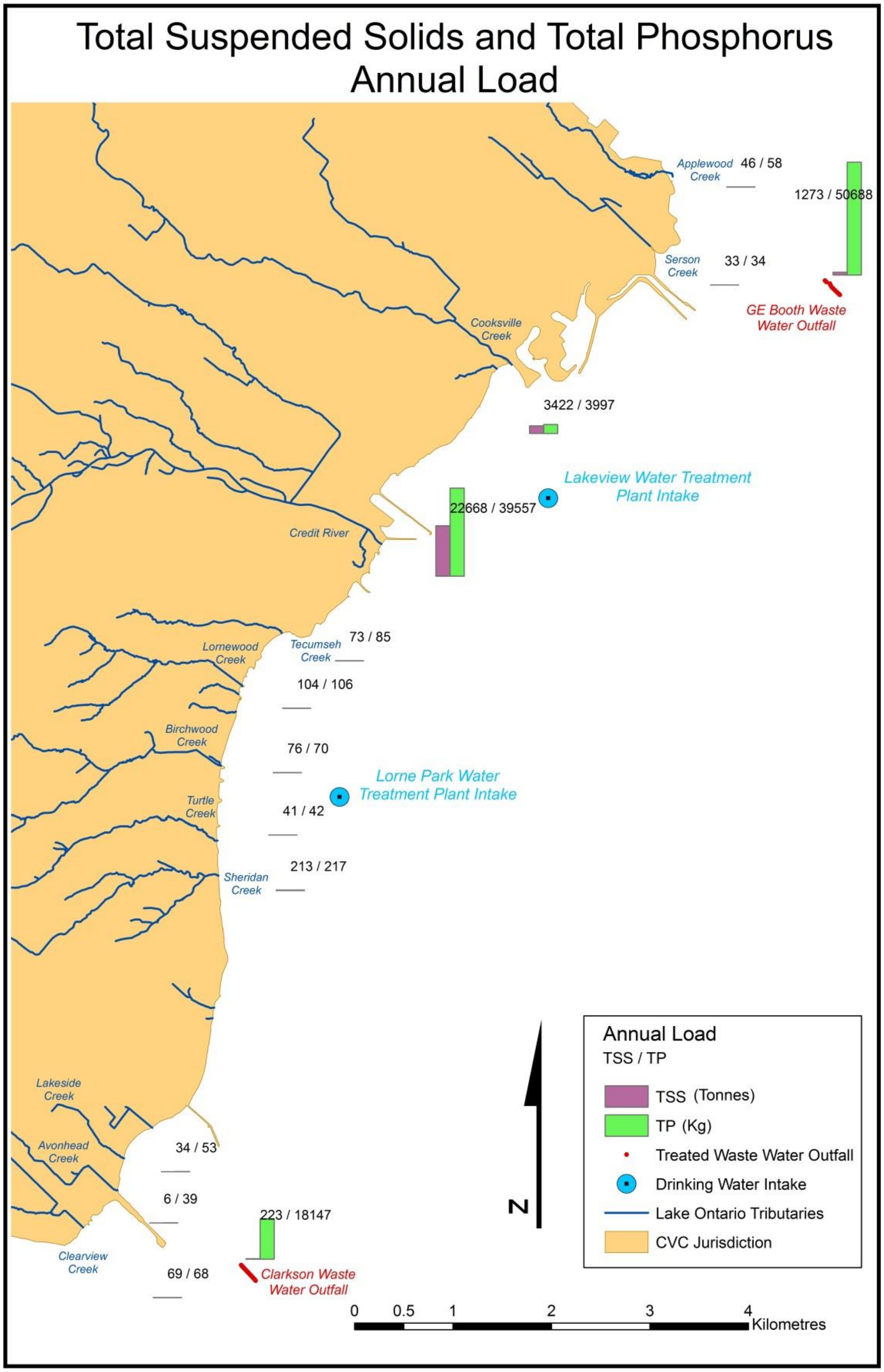


Figure 3-24: Modelled watercourses and monitored Waste Water Treatment Plant Total Suspended Solid and Total Phosphorus loading to Lake Ontario in LOISS study area in 2011 (Source: CVC LOISS instream modeling, 2011)

Total Phosphorus

Phosphorus is an essential nutrient for plants and animals. Introducing a small amount of additional phosphorus into a waterway can have adverse effects since it is naturally not as abundant as carbon and nitrogen. Sources of phosphorus include soil and rocks, wastewater treatment plants (WWTPs), runoff from fertilized lawns and cropland, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, decomposition of organic matter, and commercial cleaning preparations. Phosphorus in the Great Lakes is recognized as a limiting nutrient for *Cladophora* growth and is generally reported as total phosphorus (TP), which includes particulate phosphorus (PP) and dissolved phosphorus (DP). *Cladophora* algae is a nuisance alga that that grows on substrate then detaches, fouling water intakes and washing up on shorelines. Decaying *Cladophora* can cause botulism in birds. The Provincial Water Quality Objective (PWQO) for watercourses and lake water TP are 0.03 mg/L and 0.02 mg/L, respectively and the International Joint Commission's (IJC) TP objective is 0.01 mg/L. There is no PWQO or IJC objective for PP or DP.

Instream and nearshore phosphorus levels are generally high. By contrast, phosphorus levels in the offshore of Lake Ontario have declined to historic lows. Open-water plankton, algae and preyfish populations are declining (ECCC 2018).

In this study, both TP and DP were measured. DP is of interest since it is the portion of TP that is readily available to aquatic plants for biological activities. The normal phosphorus cycle in aquatic systems is seasonal, with phosphorus being released from the sediment as the water warms in the spring and taken up by vegetation throughout the growing season. In the late summer and fall, vegetation begins to die off and phosphorus is returned to the sediment through decomposition.

The 75th percentile of phosphorus concentration in the watercourses, based on monitored data, ranged from 0.051 mg/L in the Credit River to 0.188 mg/L in Turtle Creek (Table 3-19). All the water courses exceeded the PWQO and are, therefore, Policy 2 tributaries for TP. Policy 2 means that "water quality which presently does not meet the Provincial Water Quality Objectives shall not be impacted further and all practical measures shall be taken to upgrade the water quality to the Objectives (Ministry of the Environment 1994)." The primary reason for high instream TP concentrations could be the fact that the study area is highly urbanized and was developed without stormwater quality control measures. This means that the contaminants have an opportunity to be transported to the receiving waters without undergoing any treatment.

The monitored nearshore 75th percentile of TP levels for the lake transects ranged from 0.013 mg/L to 0.023 mg/L (Figure 3-25). TP levels were higher closer to the shore than farther offshore indicating influence of TP loading from the watershed. The Applewood transect sampling location about 1.5 km offshore showed the highest 75th percentile TP value. This location may have been influenced either by the plume coming from Etobicoke Creek (just east of the LOISS study area) or from the G.E. Booth WWTP discharge. The TP levels exceeded the IJC objectives at all sampling locations; therefore, management measures to lower the concentration should be implemented.

The lake TP concentration was also modelled using the lake model (Mike3) from May-October 2011. Figure 3-26 shows the time series TP plot for the Credit River transect at the mouth of the river and 180, 360, 540 and 720 m distances offshore. The spikes in TP concentration coincide with rain events, and were estimated as high as 0.36 mg/L.

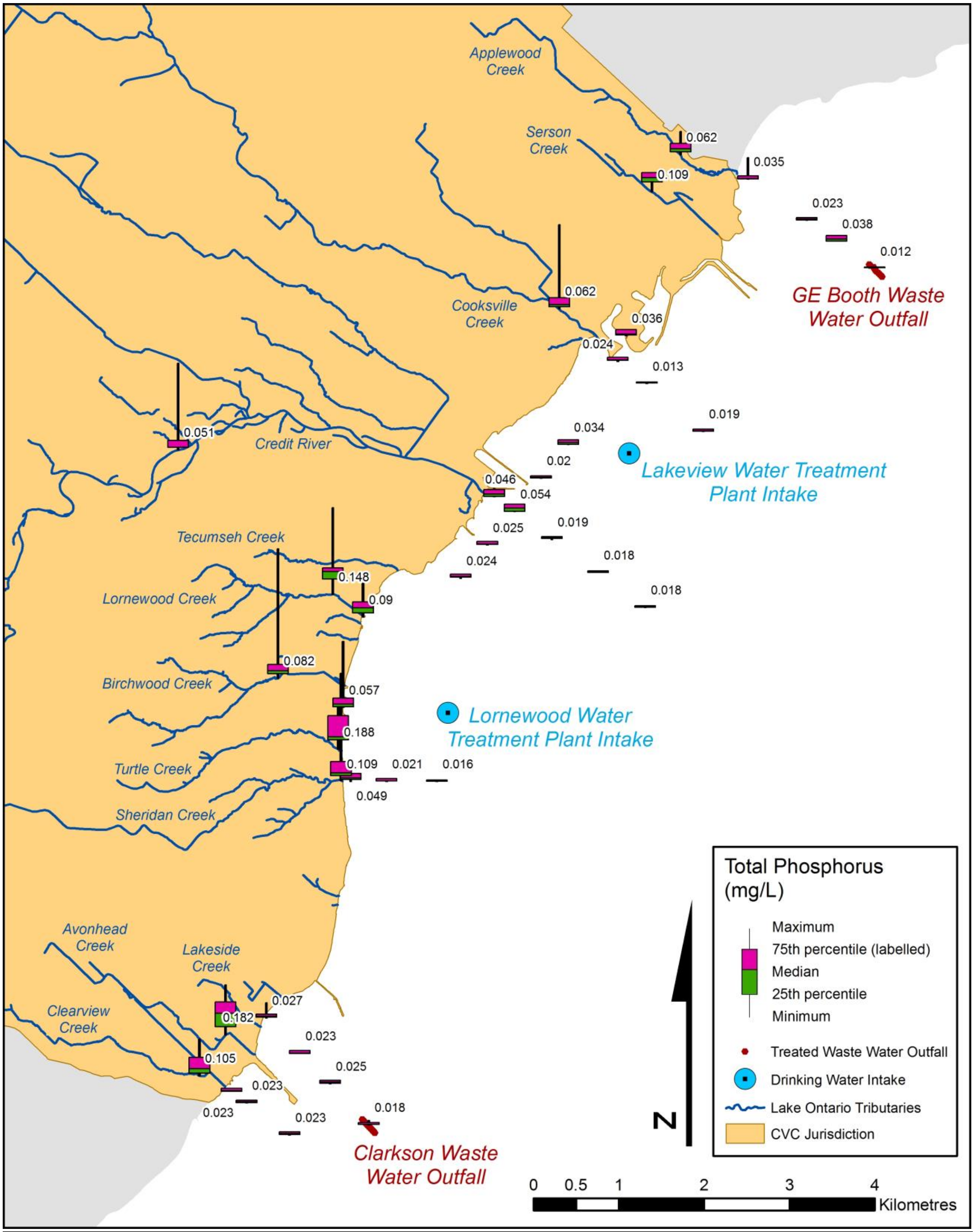


Figure 3-25: Instream and nearshore monitored Total Phosphorus concentration from 2011-2013 (Source: CVC LOISS study instream and nearshore monitoring data 2011-2013)

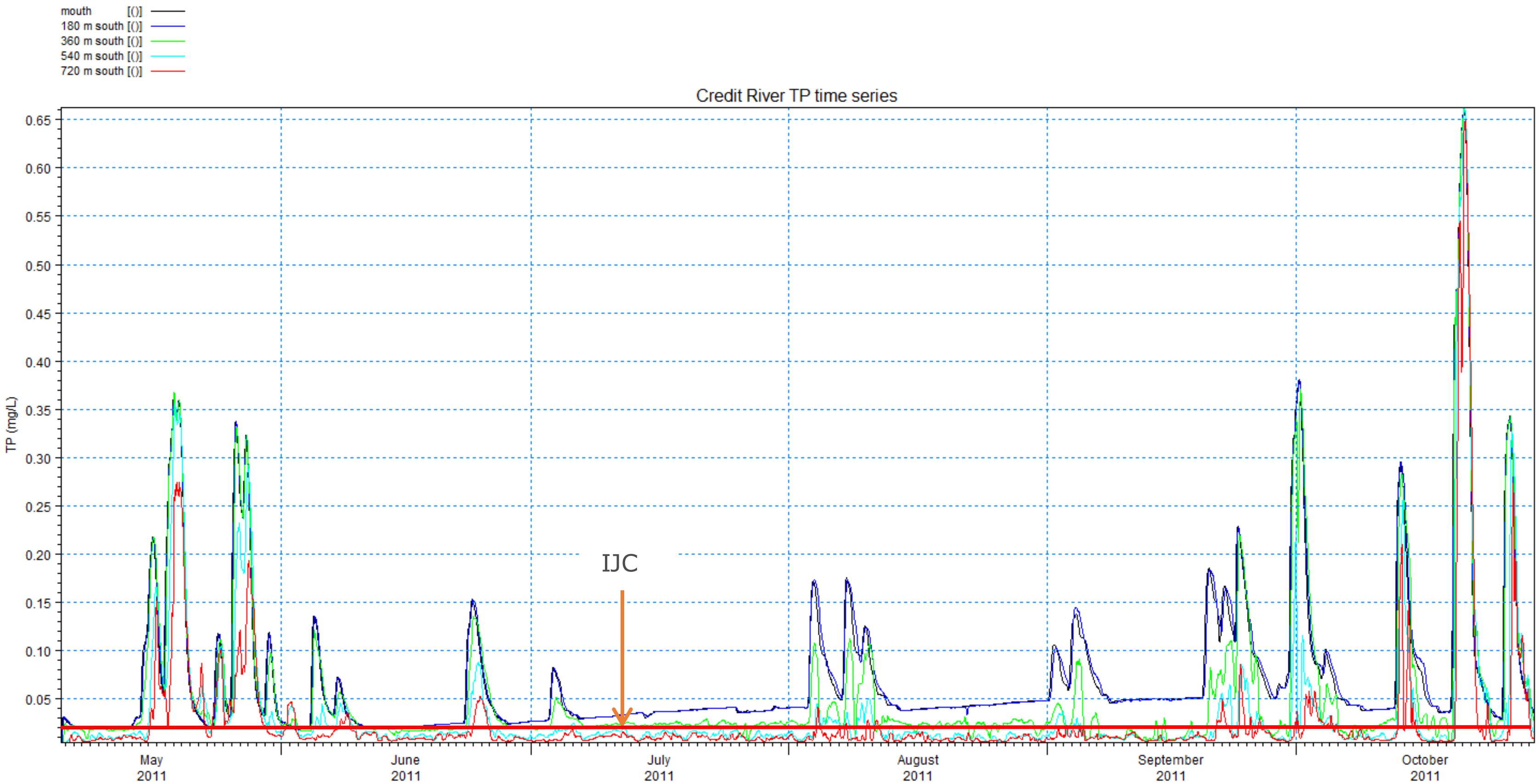


Figure 3-26: Modelled Total Phosphorous concentration (mg/L) time series at the mouth of the Credit River and 180m, 360m, 540m, and 720m offshore in Lake Ontario from May- October 2011 showing nearshore TP (blue line) above IJC objective and offshore TP (red line) below IJC objective. (Source: CVC LOISS watershed and lake modelling studies 2011)

Dissolved phosphorus levels, which is a part of TP, were also elevated in most of the streams and even exceeded the PWQO for TP. This means instream system is very productive which could enhance aquatic plant growth.

Figure 3-26 presents modeled TP loading for the watercourses and actual TP loading from the WWTF in the study area in 2011. There are two Region of Peel WWTF – Clarkson and GE Booth – that have outfalls in the section of Lake Ontario that is under CVC's jurisdiction.

The model calculated the Credit River and Cooksville Creek contributes approximately 39,557 kg/year and 3997 kg/year TP to the lake, respectively. These values are consistent with Credit River TP loading value reported by Makarewicz et al. (2012). Makarewicz et al. recognized that the Credit River is one of the larger contributors of TP in western Lake Ontario. The smaller streams' contributions range from 34 kg/year for Serson Creek to 270 kg/year for Sheridan Creek. In the study area, loadings are largely associated with the catchment areas of the watercourses. The Cooksville Creek watershed contributed the highest per unit area TP loading of 1.1 kg/ha, which is because the Cooksville Creek watershed has highest urban land use density compared to the watersheds of other watercourses in the study area (Figure 3-27). It is also important to note here that most of the urban development in the study area has no stormwater water quality control. Therefore, all the contaminants washed off with the stormwater end up in the receiving waters. Thus, there are many opportunities within the study area for restoration activities to reduce contaminants loadings, including total phosphorus, to Lake Ontario.

The two Region of Peel WWTFs collectively delivered 68,835 kg of TP to the lake in 2011.

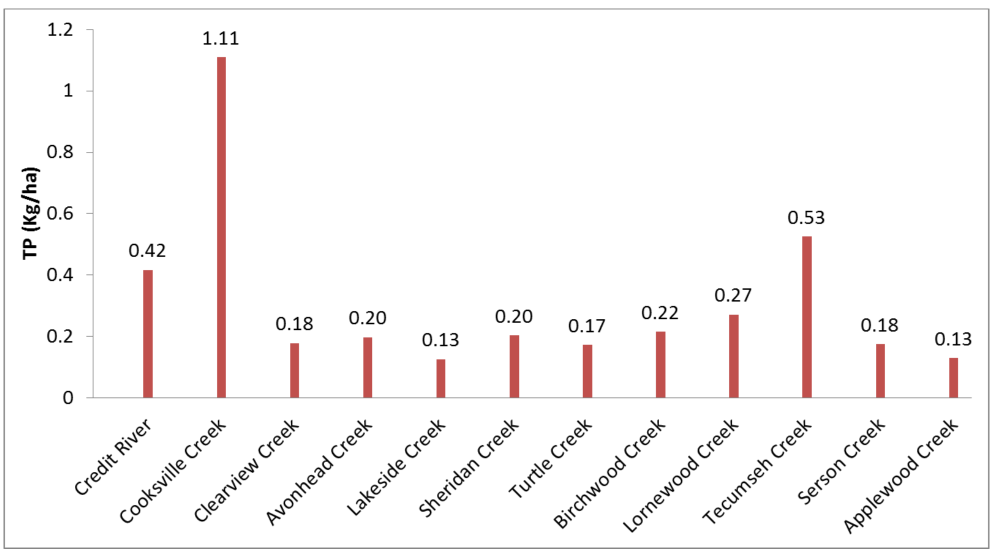


Figure 3-27: Modelled per unit area Total Phosphorous (kg/ha) contributed by the Credit River watershed and 11 other sub-watersheds in LOISS study area in 2011 (Source: CVC LOISS study watershed modelling 2011)

TP concentrations observed at the three public beaches exceeded the PWQO of 0.03 mg/L[5] with 75th percentile values of 0.09, 0.057 and 0.036 mg/L for Richard's Memorial, Jack Darling and Lakefront Promenade parks, respectively. DP levels followed the same trend as

5 PWQO for streams is used as reference since there is no PWQO objective for beaches

TP. The sources and causes of higher concentrations of phosphorus at Richard's Memorial Park are yet to be identified; however, they are consistent with the higher levels of *E.coli*, another indicator of urban influence.

Nitrate-Nitrogen (NO_3-N)

Nitrate (NO_3) is a common inorganic form of nitrogen. Because it is an anion, it is soluble in water. Plants normally use nitrate as their source of the nitrogen which is needed by all living things. Nitrate is often measured as nitrogen and is symbolized using No_3-N. Concentrations of NO_3-N in lakes and streams greater than about 5 mg/L (measured as nitrogen), depending on the water body, can cause excessive growth of algae and other plants, leading to accelerated eutrophication or 'aging' of lakes, and occasional loss of dissolved oxygen. Animals and humans cannot use inorganic forms of nitrogen, so nitrate is not a nutrient for us. If NO_3-N exceeds 10 milligrams per litre in drinking water, it can cause a condition called methemoglobinemia or "blue baby syndrome" in infants. Additionally, some recent studies have indicated a possible connection between elevated nitrate concentrations and cancer. Nitrate-nitrogen is also toxic to aquatic organisms if its concentration exceeds 3 mg/L (Canadian Council of Ministers of the Environment 1999).

Natural sources of nitrate to surface waters include wet and dry deposition of HNO_3 or NO_3^-, which are formed through nitrogen cycling in the atmosphere. Atmospheric deposition of dissolved inorganic nitrogen in Canada is estimated to contribute 182 kilotons of nitrogen per year (kt N·yr-1) to surface waters (Chambers et al. 2001). Other natural sources of nitrate include igneous rocks and volcanic activity, mineralization of native soil, organic nitrogen and the complete oxidation of vegetable and animal debris (Nordin and Pommen 1986). Anthropogenic discharges of nitrogen include point sources such as municipal and industrial wastewaters, and water discharges from mining activity (explosives), and nonpoint sources such as agricultural runoff, feedlot discharges, septic beds, urban runoff, lawn fertilizers, landfill leachate, nitric oxide and nitrogen dioxide from vehicular exhaust, and storm sewer overflow (NRC 1972; NRC 1978). Organic forms of nitrogen undergo ammonification and are eventually transformed to ammonia, (NH3) or ammonium ($NH4^+$) by a variety of micro-organisms. All forms of inorganic nitrogen, ammonia, (NH3) or ammonium ($NH4^+$), released into surface waters have the potential to undergo nitrification to nitrate.

Water quality regulatory agencies seek to avoid high concentrations of nitrate in water to minimize the three problems noted above. Nitrate standards take three forms: drinking-water standards, designed to prevent adverse human-health effects (10 mg/L), ambient-water standards, designed to prevent excessive eutrophication in lakes and streams (5 mg/L), and aquatic toxicity (3 mg/L).

Generally, NO_3-N is not considered a limiting parameter for algae growth in Lake Ontario.

The 75th percentile NO_3-N concentrations in the watercourses, based on monitored data, ranged from 0.065 mg/L to 3.47 mg/L (Table 3-20). Serson Creek (3.47 mg/L) had the highest NO_3-N levels followed by Lornewood Creek (2.54 mg/L) and Birchwood Creek (2.38 mg/L). These higher levels could be attributed to the sampling station being located in the vicinity of the G.E. Booth WWTF for Serson Creek and contribution from septics for Birchwood and Lornewood Creeks. The lowest NO_3-N values were recorded for Sheridan Creek (0.65 mg/L), which is located downstream of Rattray Marsh. The lower levels of nitrates in Sheridan Creek could be a result of sequestration of nitrates by marsh vegetation.

The monitored nearshore 75th percentile NO_3-N levels for the lake transects ranged from 0.4 mg/L to 1.3 mg/L (Figure 3-28). Nitrate-nitrogen levels were higher closer to the shore (highest at the first node on the Credit River transect) than farther offshore indicating influence of NO_3-N loading from the watershed. The off-shore levels were around 0.4 mg/L except for the Applewood transect sampling location about 1.5 km offshore. This location may have been influenced either by the plume coming from Etobicoke Creek or from the WWTF discharge.

The instream (with Serson Creek being an exception) and nearshore NO_3-N levels did not exceed the drinking water, eutrophication, or aquatic toxicity guidelines. Serson Creek exceeded the CWQG of 3.0 mg/L for aquatic toxicity.

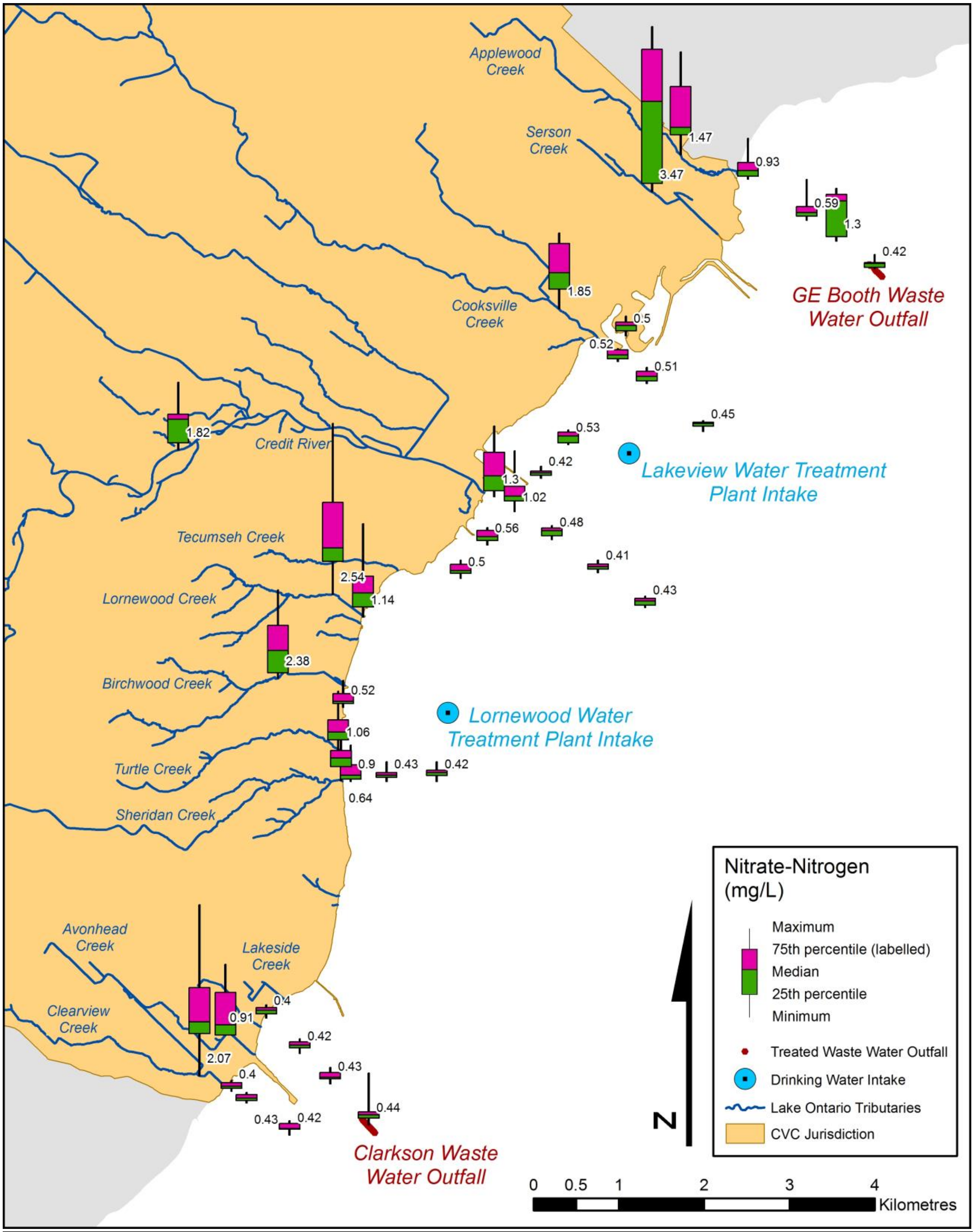


Figure 3-28: Instream and nearshore monitored Nitrate-Nitrogen (NO_3-N) concentration from 2011-2013 (Source: CVC LOISS study instream and nearshore monitoring data 2011-2013)

Escherichia coli (E. coli)

Fecal Coliform bacteria indicate the presence of sewage contamination of a waterway and the possible presence of other pathogenic organisms. Common sources of *E.Coli* in urban environments are cross connections between sanitary and storm sewers, leakage from septic systems, and droppings from animals such as geese and pets. Specific sources of *E.Coli* have not been traced in this study.

Escherichia coli (*E. coli*) is the only member of the total coliform group found in the intestines of humans and mammals. The presence of *E.coli* indicates recent contamination due to fecal material and may indicate the possible presence of other disease causing pathogens such as bacteria, viruses and parasites. Although most strains of *E.coli* are harmless, certain strains such as *E. coli* O157:H7 may cause serious illness.

E. coli concentrations are of concern for drinking water and for beaches used for recreational purposes. The drinking water standard for *E. coli* is 0 cfu/100ml (Government of Ontario 2006) i.e. it should be non-detectable. Though the water treatment facilities are well equipped to deal with fecal related contamination, understanding their concentration in the source water before treatment is important. Beaches are posted closed for swimming if the geometric mean (the nth root of the product of n numbers) of *E. coli* levels of 5 samples collected along the beach exceeds 100 cfu/100ml (Ministry of the Environment 1994). Beach monitoring in the study area is conducted by the Region of Peel under the Public Bathing Beach Testing Program.

As is typical for urban environments, all tributaries in the study area had high *E. coli* concentrations (Figure 3-29). Further, like other sediment-adsorbed contaminants, *E. coli* concentrations were also higher after storm events as larger amounts of bacteria are transported from land to the watercourses with the sediment that are displaced during storms. During this study, a single sample was collected during each sampling event. Therefore, instead of calculating geometric mean (which is done on at least 5 samples taken from different spatial locations at the same site), the 75th percentile was used. The instream *E. coli* concentrations 75th percentile ranged from 152 cfu/100 ml for the Credit River to 5400 cfu/100 ml for Lornewood Creek (Table 3-20). The fact that NO_3-N was also high for Lornewood Creek suggests that septic system leakage could be responsible, since some of the residential developments in this catchment are on septic systems. High concentrations of both *E.Coli* (3800 cfu/100mL) and NO_3-N in Serson Creek, as well, indicate that these contaminants could be coming from a similar source, possibly storm and waste water sewer cross connections.

Out of the three beaches monitored, the highest *E. coli* level was recorded for Richard's Memorial beach (2500 cfu/100 ml) followed by Jack Darling (272.5 cfu/100 ml) and a relatively clean Lakefront Promenade (24.75 cfu/100 ml). The beach monitoring program for the beaches in the study area is run by the Region of Peel and the beach closures are posted on their website https://www.peelregion.ca/health/beach/enbeach.asp. Beach closures are dependent on storm events hence the number of closures varies year to year.

The monitored 75th percentile *E. coli* levels for the lake transects ranged from undetected to 100 cfu/100ml (Figure 3-29). *E. coli* levels were higher closer to the shore than farther offshore indicating *E. coli* levels influenced by the loading from the watersheds. The highest *E. coli* levels were observed at the first node on the Applewood Creek transect, which potentially is influenced by the discharge from Etobicoke Creek. Etobicoke Creek has been reported discharging higher *E. coli* loadings to Lake Ontario (TRCA 2010). The off-shore *E. coli* levels close to the water intake locations of the two water treatment plants were non-detect. This indicates that during ambient conditions lake *E. coli* levels are not a drinking water concern.

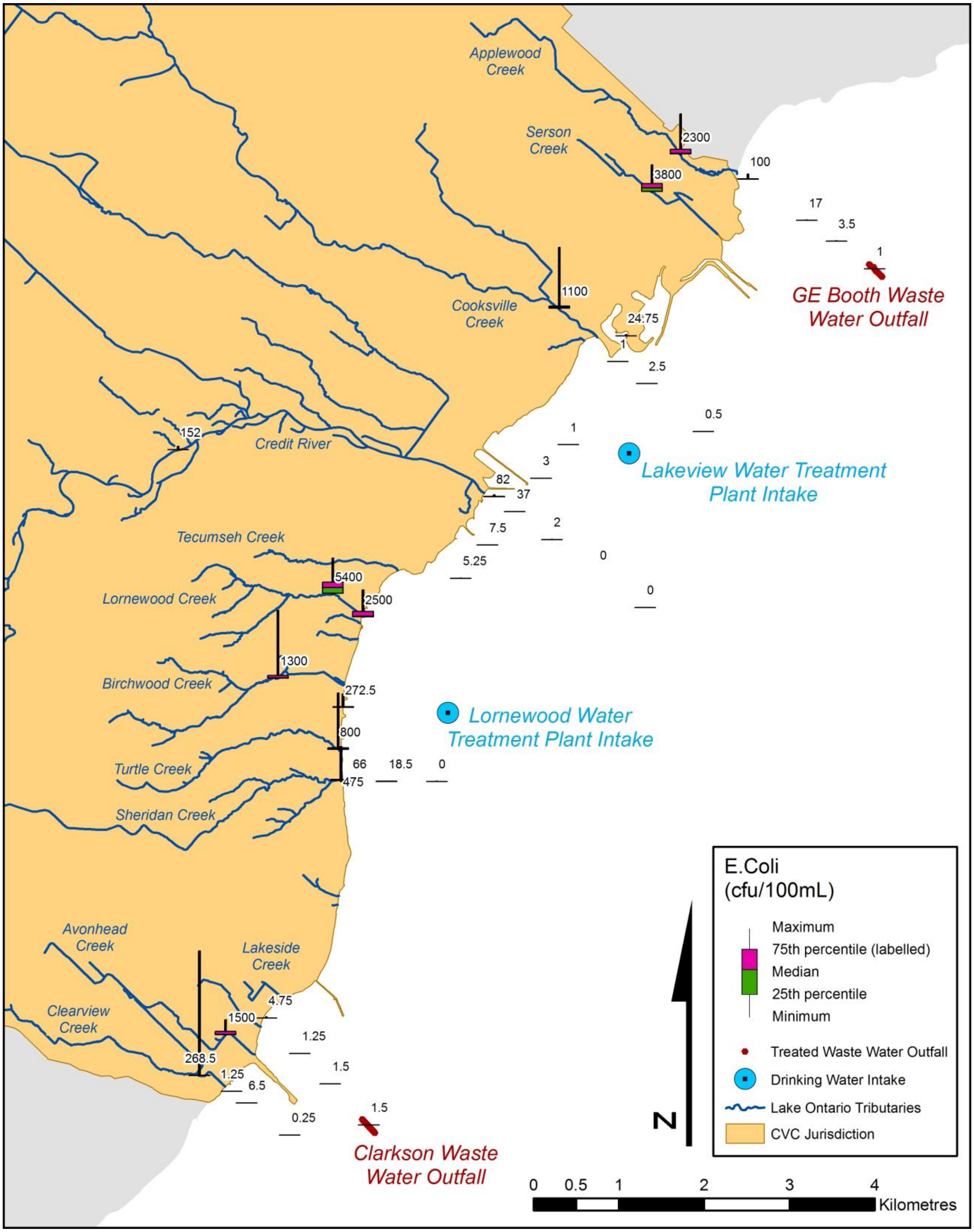


Figure 3-29: Instream and nearshore monitored *E. coli* concentration from 2011-2013 (Source: CVC LOISS study instream and nearshore monitoring data 2011-2013)

<u>Specific Conductivity</u>

Specific conductivity is a measure of how fast an electric current passes through a medium. It is used as a tracer of the effect of land on a lake. Higher conductivity means higher land influence. There is no provincial objective or federal guideline for conductivity.

In watercourses draining urban watersheds, conductivity values are usually elevated due to the application of road salt as a de-icer in winter. Applewood Creek had the highest monitored 75th percentile conductivity value (3,332 μS/cm) followed by Clearview Creek (2,945 μS/cm) and Cooksville Creek (2,403 μS/cm) (Table 3-20).

Out of the three beaches, Richard's Memorial once again showed the highest impact of urbanization with monitored 75th percentile conductivity value of 1,073 μS/cm followed by Jack Darling (370 μS/cm) and Lakefront Promenade (350 μS/cm). High conductivity suggests Richard's Memorial may be more susceptible to high levels of *E.coli*.

The monitored nearshore 75th percentile of specific conductivity for the lake transects ranged from 309 μS/cm to 778 to μS/cm (Figure 3-30). Specific conductivity levels were higher closer (highest at the first node on the Applewood transect) to the shore than farther offshore indicating influence of urbanization on nearshore waters. The off-shore levels were around 310 μS/cm. The Applewood Creek transect sampling location about 1.5 km offshore also showed a blip confirming that this location is being influenced either by Etobicoke Creek or from the WWTP discharge.

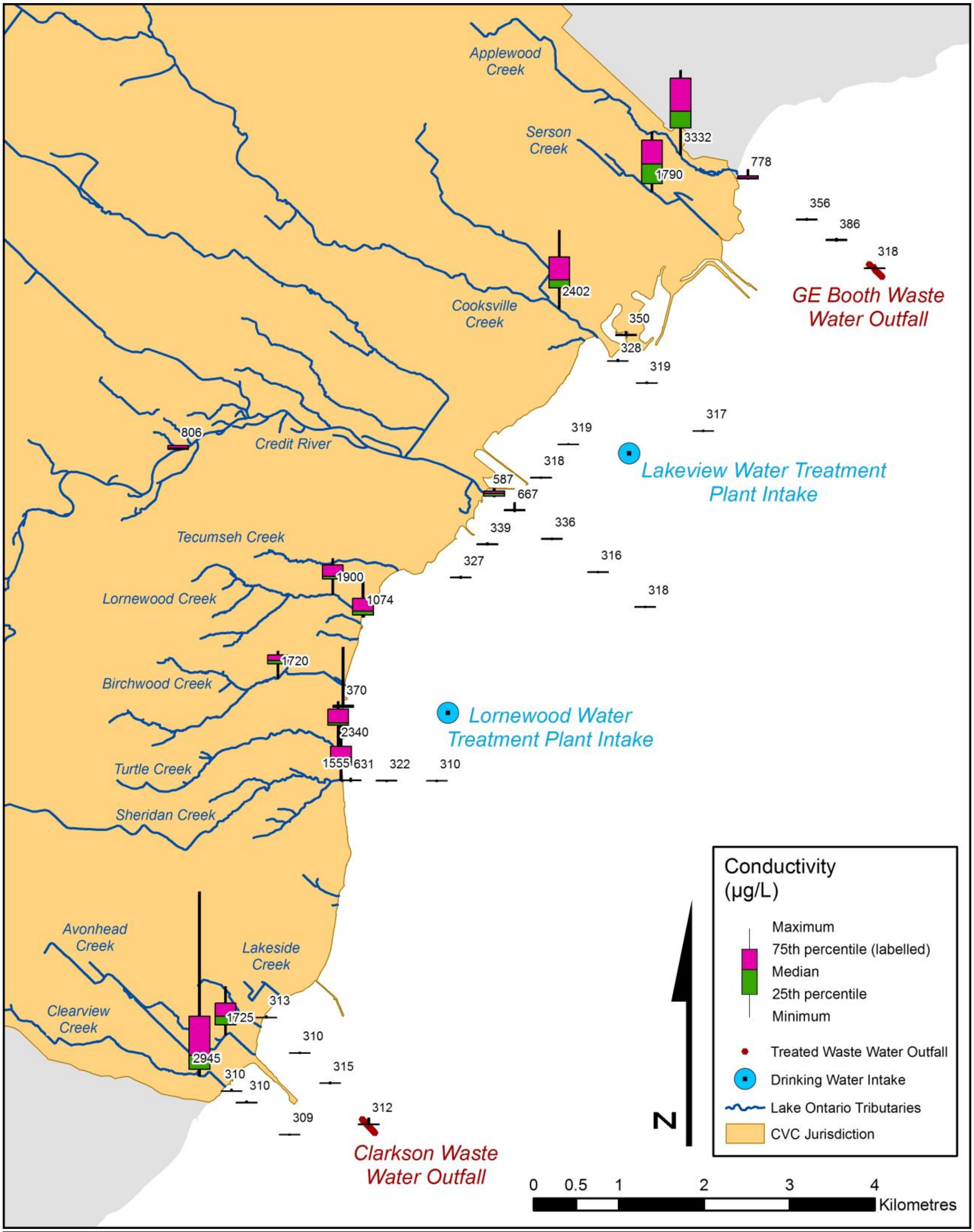


Figure 3-30: Instream and nearshore monitored Specific Conductivity from 2011-2013 (Source: CVC LOISS study instream and nearshore monitoring data 2011-2013)

Chloride

CVC has a unique real-time watercourse water quality network with 11 stations across its jurisdiction measuring indicator water quality parameters throughout the year at 15-minute intervals. One of the parameters measured at these stations is chloride. Like temperature (as explained in the temperature section), chloride also impacts the density of water and may change the dynamics of water flow into the lake during spring time when road salt used as a de-icer during winter gets washed into the receiving waters. Water temperature and density for the station close to the mouth of the Credit River are presented in Figure 3-31 to illustrate the impact of chloride on water density. Denser river water means negative buoyancy compared to lake water; thus, the river water will enter the lake as underflow or interflow instead of overflow.

Figure 3-31 shows the density of Credit River water as a function of temperature alone and as a function of temperature and chloride concentration from January 2013 to February 2014 in relation to the density of lake water. The circles highlight periods of negative buoyancy due to the presence of chlorides in the water. The stream water is denser in winter and spring when heavy loads of pollutants are transported from land to lake thus has a sinking tendency (i.e., will enter the lake as inter- or under- flow).

Further, the lake model was run to simulate a Credit River total phosphorus plume under normal chloride levels and the observed elevated chloride level for an event occurring in spring 2011 (Figure 3-32a,b). The model results show that under elevated chloride levels, the TP plume reaches deeper into the lake as underflow, thereby increasing TP concentration to 0.07 mg/L even at a depth of 14 m, approximately 1.5 km offshore. Thus phosphorus could potentially be available to *Cladophora* (a filamentous algae) for uptake leading to a bloom. Further investigations need to be conducted to better understand the role of chloride-rich water on pollutant dynamics and *Cladophora* resurgence.

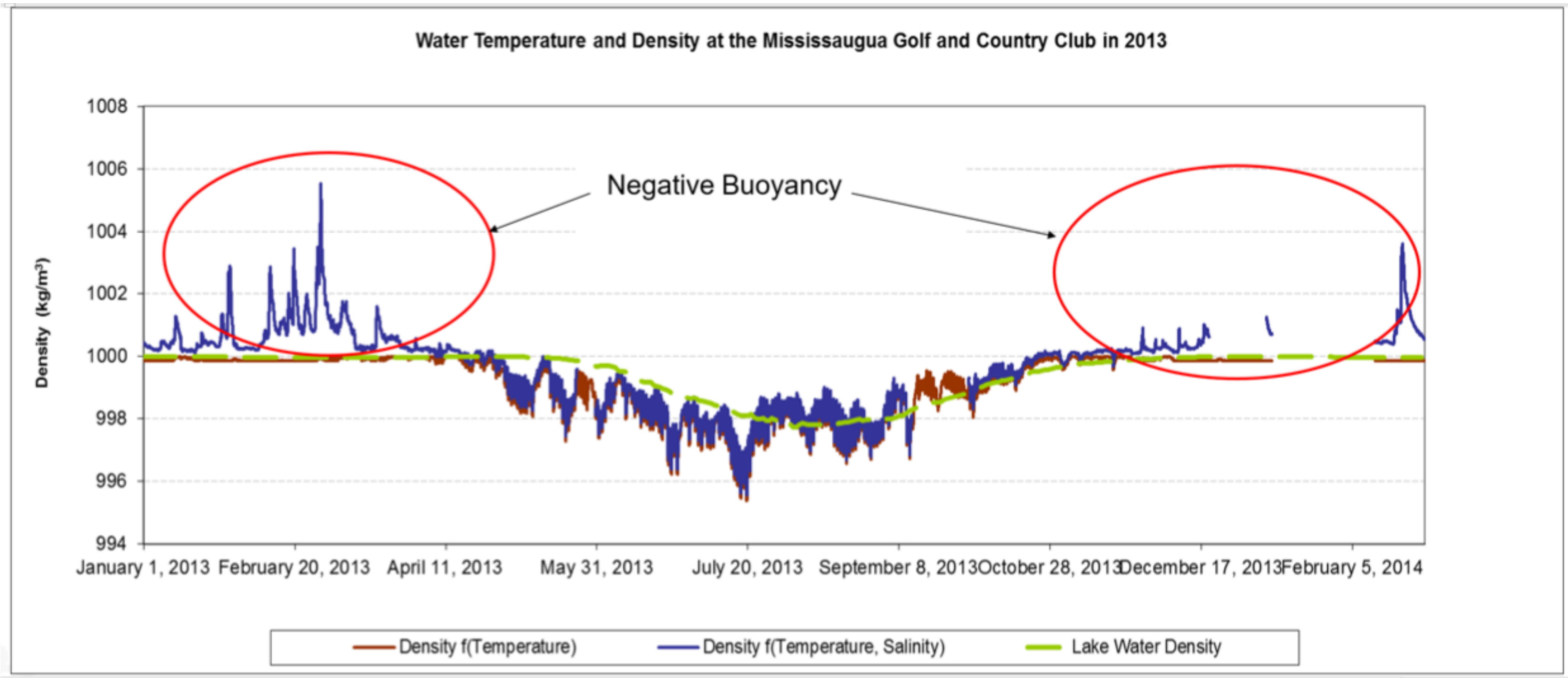


Figure 3-31: Credit River density time-series as a function of temperature and temperature and chloride concentration (salinity) monitored in 2013 against expected lake density (Source: CVC real-time water quality monitoring data 2013)

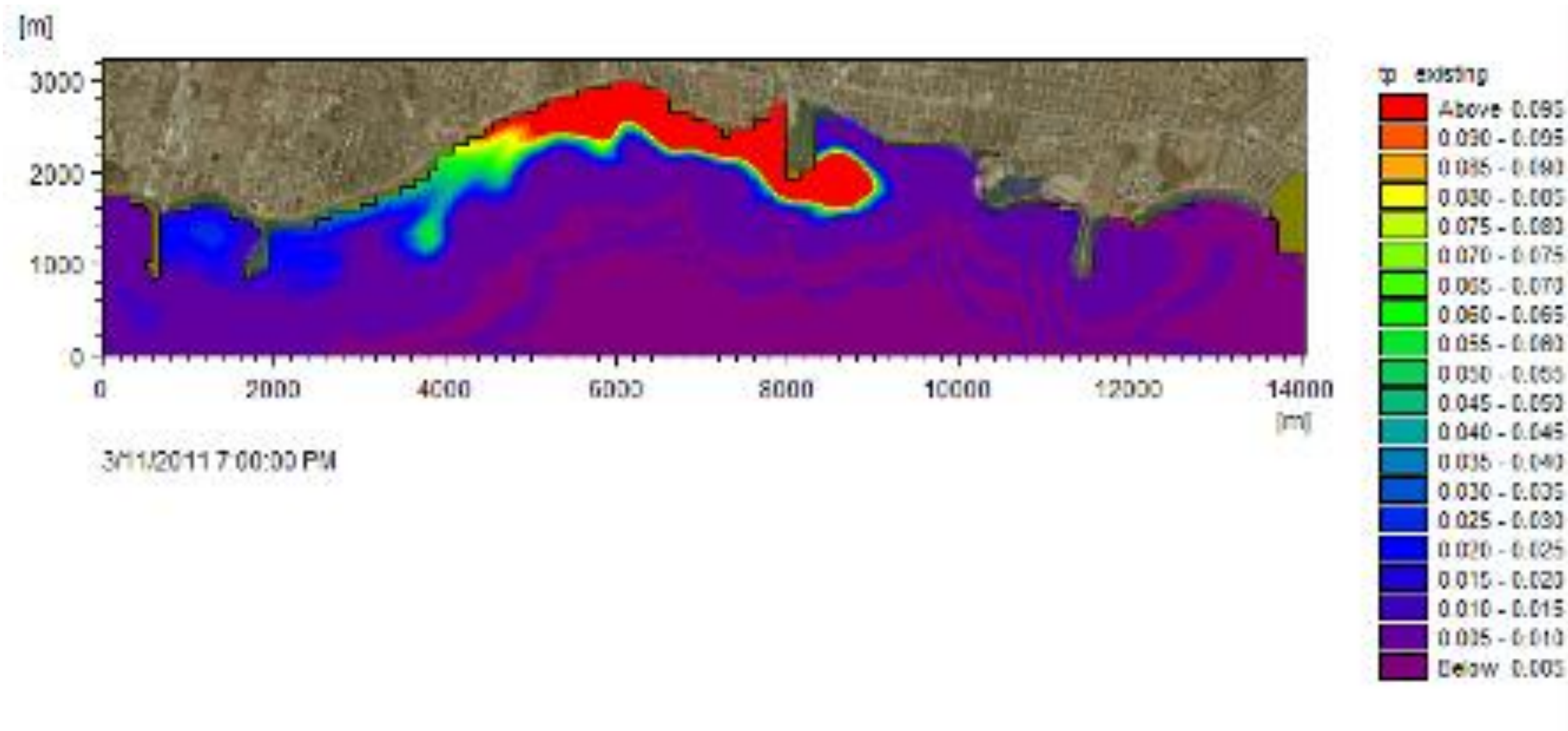


Figure 3-32a: Credit River plume entering Lake Ontario with ambient chloride concentration of 50mg/L. The red color indicates TP concentration greater than 0.01 mg/L. (Source: CVC lake modeling for LOISS study 2011)

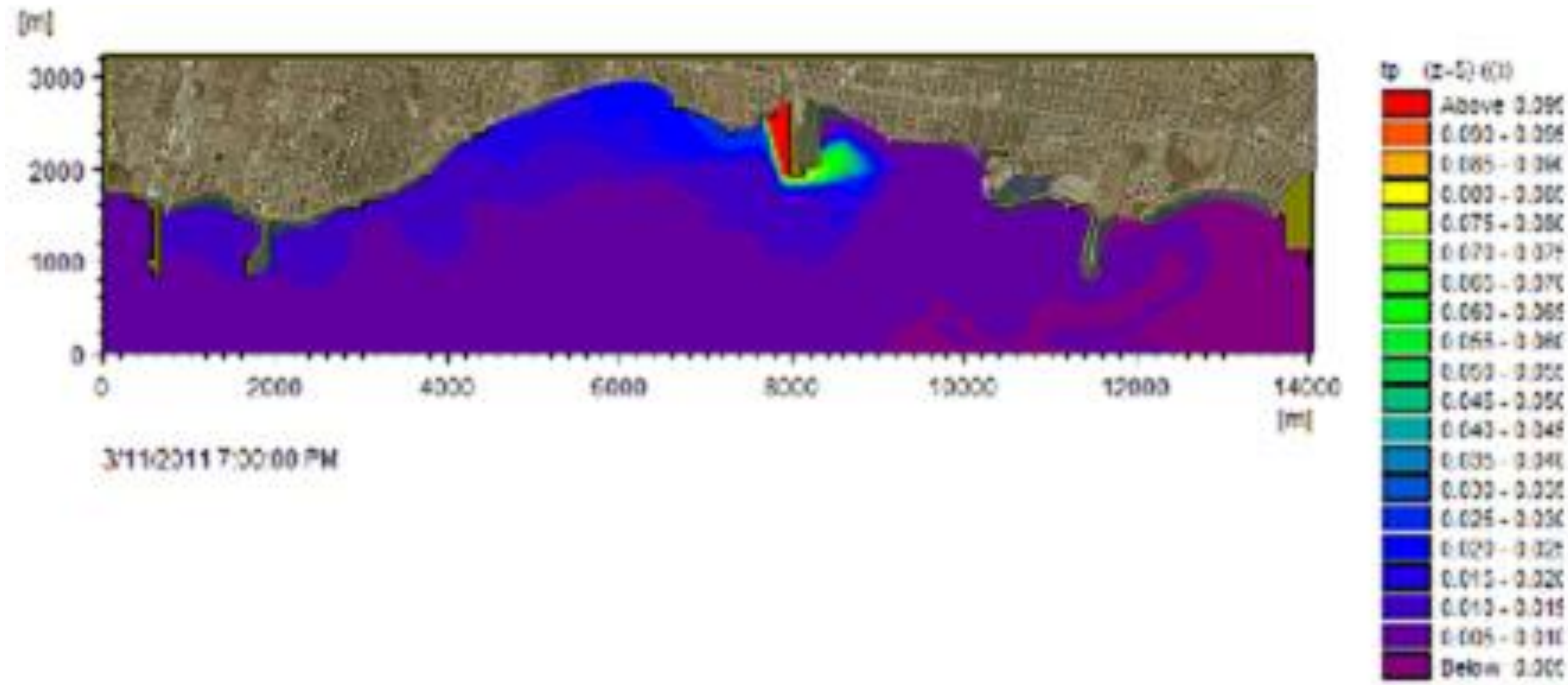


Figure 3-32b: Credit River plume entering Lake Ontario with elevated chloride concentration of 2,500mg/L. The red color indicates TP concentration greater than 0.01 mg/L. (Source: CVC lake modeling for LOISS study 2011)

3.5.2 Synthesis of Water Quality

Lake Ontario is important as both an aquatic habitat and to enhance the quality of life of the area residents. The lake provides drinking water for residents of the Greater Toronto Area, is used for recreation (swimming, boating, and fishing), provides economic value as a fishery, and adds aesthetic value. Maintaining a healthy lake is vital to ensuring the continued provision of these beneficial uses. In the LOISS Background Review eight water quality parameters; temperature, total suspended solids (TSS), nutrients (total phosphorus (TP), nitrate-nitrogen (NO_3-N)), *E. coli*, specific conductivity (SC), and chloride were identified as parameters of concern that could threaten the beneficial use of Lake Ontario.

The water quality of Lake Ontario in the study area is primarily influenced by activities on land in the watersheds draining to the lake. Urban land-uses in particular have the largest impact. During storm events pollutants from these urban areas are washed into the lake, increasing the concentrations of the parameters of concern, and reducing the suitability of the lake for beneficial uses.

To gain a better understanding of these influences instream and nearshore lake water quality sampling was conducted (from 2011 to 2013), and modeling of both the watershed (instream water quality and quantity) and the lake (nearshore water quality and pollutant movement) was conducted. Some of the key findings of this sampling and modelling as they relate to specific parameters of concern are discussed below.

Temperature was identified as an important parameter for its role in aquatic plant growth processes and identifying lake water stratification and mixing events. Temperature could also exacerbate biomass decay and potentially change lake bottom dissolved oxygen concentration. Higher winter/spring temperatures anticipated due to climate change may also change lake algae resurgence and extent. Such an event was observed in 2012. Historically algae in the lake grows in late summer; however, in May 2012 early and heavy algae blooms clogged the intake and broke screens at one of the water treatment plants in the study area. As a result, the plant had to be shut down for several hours for repair (Hennings 2017).

Since temperature helps to understand a number of lake phenomenon, is relatively inexpensive to monitor, and is an important water quality parameter, it is recommended that long-term year round continuous instream and lake temperature monitoring be establish.

Our analysis points out the relationships that requires additional science include temperature and algae resurgence (important for source protection), studying the effect of temperature changes on contaminant and organic matter decay as it could change oxygen levels in the hypolimnion layer and, climate change trend analysis.

Suspended solid concentration plays a double-ended role. Higher suspended loads bring in larger quantities of sediment bound contaminants to the lake, while lower suspended solids mean clearer water, deeper light penetration and a higher photosynthesis rate. Watershed modelling estimated around 230,000 tonnes of TSS delivered to the lake from the watersheds in CVC's jurisdiction. The ambient lake TSS levels were low indicating clearer conditions. Since suspended solids are the contaminant carriers, controlling them at source will not only reduce their contamination but also the associated contaminants. Therefore, a watershed-scale study is suggested to identify sediment release hotspots, rank them based on severity, and find suitable best management retrofit practices to reduce sediment release.

The watercourses and nearshore total phosphorus concentrations were higher than their respective objectives. The Credit River and Cooksville Creek TP loadings were estimated to be high. The urban centres in the watersheds were identified as the major TP contributors since the stormwater management in these centres do not have water quality control, therefore no TP attenuation. Since TP is the limiting factor for algae growth in the lake, at-source TP reduction opportunities within the LOISS study area should be identified, ranked, and the site specific retrofit best management practices (BMPs) implemented to control the release of TP. This study would tie well with the sediment release study to reduce particulate bound phosphorus; however, for dissolved phosphorus attenuation a different approach would need to be implemented.

Nitrate-nitrogen is not considered as a limiting factor for instream and nearshore productivity. However, projected temperature increases due to climate change may change NO_3-N concentrations because of accelerated ammonia and organic-N nitrification. Therefore, continuing NO_3-N monitoring is important. It is also suggested continuous NO_3-N monitoring be conducted at some of key locations like Serson Creek and Lornewood Creek to identify sources of high NO_3-N in these two watercourses.

The study showed high *E. coli* concentrations are a concern for the urban watercourses and beaches for recreational activities. However, nearshore *E.coli* levels were low and not found to be a threat to the lake-based water intakes.

The elevated chloride levels in the urban watercourses due to de-icer application may influence pollutants delivery from land to the lake and change the lake pollutant dynamics. A chloride rich spring plumes may have potential to deliver nutrients towards the bed of the lake, which then would be available for *Cladophora* to uptake. Therefore, salt application best management practices are strongly suggested to reduce impact of de-icers on the receiving waters.

The outcome of the water quality analysis also suggests that a lake based real-time water quality station be established to provide continuous long-term data for trend analysis, algae resurgence prediction, spill alarms for source protection, and calibrating lake model.

These recommendations and next steps are summarized in Table 3-21.

Table 3-21: Summary of Water Quality Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Year-round temperature monitoring	Tributaries and Lake Ontario	Low	CVC/ECCC/MECP/RoP
Temperature and algae resurgence correlation study	Lake Ontario	Low	MECP/ECCC/RoP
Sediment source study	CVC watershed	Medium	ECCC
TP reduction opportunities assessment	CVC watershed	Medium	CVC/ECCC

Action	Location	Priority (High, Medium Low)	Lead Agency
Continuous NO_3-N monitoring and source determination	Serson Creek, Lornewood Creek	Low	CVC/MECP
Salt application best management practices	CVC watershed	High	All Municipalities
Establish a real-time water quality station	Lake Ontario	Medium	CVC/Region of Peel
Investigate role of chloride-rich water in pollutant dynamics and Cladophora resurgance	Lake Ontario	Medium	MECP/Academia

3.6 AQUATIC NATURAL HERITAGE

This section summarizes available information related to aquatic natural heritage with a focus on fish and benthic macroinvertebrates.

The health of fish and benthic macroinvertebrate communities reflects what is occurring on the landscape and in the water in which they live. They are excellent integrators of environmental conditions for a number of reasons:

- extensive life-history information is available;
- occupy a variety of trophic levels;
- relatively easy to collect and identify; and
- typically present in all waters.

Establishing an understanding of baseline conditions as far as abundance and distribution of various trophic levels including piscivores, forage fish, and macroinvertebrates is key to characterizing the current health of the study area. Additionally, the interaction between these communities is a significant factor of influence on their health.

Typically, in urban landscapes, the fish and macroinvertebrate communities in streams consist predominately of species, tolerant of poor water quality, that are able to withstand increases in pollution, flashier hydrology, warmer water temperatures, and simplified in-stream habitats indicative of urban systems.

Urban development along the shores of the Great Lakes has altered the nearshore habitat through infilling shallow waters, hardening the shoreline to reduce erosion, and dredging to facilitate navigation reducing suitable habitats for fish species to complete their life cycles. Further, inputs (sediment, pollution, etc.) from within connected watersheds are transported downstream and settle in rivermouths until they are diluted in nearshore waters, contributing additional stressors to nearshore habitats (Edsall and Charlton 1997). All but five Great Lakes fish species (Deepwater Ciscoes (*Coregonus* sp.) and Deepwater Sculpin (*Myxocephalus thompsoni*)) use the nearshore to complete one of more critical life stages (Edsall and Charlton 1997). Nearshore fish species diversity and productivity is higher than those of offshore habitats. Two thirds of adult fish species and three quarters of young of the year fish species show a high affinity for sand, gravel or silt substrates often associated with vegetation in the nearshore area (Lane et al 1996).

The Background Review (ABL 2011) summarized the aquatic community and habitat at three scales: Great Lakes Basin, Lake Ontario, and the LOISS study area. This Characterization report focuses on updating and responding to data gaps at the LOISS study area scale.

The Background Review identified the following gaps (Table 3-22) in the aquatic community data for which CVC is identified as the lead agency (additional data gaps are to be filled by other agencies):

Table 3-22: Status of Aquatic Natural Heritage Data Gaps (ABL 2011)

Data gap	2017 Status
Nearshore fish abundance/IBI	Nearshore fish abundance complete IBI incomplete
Beach/offshore spawning locations	Incomplete
Rearing/nursery habitats	Incomplete
Tributaries: seasonal fish use and access	Seasonal fish use incomplete. Access assessment complete.
Wetland evaluations and potential wetland creation areas	Wetland evaluations complete (see Section 3.7.1.2). Wetland creation areas incomplete (to be addressed in LOISS Implementation report)
Nearshore Benthic invertebrate community	Complete
Tributaries: macroinvertebrates (except Sheridan and Cooksville)	Complete
Nearshore water temperature	Complete (see Section 3.5.1.1)
Tributaries water temperature	Complete (see Section 3.1.1)
Areas of aquatic vegetation	Complete

3.6.1 Characteristics

This discussion is divided into 'Fish Communities and Habitat' and 'Benthic Macroinvertebrates' and then into two functional groups: tributaries (streams and rivers) and Lake Ontario (within the LOISS study area), although the aquatic habitat features are linked.

3.6.1.1 Fish Communities and Habitat

The Background Review characterized the fish community and habitat according to defined habitat type (i.e. tributaries, benthic offshore, offshore/pelagic/coldwater, and nearshore/warmwater).

Surveys were conducted in the summers (July and August) of 2011 and 2012 at thirteen tributary fish stations and in the summer between 2008 and 2014 at 22 lake fish stations (Figure 2-1). Tributary fish sampling stations were chosen based on accessibility of the site and the presence of representative habitat within the sampled stream. Lake fish sampling stations include representation of the three habitat types (rivermouth (3 stations), wetland/sheltered embayment (4 stations) and open coast (15 stations)) and were randomly selected within in each habitat type.

Fish community sampling in the tributaries and lake were conducted using CVC's standard electrofishing survey methods. Presence of fish in the tributaries was sampled by single pass electrofishing per the Ontario Stream Assessment Protocol (Stanfield 2013). Biomass data was collected in the lake habitat types using a 5.5 m Smith-Root electrofishing boat. Each sampling site consisted of transects of one thousand (1000) seconds parallel to shore and in depths of less than 3m. Fish were netted and collected on the boat for processing (data collected included species identification, total length, and weight) and then released. Table B1 in Appendix B provides a list of species identified in the study area (by habitat type and location) from all surveys between 2008 and 2014 to fulfill the identified data gaps.

The following characterizes the fish community and habitat in the tributaries and lake based on the consolidated findings of the Background Review and data gap studies.

Tributaries

Most of the tributaries in the study area are shallow and narrow. Continuous temperatures taken in July and August of 2011 averaged 15°C or higher (range: 14-37°C) for most tributaries (Table 3-2). The tributaries are negatively affected by development (Section 3.3.1.1) and often have numerous barriers to fish movement. Generally, channelization, armoured beds and banks, uncontrolled stormwater discharge, diversions, altered riparian habitats, and poor water quality contribute to lack of substrate diversity, reduced occurrence of deep refuge pools, reduced riparian cover and allochthanous inputs that typically contribute to instream habitat structure (Walsh et al. 2005). These conditions limit the streams' suitability to support fish; however, they provide habitat for tolerant species, some refugia for smaller fish and a variety of year classes.

The fish communities within the LOISS tributaries are composed of tolerant warmwater fish species such as Blacknose Dace (*Rhinichthys atratulus)* and Creek Chub (*Semotilus atromaculatus*), characteristic of tributaries under urban influence (Section 3.3.1.1). Despite this degradation, the tributaries (without major barriers at the shoreline) within the LOISS study area support more than the number of species predicted by Steedman's (1987) equation for assessing species richness based on watershed area (Table 3-23)[6]. This is likely due to the influence of Lake Ontario and the movement of species from the lake into these streams. The recorded number of fish species is at or near the predicted number of species once the lake species (e.g., Lake Chub (*Couesius plumbeus*) and Emerald Shiner (*Notropis atherinoides*)) have been removed.

Table 3-23: Predicted Number of Fish Species based on Watershed Area (Using Steedman's equation: Number of species = 8.24 * Log[watershed area] – 0.47) **

Coastal Reach	Watershed	Drainage Area (km^2)[1]	Predicted number of native fish species (Steedman 1987)[2]	Recorded number of native fish species (2000-2014)	Number of lake species
1 – Lakeview	Serson Creek	2.04	2	0	0
	Applewood Creek	5.97	6	5	1
2 – Lakefront Pomenade	Cawthra Creek	6.04	6	0	0
3 – Mineola	Cumberland Creek	0.44	0	0	0
	Cooksville Creek	32	12	17	8
4 – Port Credit	Credit River	900	24	58	23
5 – Lorne Park/Meadowwood	Sheridan Creek	10.35	8	20	12
	Turtle Creek	2.13	2	4	2
	Birchwood	3.4	4	12	6

[6] Number of native fish species is one metric Steedman (1987) used to score species richness and composition to develop an Index of Biotic Integrity for streams in the Toronto area. The equation for predicting the number of native fish species in a stream reflects the maximum species richness line of plots of number of native species against basin area (km^2).

Coastal Reach	Watershed	Drainage Area (km²)[1]	Predicted number of native fish species (Steedman 1987)[2]	Recorded number of native fish species (2000-2014)	Number of lake species
	Creek				
	Moore Creek	0.08	0	0	0
	Lornewood Creek	4.11	5	5	0
	Tecumseh Creek	1.67	1	3	1
6 – Refinery	Avonhead Creek	0.85	0	7	7*
	Lakeside Creek	2.5	3	2	2*
7 – Clearview	Clearview Creek	4.14	5	2	0

1 Drainage areas are subject to change associated with diversions
2 watershed area must be a minimum of 1.15km²
* All fish in this stream are from the lake. There are no resident fish in this stream due to barriers.
**Creeks with barriers to fish passage at the shoreline are shaded

Fish historically had regular access between the tributaries and Lake Ontario. In many of the tributaries in the study area access has now been reduced or eliminated through the construction of erosion control structures or transportation corridors. A screening of the potential to mitigate these first barriers from the lake was undertaken by CVC aquatic restoration staff. This screening considered the type of barrier and existing land use and known infrastructure in the surrounding area. For instance, a piped stream through undeveloped land with no known infrastructure requiring protection would be screened as having a high potential for barrier mitigation. A piped stream under a residential subdivision would be screened as having low potential for barrier mitigation. Barriers with moderate potential for mitigation typically have identified infrastructure that may pose a constraint to mitigation.

Of the 10 barriers identified in Table 3-24 and Figure 3-33 that limit fish movement from the lake, five are considered to have high potential for mitigation, two have moderate potential for mitigation and six have low or no potential for mitigation. Further studies are necessary to determine the feasibility of mitigating these barriers to fish passage.

Table 3-24: Potential for Removal of First Barrier

High Potential for Barrier Mitigation	Barrier Condition	Existing Surrounding Land Use
Clearview Creek	390m concrete lined channel from Lakeshore Road to Lake Ontario	Future municipal park land (Harding Park)
Avonhead Creek	360m piped from Lake Ontario to Lakeshore Road	Undeveloped privately owned land
Lornewood Creek	300m piped under municipal park	Municipal park land (Richard's Memorial Park)
Cooksville Creek	Culvert at rail tracks	Urban residential
Serson Creek	Low flow channel 450m piped	Active and retired industrial land
Moderate Potential for Barrier Mitigation	**Barrier Condition**	**Existing Surrounding Land Use**

Sheridan Creek	Clarkson Road downstream of the rail tracks	Industrial and urban residential
Birchwood Creek	460m piped under municipal park	Municipal park land and residential (Jack Darling Memorial Park)
Low/No Potential for Barrier Mitigation	**Barrier Condition**	**Existing Surrounding Land Use**
Lakeside Creek	Headwaters piped under industrial development	Industrial
Turtle Creek	230m piped under residential and commercial development	Residential and commercial
Moore Creek	Flow constraints and geomorphic barriers	Residential
Tecumseh Creek	530m piped under residential development	Residential
Cumberland Creek	Piped under residential development upstream of Lake Ontario, perched outlet	Residential
Cawthra Creek	Diversion of flows to Cooksville Creek at Atwater Rd, piped under residential development upstream of Lake Ontario	Residential, municipal park land (Lakefront Promenade Park)

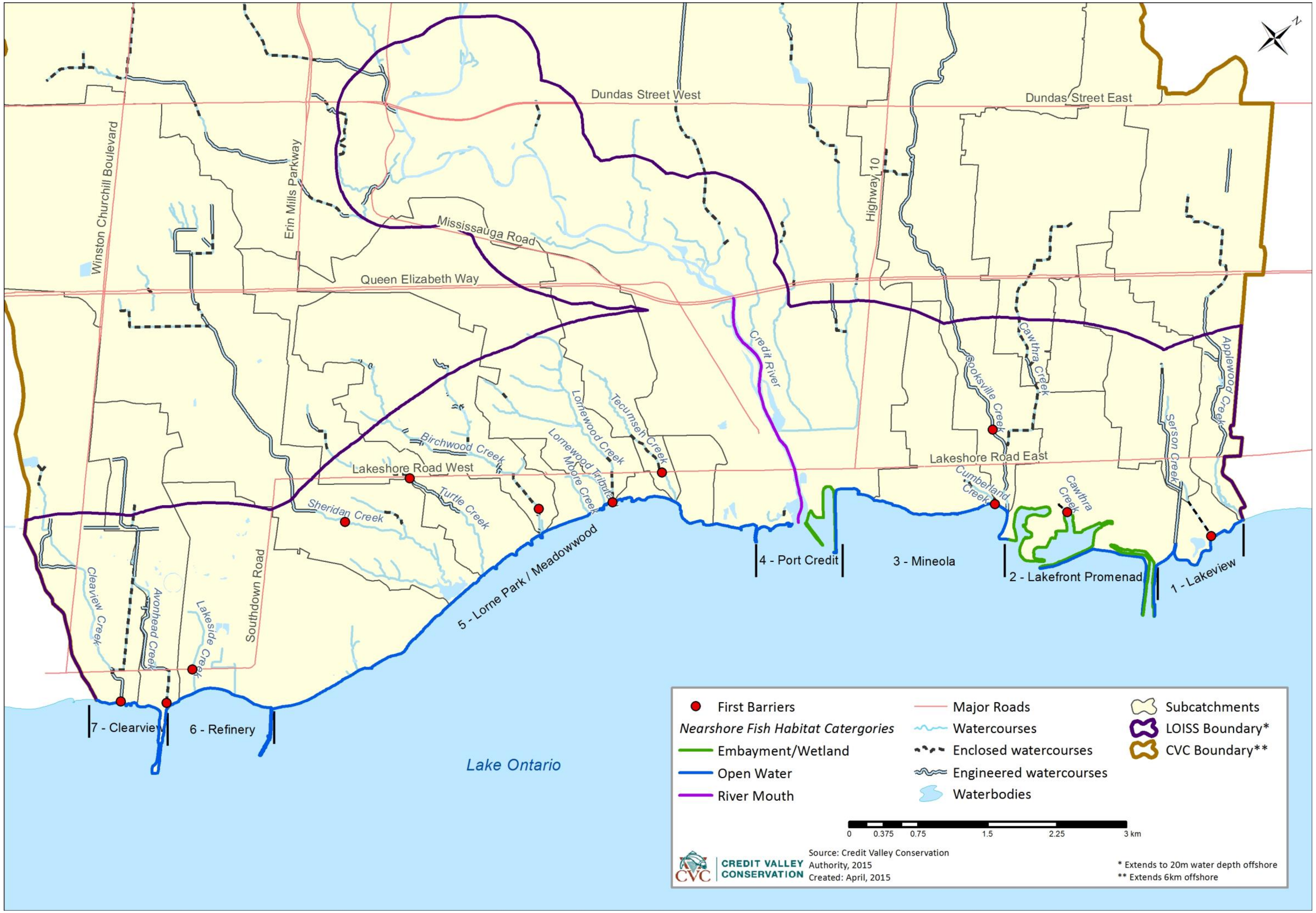


Figure 3-33: Lake Ontario nearshore fish habitat categories and first barriers to fish passage in the LOISS tributaries.

Mitigating the barriers with the highest potential would open 4,000 m of stream to fish moving from Lake Ontario (up to the next potential fish barrier). An additional 4,100 m of stream would be opened if the barriers with moderate potential for removal were mitigated. As Table 3-22 shows, fish moving from Lake Ontario have the potential to almost double the diversity of fish species within the tributaries. Connecting fish populations and increasing habitat also provide increased resilience for stream-resident fishes. Very low flows (Section 3.1.1, Section 3.2.1.1) may also prevent fish access from the lake (e.g., Turtle Creek) and between stream reaches and should be considered for further study.

Lake Ontario

Fish habitat in Lake Ontario can be broadly categorized into three communities:

1. Benthic Offshore/Coldwater
2. Offshore/Pelagic/Coldwater
3. Nearshore/Warmwater and Coldwater
    a. Open Coast
    b. Embayment and Wetland
    c. Rivermouth

While the LOISS focuses on the third category (Nearshore/Warmwater and Coldwater), it is important to understand all categories due to the transient and migratory nature of the fish in the lake. Additional detail is found in ABL (2011); however, the following is a summary of the three communities:

1. Benthic Offshore/Coldwater

    The offshore zone is considered to be any permanent coldwater habitat greater than 20 metres in depth (Lake Ontario Biodiversity Strategy Working Group 2009). The benthic habitat area specifically refers to the hypolimnion zone (Stewart et al. 2013). This community was not sampled as part of LOISS; however, expected fish species include Lake Trout (*Salvelinus namaycush*), Deepwater Sculpin (*Myoxocephalus thompsonii*), Lake Whitefish (*Coregonus clupeiformis*) and Burbot (*Lota lota*).

2. Offshore/Pelagic/Coldwater

    The offshore pelagic zone includes the epiliminion and metalimnion stratification layers (Stewart et al. 2013). MNRF and DFO both collect data on the offshore communities in Lake Ontario; however, limited data are available for the study area. No surveys were completed in this area for the purposes of LOISS.

    In general, the offshore pelagic fish community is composed of coldwater piscivores including Rainbow Trout (*Oncorhynchus mykiss*), Brown Trout (*Salmo trutta*), Atlantic Salmon (*Salmo salar*), Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*). Forage fish in this zone include Alewife (*Alosa pseudoharengus*), Rainbow Smelt (*Osmerus mordax*) and Emerald Shiner.

3. Nearshore/Warmwater and Coldwater

    For the purposes of this report, nearshore areas are considered those less than 20 m in depth; this includes the Credit River up to the first riffle (generally located just upstream of the Queen Elizabeth Way). With greater depth, the impacts of wave, wind and temperature fluctuations decrease, creating more stable conditions and areas of refuge from the harsh conditions experienced at shallower depths (<2 m). Notably, while CVC fish sampling takes place in the very nearshore (depths <5 m), other agencies, such as MNRF and DFO, conduct sampling at greater depths in the nearshore. Their data is not included in this summary.

a. Open Coast/Coldwater/Variable

Open coast sites subjected to the conditions of the lake are exposed to waves, winds and currents and are challenging environments in which to survive. Wave action caused by winds results in rapid temperature changes (see Section 3.4.1.3). The resulting upwellings, which bring colder water from deeper areas of the lake to the surface, and downwellings, which do the opposite, are common along the north shore of Lake Ontario and make open coast areas too dynamic for continuous use by many fish species. Spot temperatures were taken by CVC from 2008 to 2014 prior to undertaking boat electrofishing surveys at open coast sites in the LOISS study area. The range in summer water temperatures (10.5–23.9^{o}C) compared to air temperatures (Table 3-25, 3-26) demonstrate the variability in thermal conditions in open coast habitats (Lake Ontario water temperatures are also discussed in Section 3.5.1.1). These areas are used as migration routes or feeding or spawning areas for species such as Alewife, Emerald Shiner, Lake Trout, Lake Chub, Rainbow Smelt, Mottled Sculpin (*Cottus bairdii*), juvenile Chinook, Coho Salmon and Brown and Rainbow Trout (Goodyear et al. 1982; Clayton 2014 personal communication). Open coast habitat preferences by these species are reflected in the Fish Community Objectives for Lake Ontario (Stewart et al 2013) that include objectives for restoring self-sustaining populations of species that rely on nearshore waters for part of their life cycle (e.g. Lake Trout, Lake Whitefish (*Coregonus clupeaformi*), Alewife). Coolwater fish species such as Yellow Perch (*Perca flavescens*), American Eel (*Anguilla rostrata*), and Johnny Darter (*Etheostoma nigrum*) are also commonly found in the littoral areas of the open coast.

Table 3-25: Night-time spot water temperatures and daytime air temperatures for open coast sites in summer 2008 to 2014 by coastal reach and by year (Source: CVC boat electrofishing data)

Coastal Reach	Average water temperature (°C)	Water temperature range (°C)	Average Air temperature (°C)	Air Temperature range (°C)
1 – Lakeview	18	12.9-21.1	22	13.9-26
2 – Lakefront Promenade	20	15.8-23.9	22	15.3-29.1
3 – Mineola	19	12.7-22.7	20	17-24.5
4 – Port Credit	20	16.4-22.5	21	16.5-25
5 – Lorne Park/Meadowwood	20	11.7-22.6	22	18-24.8
6 – Refinery	19	10.5-21.9	22	20-23.4
7 – Clearview	21	18.9-22.4	22	20.8-24

Table 3-26: Average Air and Water Temperatures During Sampling Period (Source: CVC unpublished data)

Year	Average water temperature (°C)	Water temperature range (°C)	Average Air temperature (°C)	Air Temperature range (°C)
2008	20	19-22.2	21	19-24
2009	19	17.9-22	20	17-26
2010	19	17.5-22.4	22	19-29.1
2011	21	17.8-23.9	23	19-26
2012	21	16.1-23.9	24	20.8-26
2013	15	10.5-18.8	20	17-21.5
2014	16	15.8-16.4	16	14.5-20

Boat electrofishing conducted by CVC between 2008 and 2014 were completed between 7pm and 11pm in July and August (see Table B1 in Appendix B). The number of sites varies annually and is shown in Table 3-27.

Table 3-27: Number of open coasts sampled by CVC annually by reach.

Coastal Reach	2008	2009	2010	2011	2012	2013	2014
1 – Lakeview	3	1	1	1	2	2	2
2 – Lakefront Promenade	1	1	0	1	1	0	0
3 – Mineola	2	2	1	2	1	1	1
4 – Port Credit	1	4	1	1	0	1	1
Lorne Park/ Meadowwood	5	3	3	3	0	1	1
6 – Refinery	2	1	1	1	0	1	1
7 – Clearview	1	1	1	1	0	0	0
Total	15	13	8	10	4	6	6

The average number of individuals per 1000 seconds for most coastal reaches is below 100 (Figure 3-34), except for reaches 4 – Port Credit and 6 – Refinery, where the average number of individuals are more than double the other reaches.

Comparison of the average number of individuals per 1000 seconds and fish species richness for the 4 – Port Credit Coastal Reach and the 6 – Refinery Coastal Reach suggests the average number of individuals per 1000 seconds at 6 – Refinery Coastal Reach is being driven by an abundance of fish from a limited number of species. Looking closer at the data (Appendix B) for 6 – Refinery Coastal Reach reveals a high number of Alewife (411 individuals) caught in 2008 and Lake Chub (246 individuals) and Emerald Shiner (159 individuals) caught in 2009. While the exact reason for the high average number of individuals per 1000 seconds and low species richness in 6 – Refinery Coastal Reach is unknown, this spike may be related to the relatively sheltered area created between the piers that bookend this coastal reach. The piers afford some protection from the prevailing current from the east and the less frequent but equally powerful forces from the west. Calculations of fish species richness using the same data reveals fish species richness at the mouth of the Credit River (4 – Port Credit Coastal Reach) is the highest of all open coast sites. It is 3-fold higher than in 6 – Refinery Coastal Reach that has the lowest species richness of all open coast sites. Higher fish species richness in 4 – Port Credit Coastal Reach at the mouth of the Credit River is attributed to higher habitat diversity in this location; the combination of fishes from embayments and wetlands, river mouth, and open coast habitats.

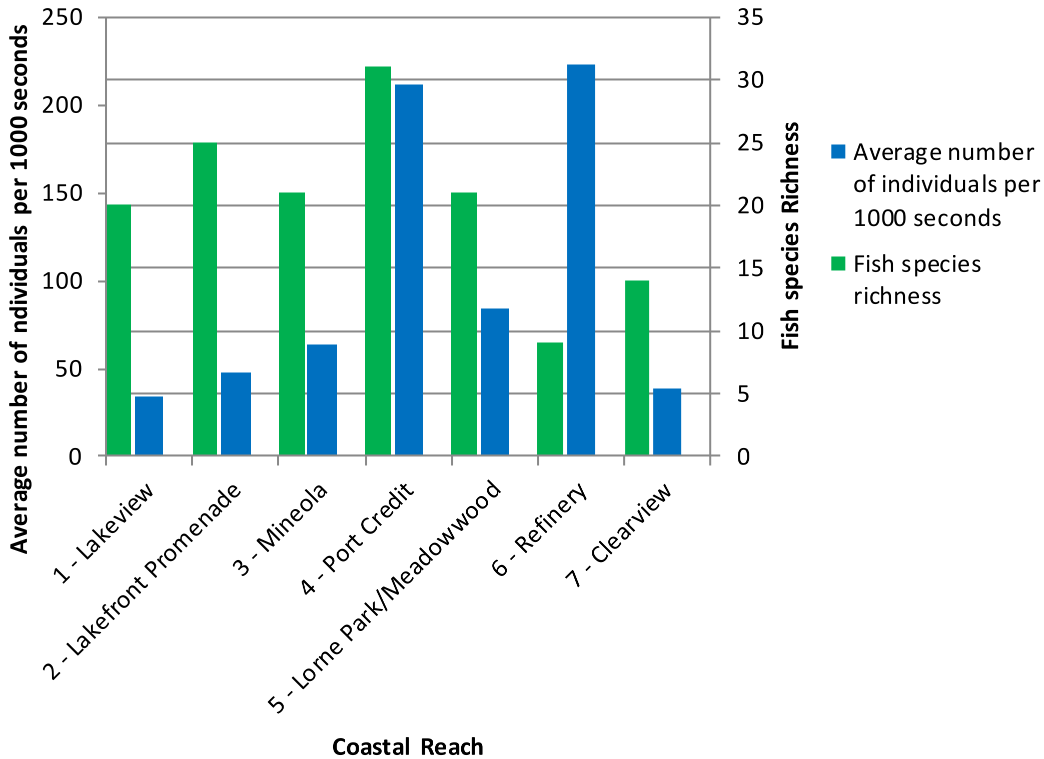


Figure 3-34: Fish species richness and average number of individuals per 1000 seconds by coastal reach from boat electrofishing surveys in LOISS study area between 2008 and 2014. (Source: CVC boat electrofishing data)

Analysis of fish biomass for the open coast sites reveals that, overall, 5 – Lorne Park/Meadowwood Coastal Reach has the highest fish biomass (Figure 3-35). This is expected in part due to the higher number of sampling sites located within this coastal reach. Wide ranges in biomass at all sites over seven years of sampling suggests that the presence of very large fish, such as carp, may skew the data, making some areas appear more productive. Removing carp from the data provides a more comparable data set across the open coast sites (Figure 3-36). Due to their size, even one individual carp can greatly skew the biomass of a site. Removing carp from the biomass calculation shows a much larger reduction in biomass in the embayment sites where more preferred carp habitat is located than the rivermouth sites. Common Carp (*Cyprinus carpio*) is an invasive species and not desirable. The number and weight of Common Carp caught at each site (and removed from the biomass calculated in Figure 3-36) are noted in Table 3-28.

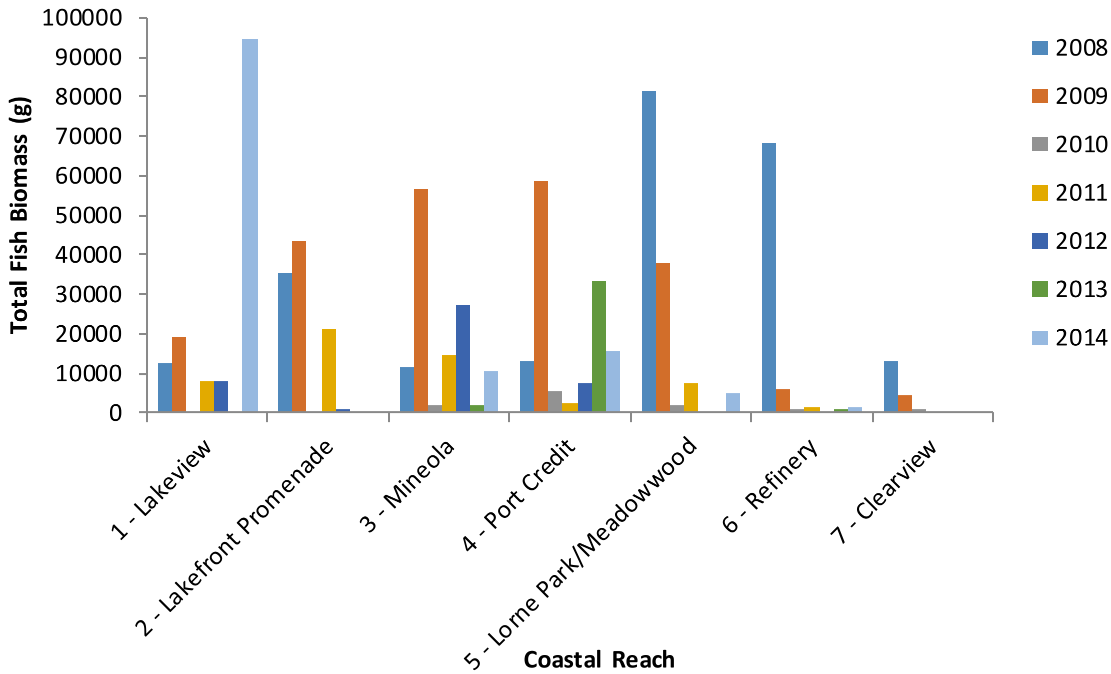


Figure 3-35: Fish biomass (g) by year at open coast sites in LOISS study area between 2008 and 2014. (Source: CVC boat electrofishing data)

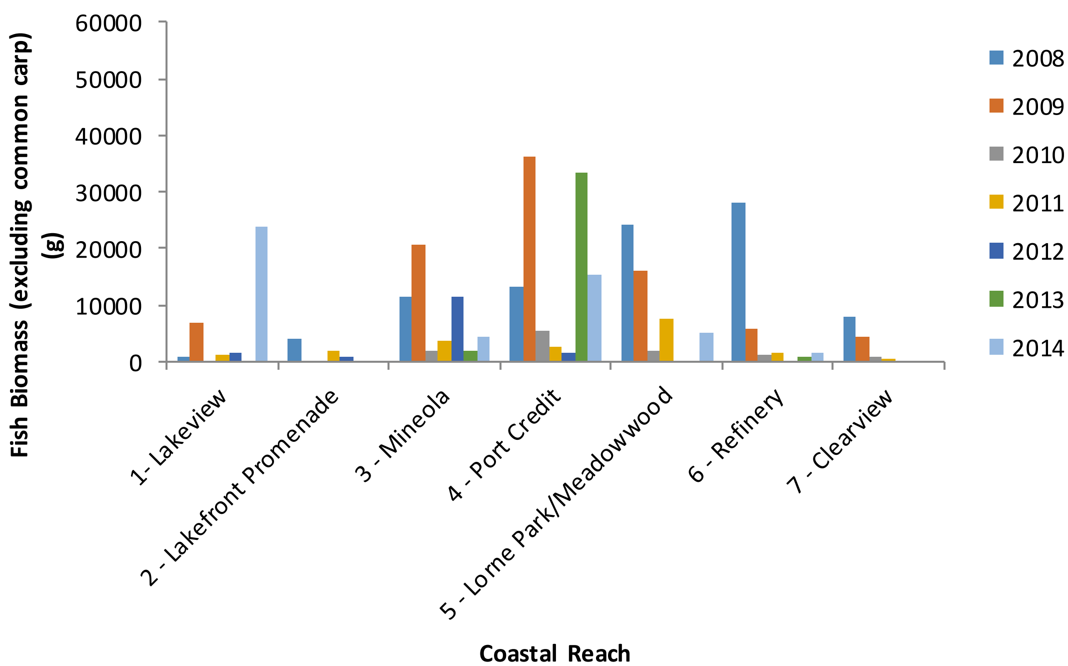


Figure 3-36: Fish biomass (g) excluding Common Carp by year at open coast sites in LOISS study area between 2008 and 2014. (Source: CVC boat electrofishing)

Table 3-28: Abundance of Common Carp and associated biomass (g) in parentheses at open coast locations removed to create Figure 3-37. (Source CVC boat electrofishing data)

	Year/Number and Biomass (g)						
Coastal Reach	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1 – Lakeview	2 (11500)	2 (12250)		1 (7100)	1 (6180)		10 (70730)
2 – Lakefront Promenade	4 (31500)	5 (43500)		3 (19150)			
3 – Mineola		5 (36100)		2 (10900)	2 (15830)		1 (5800)
4 – Port Credit		2 (22100)			1 (5920)		
5 – Lorne Park/Meadowwood	10 (57250)	4 (22000)					
6 – Refinery	4 (40250)						
7 – Clearview	1 (4750)						

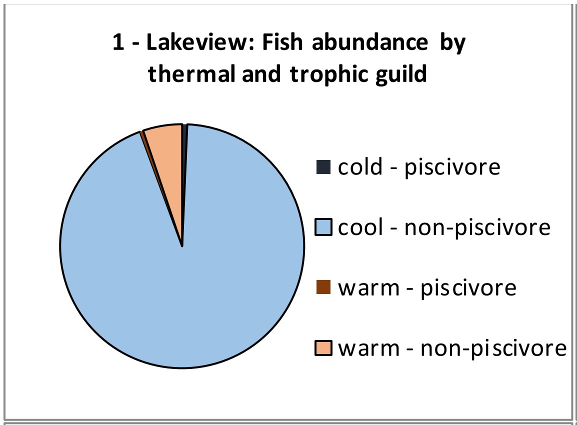
Fish species composition by trophic guild (piscivore, non-piscivore) and abundance of each thermal guild (warm, cool, cold) (see Table B2 in Appendix B) for open coast sites in the LOISS study area were analysed to determine if the fish data were reflective of the expected fish community composition (i.e., coldwater fish community) in open coast habitats. For all coastal reaches, warm and coolwater species outweighed the coldwater species in both species composition and abundance (Figure 3-37) Comparing fish abundance and species composition suggests that there is high number of fish representing a diversity of coolwater species across all coastal reaches.

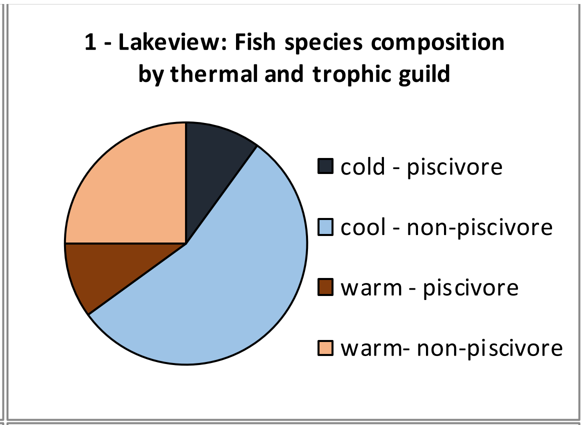
Data from 2008-2014 (Appendix B) shows Alewife and Emerald Shiner, coolwater species, being the most abundant along the shoreline. This is contrary to the expected dominance of coldwater fish species. This discrepancy may be explained by the changes in habitat along the shoreline from an open coast system to a more diverse matrix including embayments and wetlands that support warm and coolwater fish species, as well as impacts from stonehooking and shoreline protection and hardening. Additionally, the summer fish surveys collected for this study are not ideally timed to collect coldwater fish which typically use shoreline habtiats in the fall or winter. Finally, species composition in the lake has also changed with lake-wide declines of top predatory fish abundance (Morrison et al 2007).

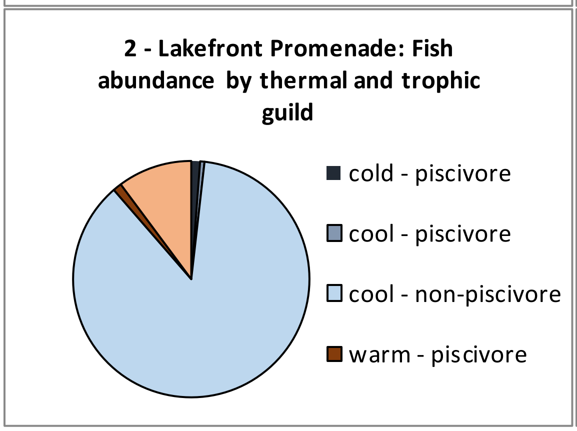
The dominance of non-piscivorous (Figure 3-37) fish species in the open coast community provides a diverse food source for piscivorous fish. Of note is the relative abundance of warmwater piscivorous fish species to coldwater piscivorous fish species. In all open coast habitats from the Credit River mouth to the east end of the LOISS study area, the coldwater (e.g., Rainbow Trout, Brown Trout, Atlantic Salmon) and warmwater piscivorous (e.g., Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*)) fish species abundance is nearly equal. West of the Credit River mouth, coldwater piscivorous fish species abundance is double or more than warmwater piscivorous fish species abundance. The presence of warmwater embayments at the marina at the mouth of the Credit River (4 – Port

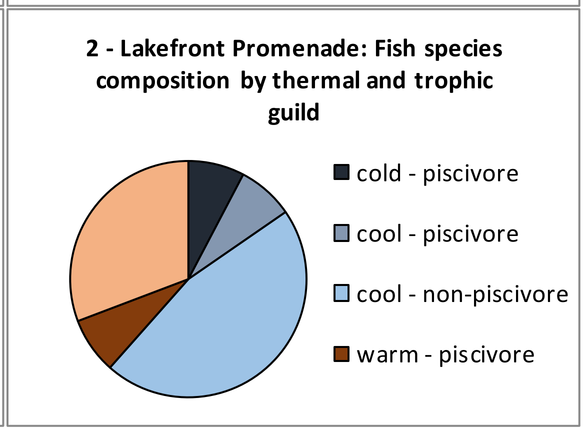
Credit Coastal Reach), and Lakefront Promenade Park and OPG intake channel (2 – Lakefront Promenade Coastal Reach) and the absence of warm water embayments west of the Credit River in the LOISS study area may account for this difference. In general, the constant fluctuation in temperature, waves, and currents typical of open coast environments highly influence the fish species along the shoreline at any given time (Edsall and Charlton 1997).

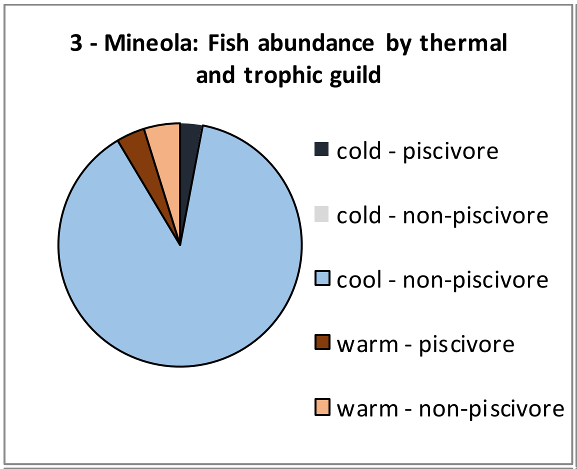
Habitat usage of multiple life stages of coldwater fish has not been assessed. Spawning success of coldwater species (Lake Trout, Lake Whitefish) is unknown but likely little to none. While the existing data suggests coldwater fish are not a significant user of the open coast habitat in the LOISS study area, more data are needed (including fall and spring surveys) to fully assess coldwater fish usage of this area.

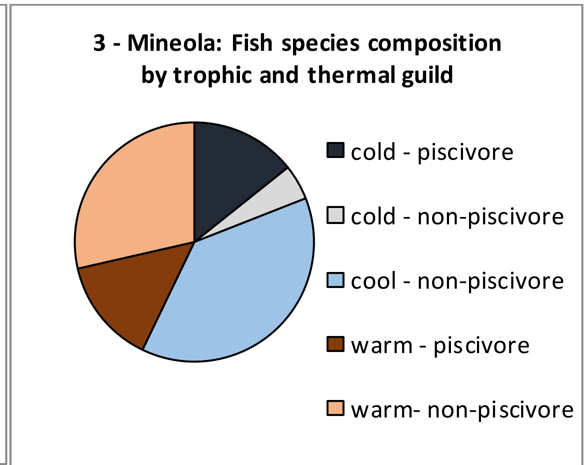


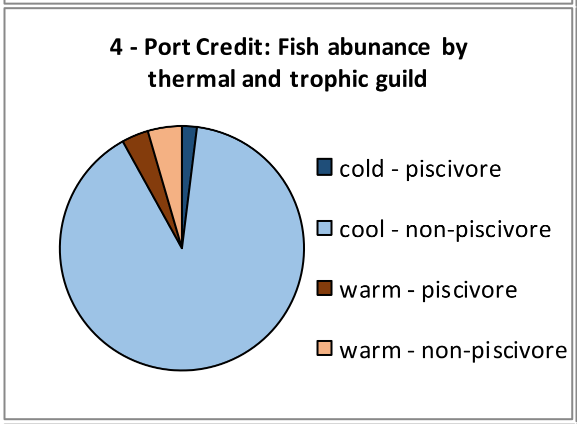


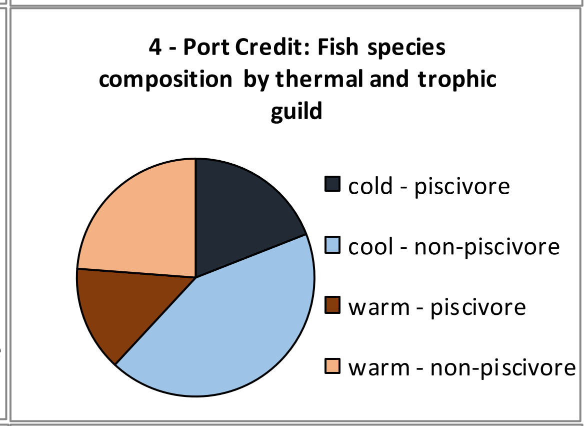


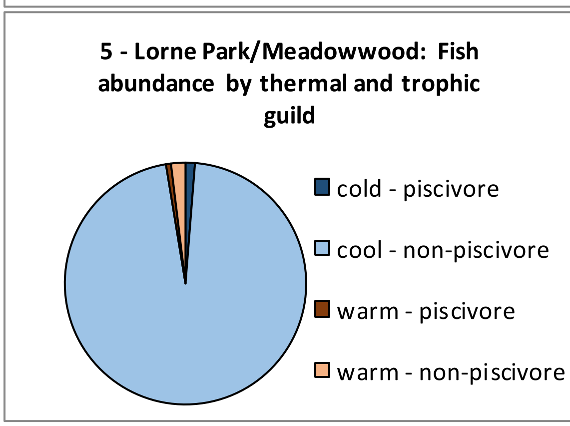



3 - Mineola: Fish abundance by thermal and trophic guild
cold - piscivore
cold - non-piscivore
cool - non-piscivore
warm - piscivore
warm - non-piscivore


3 - Mineola: Fish species composition by trophic and thermal guild
cold - piscivore
cold - non-piscivore
cool - non-piscivore
warm - piscivore
warm- non-piscivore


4 - Port Credit: Fish abunance by thermal and trophic guild
cold - piscivore
cool - non-piscivore
warm - piscivore
warm - non-piscivore


4 - Port Credit: Fish species composition by thermal and trophic guild
cold - piscivore
cool - non-piscivore
warm - piscivore
warm - non-piscivore


5 - Lorne Park/Meadowwood: Fish abundance by thermal and trophic guild
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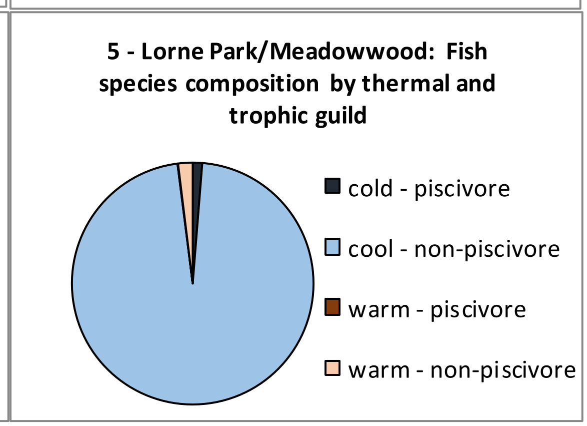
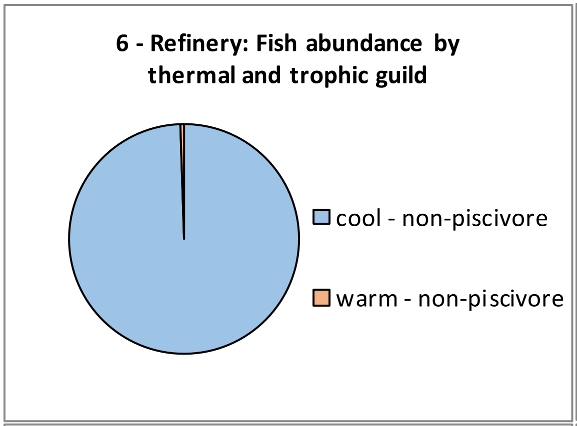
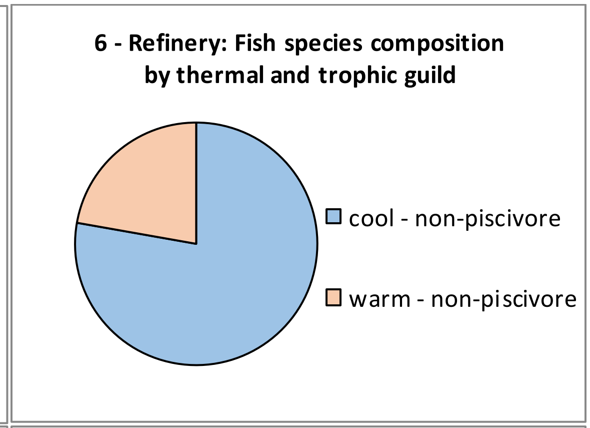
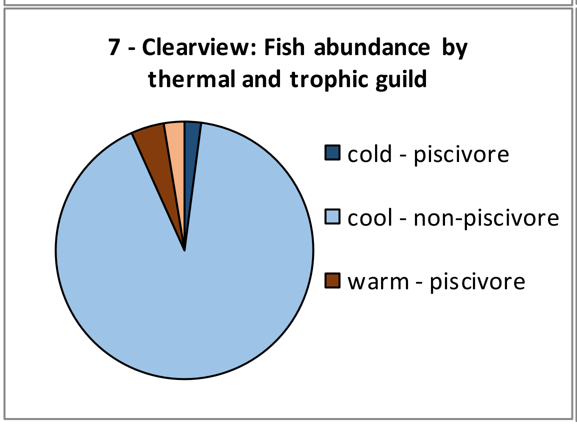
cool - non-piscivore
warm - piscivore
warm - non-piscivore


5 - Lorne Park/Meadowwood: Fish species composition by thermal and trophic guild
cold - piscivore
cool - non-piscivore
warm - piscivore
warm - non-piscivore







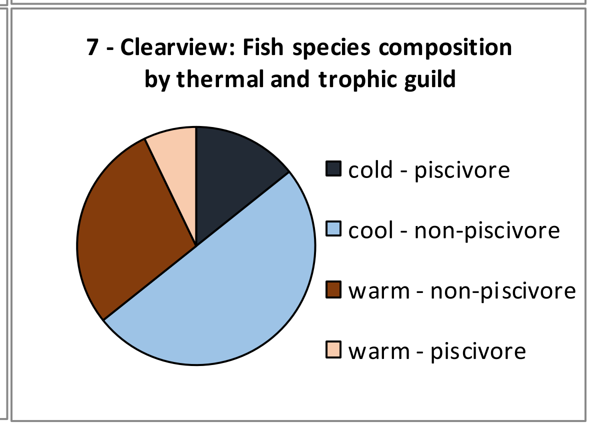


Figure 3-37: Fish abundance by thermal (warm, cool, cold) and trophic guild (non-piscivore, piscivore) and fish species composition by thermal guild and trophic for open coast sites in each coastal reach in the LOISS study area. (Source: CVC boat electrofishing data 2008-2014). Trophic guilds are listed in Appendix B.

b. Wetlands and Embayments (Warmwater)

Boat electrofishing was undertaken at seven wetland and embayment habitat locations in the LOISS study area (Table 3-29)

Table 3-29: Wetland and Embayment site names and associated station, reach and site descriptions.

Name	Coastal Reach	Description
Port Credit Marshes	4 – Port Credit	River mouth
JC Saddington Upstream (US)	4 – Port Credit	River mouth
Lakeshore Road Upstream (US)	4 – Port Credit	River mouth
Port Credit Harbour Marina	4 – Port Credit	Embayment
Lakefront Promenade Boat Ramp	2 – Lakefront Promenade	Embayment
Lakefront Promenade Park Marina Basin	2 – Lakefront Promenade	Embayment
Lakeview Generating Station Intake	2 - Lakefront Promenade	Embayment

Wetlands are well protected from lake processes; currents are typically weaker, waves are smaller and the thermal regime is more stable than areas exposed to the lake. These conditions also allow for the establishment of aquatic vegetation which in turn supports a diverse warmwater fish community and increases the overall diversity of nearshore habitat types and species assemblage.

Evaluated coastal wetlands found in the study area include the following:

1. 4 – Port Credit Coastal Reach: Credit River Marshes
2. 5 – Lorne Park/Meadowwood Coastal Reach: Rattray Marsh, Turtle Creek Marsh, Fudger's Marsh

Fish species assemblages in Rattray Marsh (29 species) and the Credit River Marshes (40 species) are similar and comprised of resident fishes and fishes that have moved in from the lake. Owing to the higher flows in the Credit River and the overall increased habitat diversity associated with a larger marsh and river system, the Credit River Marshes have additional riverine species such as Shorthead Redhorse (*Moxostoma macrolepidotum)* and Channel Catfish (*Ictalurus punctatus*).

Fish sampling in Turtle Creek was completed by CVC in 2014 using a backpack electrofisher. This sampling event identified five species and over 320 individuals within Turtle Creek marsh. Surprisingly, White Sucker (*Catostomus commersonii*), a common species throughout the study area, has not been observed in the marsh possibly because of insufficient flows to draw them in from the lake.

Fudger's Marsh located upstream of Lakeshore Road on Birchwood Creek has not been adequately sampled. Lake species are not expected to exist in this location due to the piped section of stream downstream, which inhibits the passage of fish from the lake.

A number of other wetlands and potential wetlands are found in the study area that either do not meet the definition of coastal wetlands (Ministry of Municipal Affairs and Housing 2014) and/or have not yet been evaluated. These are discussed in Section 3.7.1.2.

Embayments possess somewhat similar habitat characteristics as the coastal wetlands in the study area, despite the lack of rivers flowing through them. Embayments within the study area are anthropogenic, or influenced by human use (e.g., marina activities, regular disturbance). It is suspected that the embayments in the study area are exposed to the thermal dynamics of the lake more so than the relatively protected coastal wetlands associated with tributaries. Studies are needed to confirm this assumption however, fish survey records for embayments in the study area include warmwater species (e.g., Large and Smallmouth Bass, sunfish species (*Lepomis sp*.), bullhead species (*Ameiurus sp*.)) as well as coolwater species (e.g., Northern Pike (*Esox Lucius)*, Yellow Perch) suggesting habitat conditions may be variable and suitable to support both communities within the embayments.

The study area contains four embayments (Figure 3-38):

1. 2 – Lakefront Promenade Coastal Reach: Former Ontario Power Generation intake piers.
2. 2 – Lakefront Promenade Coastal Reach: Lakefront Promenade Park marina behind DFO breakwater
3. 2 – Lakefront Promenade Coastal Reach: Lakefront Promenade Park (Thumb Basin)
4. 4 – Port Credit Coastal Reach: Port Credit Marina

Trends of greater fish species diversity in embayment/protected areas versus open coast areas are consistent across the shoreline based on LOISS boat electrofishing sampling data, where mean fish species richness in embayments is almost double that of open coast sites in most years (Table 3-30).

Figure 3-38: Identified wetlands and embayments along the shoreline in the LOISS study area.

Table 3-30: Mean Fish Species Richness: Open Coast vs Embayment based on CVC boat electrofishing surveys completed between 2008 and 2014.

	Average Number of Species Per Site	
Year	**Open Coast**	**Embayment**
2008	6	13
2009	8	9
2010	7	9
2011	5	10
2012	4	8
2013	6	9
2014	5	9

Fish biomass was also calculated for the rivermouth and embayment sampling stations (Figure 3-39). On average, the biomass at the embayment sites were higher than that at the rivermouth sites which have the benefit of hosting both river and lake fish species (see rivermouth below). The same holds true when Common Carp are removed from the analysis (Figure 3-41). The number and weight of Common Carp caught at each site (and removed from the biomass calculated in Figure 3-40) are noted in Table 3-31.

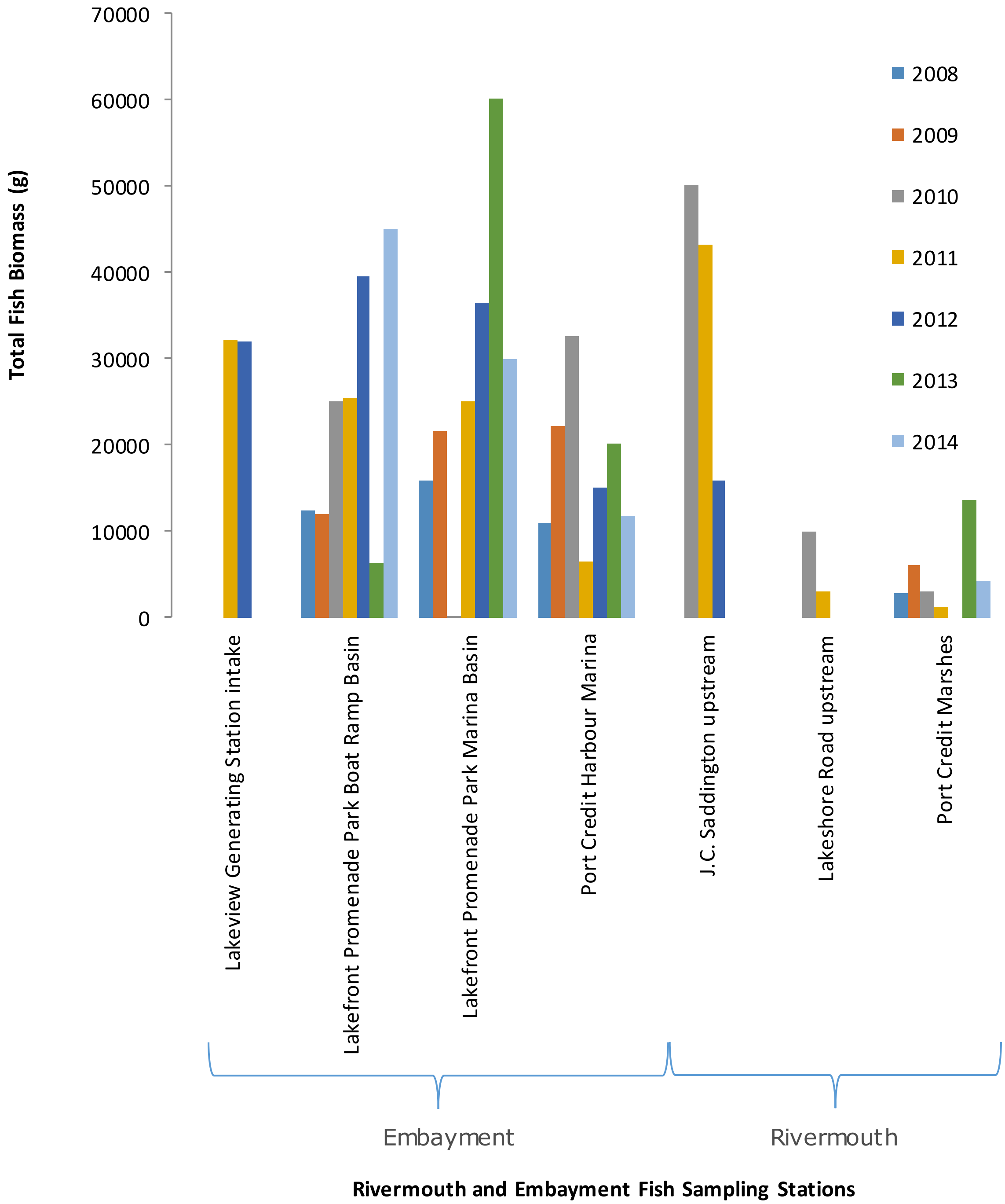


Figure 3-39 Total fish biomass for rivermouth and embayment sampling stations in the LOISS study area. (Source: CVC boat electrofishing data 2008-2014).

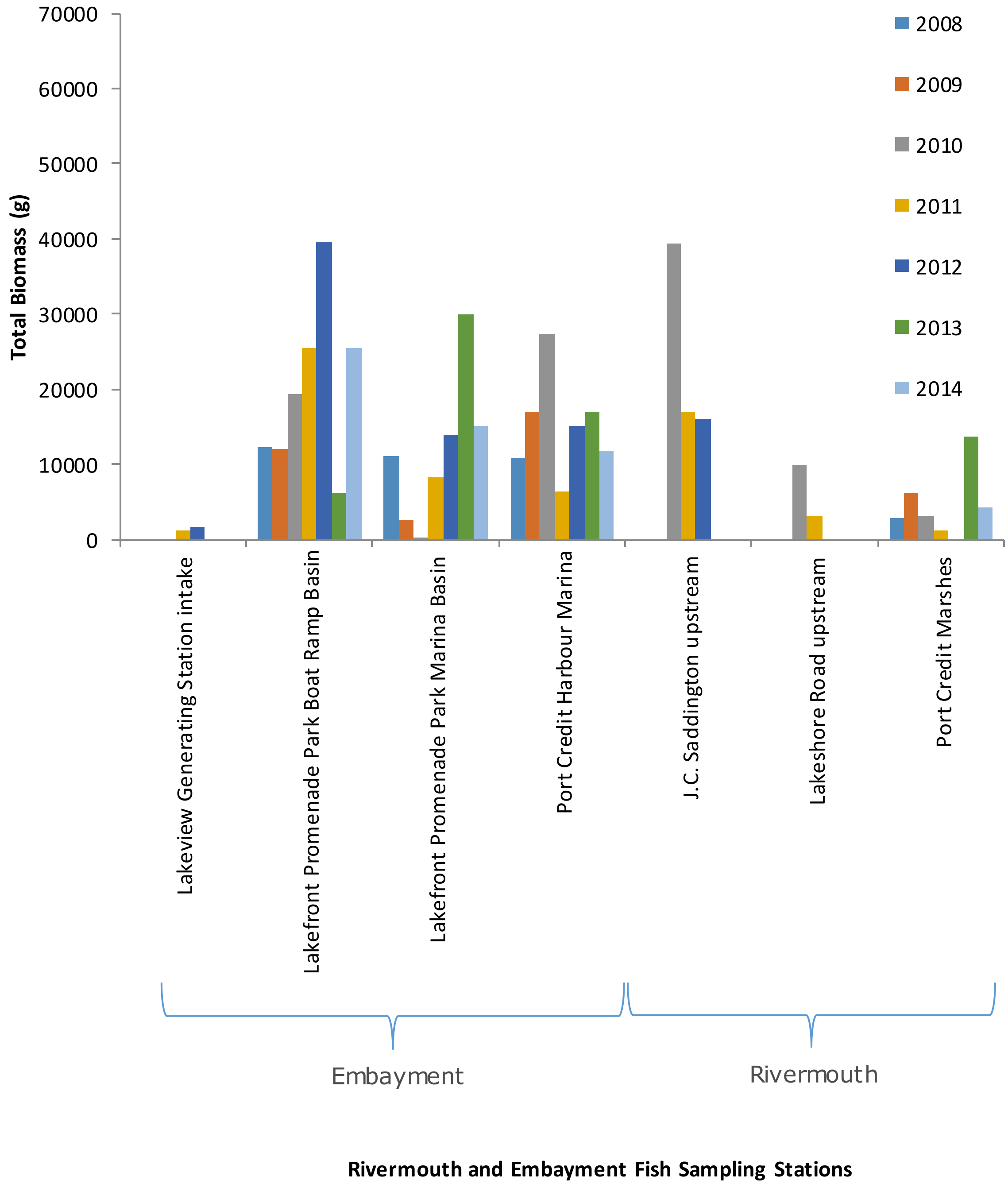


Figure 3-40: Fish biomass for rivermouth and embayment fish sampling stations excluding Common Carp for the LOISS study area (Source: CVC boat electrofishing data 2008-2014)

Table 3-31: Abundance of Common Carp (and associated biomass (g) in parentheses) removed to create Figure 3-41.

	Year						
Station	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Port Credit Marshes							
Port Credit Harbour Marina		1 (5250)	1 (5180)		1 (16)	1 (3130)	
Lakefront Promenade Boat Ramp			1 (5720)		6 (110)		3 (19600)
Lakefront Promenade Park Marina Basin	1 (4750)	3 (19000)		2 (16760)	3 (22470)	4 (30330)	3 (14900)
JC Saddington Upstream			2 (10940)	5 (26278)			
Lakeshore Road upstream							
Lakeview Generating Station Intake				3 (31140)	4 (30300)		

Shoreline associated wetlands and embayments are only present east of the Credit River in the LOISS study area. These habitats are artificial habitats which are fairly protected from coastal processes (waves, currents, erosion, etc.). These habitats support submergent aquatic vegetation containing diverse communities of warmwater species with some top predators. Northern Pike and Smallmouth Bass are found regularly. Species like Largemouth Bass, Bowfin, Black Crappie and Yellow Perch are not found in high numbers.

c. Rivermouths (Warmwater and Coldwater)

Rivermouths are semi-protected from lake processes and provide more thermally stable and protected areas than open coast habitats. Five of the streams and the Credit River in the study area are affected by backwater, where coastal processes interact with the positive flow of water from the tributaries into the lake (see Section 3.3.1.2). Rivermouth habitats are mixing zones, where flowing streams combine with the more static water levels of Lake Ontario. Substrates found here are generally finer sands and silts that have been carried as bedload by the river and deposited in a delta at the confluence with the lake. These protected areas at the mouth of the stream also allow for the establishment of aquatic vegetation.

One third of the fish species in the Great Lakes use tributaries for spawning and nursery habitat (Lane et al. 1996). Species spawn within the lower reaches of the tributaries and further upstream beyond the area affected by the lake. Tributary flows, warmer temperatures in tributaries, the amount of daylight and degree days often provide cues to lake species to migrate upstream to spawn. Higher temperatures in the tributaries not only afford a longer growing season than in the lake (Edsall and Charlton 1997), but they may also be more thermally suitable for certain species. Species assemblages in rivermouth habitats are dependent on the size and thermal regime of the tributary.

Avonhead Creek, Sheridan Creek, Turtle Creek, Birchwood Creek, Credit River, Cooksville Creek and Applewood Creek all have rivermouth habitats due to their form and interaction with Lake Ontario, although some may be small with limited or poor fish habitat. The Credit River's rivermouth habitat provides the most diverse aquatic habitat along the shoreline. The diversity of substrate, range of depths, variability in shoreline features and access to slower moving waters and vegetation are among the characteristics of this area that provide a range of habitat types for a diverse assemblage of river, lake and wetland species. Migratory, transient and resident fish populations are observed within the rivermouth. Figure 3-41 shows a substantially higher percentage of total fish species caught in 4 – Port Credit Coastal Reach (the mouth of the Credit River) compared to other sampling stations along the shoreline.

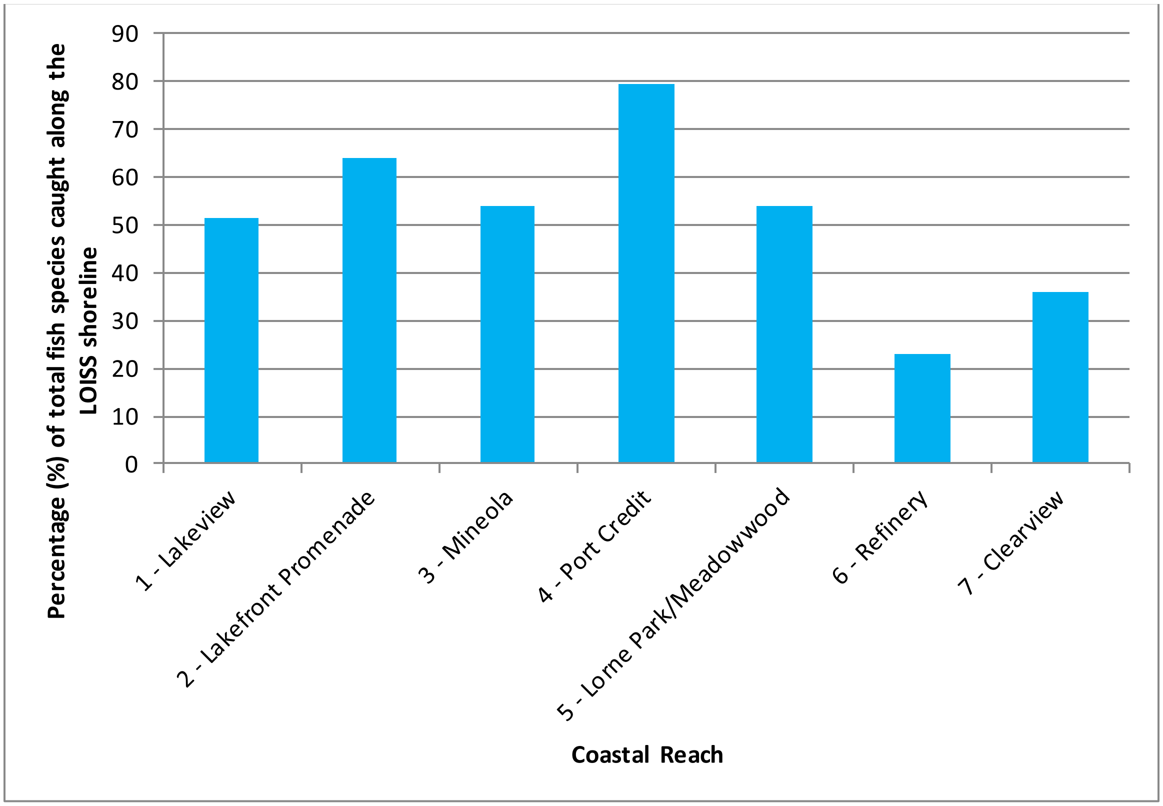


Figure 3-41: Percentage of total fish species caught between 2008 and 2014 for each coastal reach for all habitat types. The high percentage of fish species caught in the 4 - Port Credit Coastal Reach is reflective of the diversity of habitat types and functions in the Credit River mouth. (Source: CVC boat electrofishing data 2008-2014)

Port Credit marshes is the most diverse aquatic habitat in the LOISS study area but is also highly impacted. Turbidity from carp and fine sediment are an issue. Submergent vegetation is not as diverse or as abundant as expected. The presence of Round Goby (*Neogobius melanostomus*), which are food items for some species, may be negatively affecting some species through competition or egg predation. Species such as Walleye and Channel Catfish, target species for restoration in the lower Credit River (MNRF 2002), are present in low numbers in Port Credit marshes. The status of Lake Sturgeon (Provincially Threatened Species at Risk) is unknown with recorded observations of lone individuals in 1926 and 2006. Rattray Marsh is improving in the wake of restoration dredging in 2014 and 2015 that removed sediment, increased water depth and increased aquatic vegetation diversity, but low numbers of top predators are still being caught in sampling efforts. Other river mouth areas in the LOISS study area are small with limited habitat/access for fish.

3.6.1.2 Benthic Communities

Benthic macroinvertebrates are commonly used as indicators of water quality and ecosystem health due to their short life cycles, small home range and sensitivity to environmental stressors. In other words, the type and relative abundance of these organisms are influenced by their environment and therefore serve as effective biological indicators of local environmental conditions. As a critical link in the food chain (food for fish), nutrient cycles, primary productivity, and decomposition, benthic macroinvertebrates are also an important aspect of aquatic ecosystem function.

A detailed summary of benthic macroinvertebrate baseline data for Cooksville and Sheridan Creeks is found in ABL (2011); however, a number of knowledge gaps (Table 3-22) were identified in the report indicating a need for additional benthic macroinvertebrate sampling. To fill these gaps, additional data were collected in eight tributaries to Lake Ontario (inland points) and along three nearshore Lake Ontario transects within the coastal reaches (Figure 2-1).

The following summarizes the baseline data and data collected to fulfill these identified gaps:

- Tributary benthic invertebrate community surveys
- Nearshore benthic invertebrate community surveys

Tributaries

Benthic macroinvertebrates were collected following a protocol based on Reynoldson et al. (1999) which employs a series of stationary kick and sweep samples across 5 evenly spaced transects along the stream. Sampling to fulfill the identified data gaps was completed in the mid-reaches of the following stream stations in 2011:

- 1 – Lakeview Coastal Reach: Serson Creek and Applewood Creek
- 5 – Lorne Park/Meadowwood Coastal Reach: Birchwood Creek, Lornewood Creek, Moore Creek, Turtle Creek, Tecumseh Creek
- 7 – Clearview Coastal Reach: Clearview Creek

An additional station was sampled in 2013 using the same protocol:

- 5 – Lorne Park/Meadowwood Coastal Reach: Moore Creek

Biological metrics are frequently applied to benthic macroinvertebrates to assess stream health. Healthy tributaries generally consist of a diverse community of both pollution intolerant and tolerant groups, with each taxon making up a relatively low proportion of a given sample. When a stream is exposed to a stressor, this balance can shift resulting in reduced abundance and diversity of sensitive taxa, followed by proliferation of tolerant taxa (Griffiths, R.W. 1998).

Benthic macroinvertebrate samples were characterized using a range of metrics, which together indicated the health at each station (Table 3-31):

<u>%EPT (Ephemeroptera, Plecoptera, Trichoptera)</u>
These groups generally require clean, well-oxygenated water, and therefore serve as a good measure of stream health (Barbour 1999). The lack of EPT groups at most tributaries was an immediate 'red flag' indicating some level of impairment. Among all but one stream, the presence and relative abundance of mayfly (*Ephemeroptera)*, stonefly (*Plecoptera)* and caddisfly (*Trichoptera)* or EPT taxa were low (Table 3-32). Cooksville Creek was the only location that supported a healthy number of mayflies and caddisflies, albeit they consisted of the most tolerant species within their respective families.

<u>% Dominance</u>
In addition to the general absence of EPT taxa, the relative abundance of more tolerant groups in a sample can help to further understand stream health (Barbour 1999). Although present in small numbers even in healthy tributaries, high relative abundances (%Dominant) greater than 40 per cent of the most tolerant groups such as scuds (amphipods), aquatic sow bugs (isopods), midges (chironomids) and aquatic worms (tubificids) can indicate impairment. All tributaries (with the exception of Lornewood Creek) fell into this category (Table 3-32). Birchwood Creek and Tecumseh Creek demonstrated especially high percent dominance values for *Amphipoda* (scuds) (79%) and *Isopoda* (aquatic sow bugs) (95%), respectively.

<u>Hilsenhoff Biotic Index (HBI)</u>
The Hilsenhoff Biotic Index (HBI; Hilsenhoff 1987) is a metric that provides an indication of organic pollution based on established taxa pollution tolerances. Values range from 1 (excellent water quality) to 10 (very poor water quality). All sampled tributaries were ranked in the categories of Fair to Poor each of which are associated with some degree of significant organic pollution. HBI scores (Table 3-32), ranged from 6.01 (Moore Creek) to 7.90 (Tecumseh Creek). Although Moore Creek had the lowest HBI score of all sites, it also had the lowest total number of organisms, which may affect its comparability to other tributaries.

<u>Diversity</u>
Diversity is another useful metric for determining stream health (Barbour 1999). Sites with Diversity scores below 1 are considered impaired, 1–3 are possibly impaired, and 3 or greater are unimpaired. No sites scored 3 or greater, signifying that all tributaries have experienced some level of impairment (Table 3-32).

Collectively these results indicate that the Lake Ontario tributaries sampled in this study are, at the very least, moderately impaired.

Table 3-32: Summary of Benthic Invertebrate Metrics for Tributary Surveys (Source: ABL 2011, and CVC unpublished data)

Coastal Reach:	**1 – Lakeview Coastal Reach**		**3 – Mineola Coastal Reach**	**5 – Lorne Park/Meadowwood Coastal Reach**						**7 – Clearview Coastal Reach**
Site Name	**Serson Creek**	**Applewood Creek**	**Cooksville Creek**	**Sheridan Creek**	**Turtle Creek**	**Birchwood Creek**	**Moore Creek**	**Lornewood Creek**	**Tecumseh Creek**	**Clearview Creek**
Date	16-Sep-11	16-Sep-11	16-Aug-11	29-Aug-11	16-Sep-11	16-Sep-11	04-Sep-13	16-Sep-11	16-Sep-11	16-Sep-11
Metrics										
Number of Individuals	2370	1028	85	1331	228	564	94	256	2990	675
% EPT*	0	7	27	10	0	3	1	5	0	0
Dominant Taxa	*Isopoda*	*Tubificidae*	*Isopoda*	*Isopoda*	*Amphipoda*	*Amphipoda*	*Chironomidae*	*Isopoda/ Amphipoda*	*Isopoda*	*Amphipoda*
% Dominant	64	44	59	75	52	79	61	38	95	44
% *Oligochaeta*	0	44	0	1	13	2	1	0	0	9
% *Chironomidae*	5	24	7	3	0	4	61	5	1	3
% *Isopoda*	64	17	59	76	20	4	0	38	95	0
% *Amphipoda*	27	7	7	10	52	79	0	38	3	44
HBI*	7.29	7.48	7.15	7.40	6.76	6.15	6.01	6.19	7.90	6.20
Diversity*	1.54	2.90	1.86	1.46	2.33	1.56	2.24	2.70	0.37	2.28

EPT* = Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies)
Diversity* = Shannon-Weiner Diversity Index
HBI* = Hilsenhoff Biotic Index

Lake Ontario

Benthic macroinvertebrate communities in lakes differ in structure and composition than those in rivers and tributaries. In the past, Lake Ontario consisted predominantly of worms and leeches (Oligochaeta), midges (Chironomidae), mussels, clams and snails (Molluscs) and scuds (Amphipoda) (Kilgour et al. 2000). Within the past decade, the proliferation of invasive Dreissena species, particularly the quagga mussel (*Dreissenidae bugensis*) and zebra mussel (*Dreissena polymorpha*), has played a key role in restructuring the benthic community (Ward and Ricciardi 2013). Because of these fundamental differences in habitat and community structure, benthic samples of lakes must be interpreted differently than the tributaries.

Nearshore benthic macroinvertebrate community composition was identified as a data gap in the Background Review as the LOISS nearshore area had not been adequately characterized in the past. To fill this gap, benthic macroinvertebrate surveys were conducted by Pollutech in the September of 2012 (Pollutech Enviroaquatics Ltd 2012). Three transects perpendicular to the shoreline were selected to overlap existing water quality transects, target bedrock substrate and provide an even distribution of CVC's jurisdiction of the Lake Ontario nearshore zone. The GE Booth transect (1 - Lakeview) was located at CVC's eastern boundary directly in front of the Lakeview Wastewater Treatment Facility. The Credit transect (4 – Port Credit) was located at the mouth of the Credit River at the centre of the study area. The Clarkson transect (6 – Refinery) was located at the western boundary of the study area directly in front of the Clarkson Wastewater Treatment Facility. All three transects consisted predominantly of bedrock substrate. Each transect consisted of 4 sample locations based on water depths of 3 m, 6 m, 10 m and 18 m. Divers used an airlift sampler equipped with 250μm mesh to collect material from a 25cm x 25cm (0.0625m2) quadrat for each sample location. Triplicate samples were collected randomly at each sample depth within 5m of each other and no less than 1m apart. Only locations not previously disturbed were sampled.

Three replicate samples were collected at depths of 3, 6, 10, and 20 meters along three transects oriented perpendicular to the shoreline at the following locations:

- 1 – Lakeview Coastal Reach: Serson Creek (GE Booth)
- 4 – Port CreditCoastal Reach: Credit River
- 6 – Refinery Coastal Reach: Avonhead/Lakeside Creeks (Clarkson)

The 17 families identified and the total number of individuals enumerated (Table 3-33) through the Pollutech study best describe this community. The dominant types collected included quagga mussels, midges, scuds, worms, and sowbugs. Other groups present in low numbers were mites (Acariformes), mayflies, beetles (*Coleoptera*) and leeches (*Hirurindea*). Although zebra mussels were once dominant in the nearshore, none were collected as part of these surveys and lake-wide research has demonstrated a near complete displacement of zebra mussels by quagga mussels (Wilson et al., 2006). Consistent with previous studies throughout Lake Ontario (Lozano et al 2001), the surveys completed by Pollutech in 2012 characterized the nearshore as having low benthic macroinvertebrate abundance and diversity.

Table 3-33: Summary of 2012 Benthic Macroinvertebrates Found at Lake Ontario Transects to Fill Data Gaps

Order	Family	Total Abundance
Veneroida	Dreissenidae	4736
Diptera	Chironomidae	1521
Amphipoda	Gammaridae	677
Haplotaxida	Tubificidae	387
Amphipoda	Hyalellidae	351
Isopoda	Asellidae	264
Haplotaxida	Naididae	92
Acariformes	Lebertiidae	49
Arhynchobdellida	Erpobdellidae	45
Amphipoda	Crangonyctidae	37
Acariformes	Hygrobatidae	23
Mysidacea	Mysidae	15
Ephemeroptera	Leptohyphidae	10
Coleoptera	Elmidae	5
Acariformes	Limnesiidae	4
Odonata	Coenagrionidae	1
Decapoda	Cambaridae	1

The benthic macroinvertebrate communities varied significantly between sample locations, with depth having the most obvious effect on community structure. Physical habitat and the dominance of quagga mussels likely influenced the observed benthic communities. Substrate generally consisted of bedrock, with varying coverage of fine silt, algae (*Cladophora*), periphyton and live/empty mussels. Certain sampling depths along the Credit and GE Booth transects were overlain by coarse substrates including cobbles and sand. Although the benthic community of Lake Ontario is similar in composition to what was found in the past, Lozano et al. (2001) reports that the overall densities of these taxon have declined since the introduction of zebra mussels and quagga mussels in the early 1990s.

Dreissena bugensis (Quagga Mussels)
The distribution and abundance of quagga mussels varied substantially among sample depths (Figure 3-42). Although mussels were found throughout all transects, they were particularly abundant at depths of 3 m. The majority of mussels at this depth were veligers (the larval form of Dreissenid mussels) in the 2 to 5 mm size range, while adult mussels made up the largest sample component by percentage at depths of 18 m.

Dreissenid mussels are very effective at filtering water by removing plankton and other food sources, thereby increasing light penetration into the water column and disrupting the food web. Dreissenid mussels are also thought to alter nutrient cycling including the nearshore phosphorus cycle by converting phosphorus to a more bio-available form, which is more readily used in the production of benthic algae (Pennuto et al. 2012). As noted in Section 3.5.1.1, under elevated chloride levels, the total phosphorus plume from the Credit River reaches deeper into Lake Ontario, increasing the availability of phosphorus further offshore potentially expanding the area of algae growth.

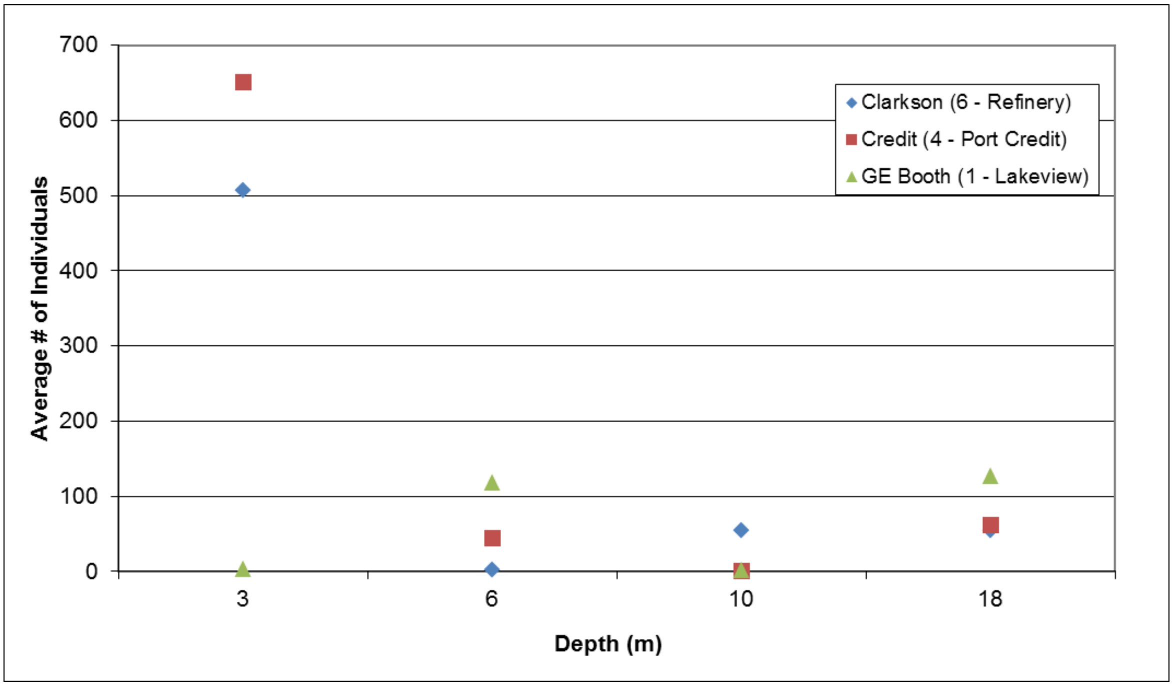


Figure 3-42: Distribution of *Dreissena bugensis* (quagga mussels) at Lake Ontario transects.

3.6.2 Synthesis of Aquatic Natural Heritage

Tributaries

The LOISS tributaries support warmwater tolerant assemblage of fish species including Blacknose Dace and Creek Chub, common species in urban streams. Lake Chub and Emerald Shiner are also routinely found in tributaries with access from Lake Ontario. No fish have been found in Avonhead Creek, Moore Creek, Cawthra Creek, Cumberland Creek, or Serson Creek.

Of the fourteen LOISS tributaries, eight support small warmwater fish communities and nine have barriers that prevent fish movement from the lake. Mitigating those barriers identified as higher potential for removal, such as Clearview Creek, Avonhead Creek, and Serson Creek, would allow recolonization by fish, increase the number of fish species to meet or exceed predicted numbers and would open access to lake fish where currently none exists. Six tributaries were found to have impacts that prevent future fish passage mitigation at their first barrier and likely limit restoration potential. Fish passage mitigation in the tributaries listed in Table 3-34 will be explored in greater detail in the final phase of the LOISS (Implementation).

Table 3-34: LOISS tributaries where aquatic habitat restoration efforts will be explored in greater detail in the next phase of LOISS (Implementation)

Coastal Reach	Tributary	Restoration Opportunity
1 – Lakeview	Applewood Creek	Culvert at Lakeshore Road
	Serson Creek	450 m piped under WWTF
3 – Mineola	Cooksville Creek	Culvert at rail tracks
5 – Lorne Park/Meadowwood	Sheridan Creek	Clarkson Road downstream of the rail tracks
	Birchwood Creek	460m piped under municipal park
	Lornewood Creek	300m piped under municipal park
6 – Refinery	Avonhead Creek	360m piped from Lake Ontario to Lakeshore Road

7 – Clearview	Clearview Creek	390m concrete lined channel from Lakeshore Road to Lake Ontario

The fish species assemblages and benthic macroinvertebrate indicators in the LOISS tributaries are typical of impacted urban tributaries. Sources of food for fish within the tributaries are not considered limited, with abundant food sources including worms, crustaceans, molluscs, algae and plants; however, the availability of some insects, such as EPT species, is limited.

In most tributaries, substrate diversity is sufficient to support and sustain tolerant fish species. In numerous cases, available habitats are not fully used because barriers reduce access from the lake and between stream reaches.

In water temperatures are suitable to support warm and coolwater fish communities in most cases. Although some stream water temperatures suggested the presence of groundwater (Table 3.3), temperatures and habitat are insufficient to support coldwater fish assemblages. Negative effects of urbanization including faster response to storm events, lower base flows during dry season, wider and shallower channel form and warmer temperatures are unsuitable to support coldwater fish species. Stanfield and Kilgour (2006) found that once percent impervious cover (an indicator of urbanization) surpasses 10% of the drainage area (approximately 50% urbanized) both fish and benthic invertebrate communities consist of warmwater pollution-tolerant species assemblage.

Fish surveys in other seasons (spring, fall) would improve understanding of fish use of the LOISS tributaries.

Lake Ontario

As a result of habitat changes, the assemblage of fish found in the nearshore open coast is dominated by warmwater transients with some coolwater lake migrant species such as Alewife and Emerald Shiner that come into the nearshore to spawn on smaller substrates and in the tributaries. In particular, the 1 – Lakeview Coastal Reach dominated by shale bedrock has the lowest average number of individuals per 1000 seconds at 33 individuals; conversely, the 6 – Refinery Coastal Reach with the presence of a cobble beach has the highest average number of individuals per 1000 seconds at 222 individuals, which is driven by the high catches of Alewife, Emerald Shiner and Lake Chub. Coldwater piscivorous fish species are noticeably less abundant in open coast habitats than other trophic guilds. Lake Ontario fish surveys have only been completed in the summer. Fish surveys in other seasons (spring, fall) would improve understanding of fish use of nearshore habitat. This is particularly true for pelagic coldwater fish that use the nearshore open coast for spawning in these seasons (e.g., Lake Trout, Lake Whitefish).

LOISS findings are consistent with research indicating that embayments are twice as productive for fish as open coast sites (Edsall and Charlton 1997). The Credit River is the largest riverine mouth/estuary in the study area. The fish assemblage in the estuary is also influenced by Credit River marshes and marine embayments resulting in this area having the highest percentage of total fish species caught. Embayments and wetlands in the nearshore support warmwater and coolwater fish communities including Large and Smallmouth Bass, Northern Pike and Yellow Perch, which is consistent with the management objectives for fish communities in Lake Ontario (Stewart et al. 2013). Thermal studies are needed to determine how the thermal dynamics of the lake affect these embayments. The thermal studies should guide restoration efforts to ensure the target fish communities or species are appropriately aligned with the thermal characteristics of the embayment (i.e., habitats should be suitable for species that are tolerant of the thermal regime).

LOISS nearshore substrates are typically fine, consisting of sand and silt overlaying bedrock, dominated by quagga mussels. Stonehooking at the turn of the century removed important rock, boulders, gravel and sand substrates from the open coast area leaving little habitat available for spawning, nursery or refuge, including habitat for the now extinct Lake Ontario population of Atlantic Salmon (Martin 2007). The loss of virtually all cobble substrates and the elimination of Lake Trout and Whitefish spawning reefs are also attributed to stonehooking (Whillans 1979, Stewart et al. 2013). Stonehooking is discussed further in Section 3.4.1.5.

Significant declines in cobble substrates in the nearshore of Lake Ontario have been linked to reductions in macroinvertebrates partly due to the loss of habitat but also because of the compounding issue of increased vulnerability to consumption by Round Goby (Wilson et al. 2006). The low abundance of macroinvertebrates collected (with the exception of quagga mussels), lack of substrate, and high abundance of Round Goby in the nearshore suggest consistency with this research. However, food sources for fish are not considered to be limited in the nearshore, as sampling identified abundant availability of crustaceans, fish, molluscs and algae in the nearshore open coast areas.

Table 3-35 identifies next steps and recommendations for Aquatic Natural Heritage.

Table 3-35: Summary of Aquatic Natural Heritage Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Potential for fish barrier mitigation (concurrent with existing public works projects)	Clearview Creek, Avonhead Creek, Sheridan Creek, Birchwood Creek, Lornewood Creek, Cooksville Creek, Serson Creek,	High	CVC
Investigate alternatives to control Common Carp in high-quality wetlands	Rattray Marsh, Credit River Marshes	High	CVC/MNRF
Seasonal fish surveys	Lake Ontario and LOISS tributaries (except Lakeside Creek, Moore Creek, Cumberland Creek)	Medium	CVC/MNRF
Thermal studies in embayments	Lakefront Promenade Park, Port Credit Marinas	Low	CVC
Restoration to improve quality and quantity of aquatic habitat	Lake Ontario nearshore, LOISS tributaries. Credit River Marshes	High	CVC

3.7 TERRESTRIAL NATURAL HERITAGE

Natural heritage systems in urban settings show consistent patterns of degradation: ecological and hydrological impacts. The ecology of natural heritage systems in urban areas are typically composed of fragmented habitats, isolated woodlands and wetlands, lower biodiversity, impacted hydrology with lowered groundwater levels and flashier surface water hydrology, and the presence of invasive species (DeFries et al 2004). Urbanization and associated microclimatic changes affect species composition; thus, as habitats simplify, the resources and competitive requirements of many wildlife species are not met (Chen, J. et al. 1999).

The LOISS study area is located at the eastern end of the Carolinian Life Zone, an area characterized by deciduous forests. In the region, forests are comprised of Sugar Maple (*Acer saccharum*), ash (Fraxinus sp.), American Beech (*Fagus grandifolia*), and oaks (*Quercus sp*.). Historically, the Lake Ontario shoreline in Mississauga was composed of a mix of natural habitats including deciduous forests, mixed forests, open savannahs and coastal wetlands. Surveyor records from the early 1800s refer to a dense forest from Burlington to Etobicoke Creek and for 'many miles northward' (Clarkson 1977). Over time, land conversion associated with agricultural operations, the expansion of burgeoning towns and the development of industry resulted in a loss of many of the natural features in the study area.

Terrestrial natural heritage data gaps (Table 3-36) identified in the Background Review pursued through the Characterization phase are summarized in the sections that follow.

Table 3-36: Status of Terrestrial Natural Heritage Data Gaps from the LOISS Background Review (ABL 2011)

Data Gap	2017 Status
Connectivity analysis	Completed
Land use (ELC) mapping	Completed
Shoreline vegetation mapping	Terrestrial Ecological Land Classification (NRSI 2009) Updated through Shoreline Structures Assessment (see Section 3.4 Coastal Processes)
Wetland evaluations	Not completed
Terrestrial and wetland community significance assessment	Significant Wildlife Habitat Assessment partially completed
Migratory Waterfowl staging/stopover areas survey	Completed
Migratory Shorebird stopover inventory	Completed
Migrant Landbird stopover inventory	Completed
Migratory bat stopover inventory	Completed
Butterfly and odonate inventory	Initiated
Turtle surveys at Rattray Marsh and Credit River Marshes	Completed
Amphibian inventory	Initiated
Invasive species surveys along the shoreline	Completed on a site-by-site basis

Coyote (*Canis latrans*) tracking was conducted by MNRF in 2013 in addition to the identified data gaps. The findings from this work have been included in this section.

3.7.1 Characteristics

As shown in the following breakdown, the study area is now dominated by residential, industrial and institutional land uses with only 22% remaining in natural and cultural cover (ABL 2011):

- Residential: 45%
- Commercial: 17%
- Open space: 10%
- Woodland: 9%
- Cultural meadow: 6%
- Cultural woodland: 4%
- Other: 3%
- Aquatic: 2%
- Cultural savannah: 1%
- Cultural thicket: 1%
- Wetland: 1%
- Agriculture: 1%

The City of Mississauga completed a Natural Heritage and Urban Forestry Strategy in 2014 (City of Mississauga 2014)[7]. This strategy identifies the natural heritage system as one component of their green system, which also includes the urban forest, natural hazard lands and parks and open space, as well as other green infrastructure. The City of Mississauga's defined natural heritage system specifically includes: untreed wetlands, meadows, watercourses, untreed valleys, wooded natural areas, residential woodlands, and wooded natural areas on the Lake Ontario shoreline covering a total of 9.5% of the City area. In this context, the natural areas within the LOISS study area may be important contributors to the City's overall natural heritage system coverage.

3.7.1.1 Connectivity

CVC developed a Landscape Scale Analysis (LSA) (CVC 2012a) for the City of Mississauga to assess the abilities of the natural and semi-natural area within the City to provide ecosystem functions. Important in-situ and connectivity/linkage functions were identified. Linkages are also identified in the City of Mississauga's Natural Heritage and Urban Forestry Strategy (City of Mississauga 2014). Aerial photographic interpretation was completed for the LOISS Study Area to identify potential local linkages (Figure 3-43) at a finer scale. This analysis was primarily a GIS exercise based on proximity of natural and semi-natural habitat and did not consider the presence of on-the-ground barriers such as fences, roads and crossings/culverts. Since connectivity for birds may be different from fish and plants etc., the analysis was not based on a single species, guild or group.

Generally, areas west of the Credit River are fairly well connected through natural and open spaces and vegetated corridors. This is largely due to the concentration of municipal parks and Rattray Marsh Conservation Area, as well as large parcels of industrial land with open manicured or semi-natural areas. East of the Credit River,

[7]The City of Mississauga has a number of reports and studies that provide additional details and direction regarding management of public spaces including (but not limted to): The Waterfront Parks Strategy, Invasive Species Plan and Credit River Parks Strategy. These reports are compatible with the objectives of LOISS and will be incorporated into the Implementation phase.

public spaces are small and not well connected, separated by small residential parcels.

The strongest linkages are in the north-south direction, following stream corridors. Because Lakeshore Road and the CN Rail Line bisect the City of Mississauga, they create a partial or, in some areas, full barrier to north-south migration for some terrestrial wildlife. Similarly, east-west linkages are predominantly located along the Lake Ontario shoreline, although the Hydro One Right of Way that crosses the study area in the 4 – Port Credit and 5 – Lorne Park/Meadowwood Coastal Reaches may be used as a corridor linking the smaller tributaries to the Credit River. Confirmation of the latter would require more detailed studies. Development at the mouth of the Credit River and other obstacles at various points (e.g., fencing) within the study area negatively affect both north-south and east-west linkages on the east and west banks.

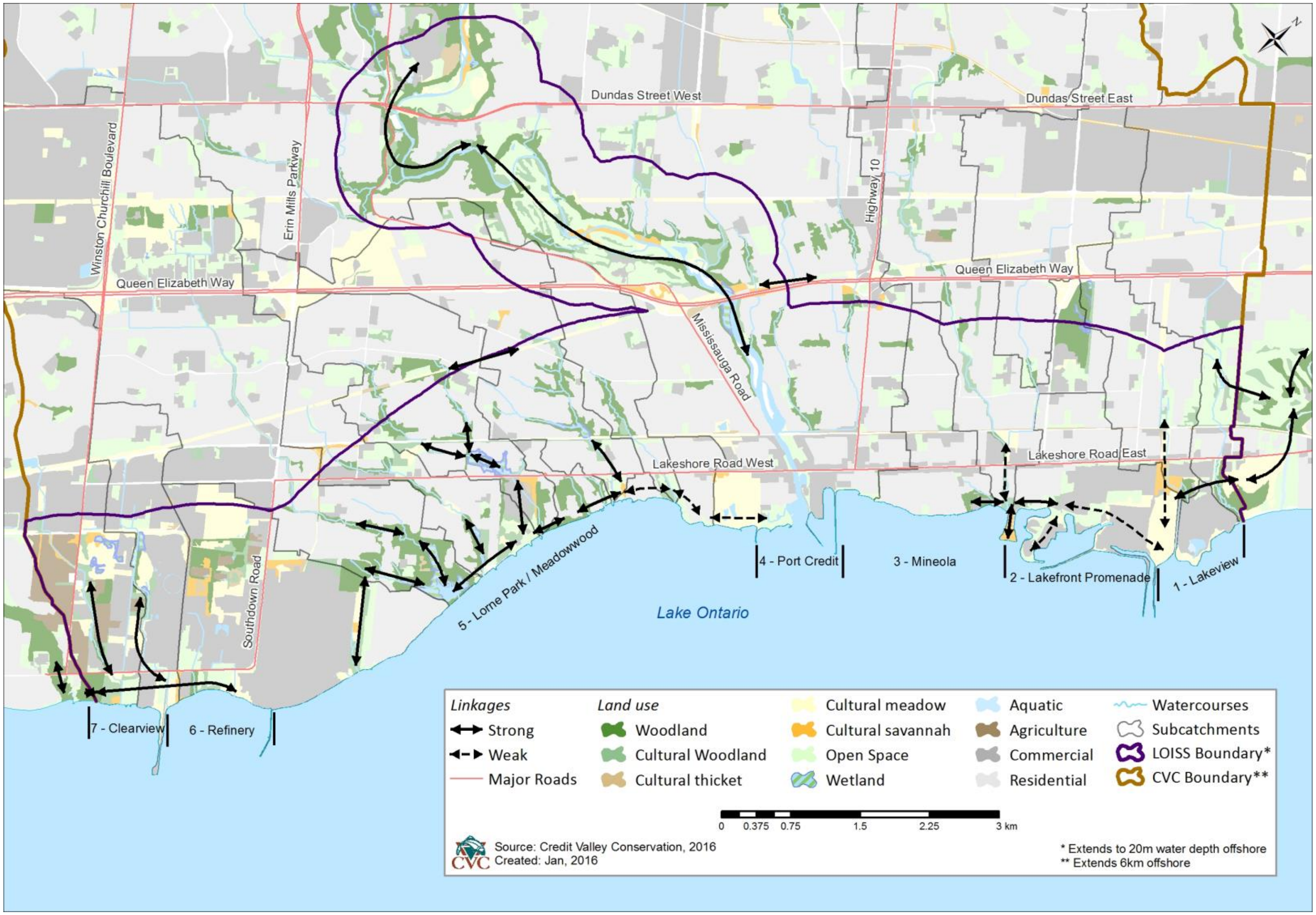


Figure 3-43: Terrestrial Connectivity analysis: local linkages.

3.7.1.2 Wetlands

Wetlands in the study area consist of marshes and swamps, with Rattray Marsh Wetland Complex and the Credit River Marshes Wetland Complex being the largest wetlands in the study area. Historically, a cranberry marsh was present at the mouth of Tecumseh Creek in 5 – Lorne Park/Meadowwood Coastal Reach (Clarkson 1977). Both the Rattray Marsh Complex and the Credit River Marshes have been designated as two of only eleven Centres for Biodiversity (CFB) in CVC's jurisdiction. CFBs represent clusters of natural heritage features and functions, and relatively high biodiversity landscapes.

All wetlands within two kilometers of Lake Ontario "1:100 year floodline (plus wave run-up)" on streams that flow into the lake are considered coastal wetlands due to their periodic influence by the lake (MNR 2010). Of particular interest is the influence of changing lake levels on coastal wetlands. Lake levels can influence hydrology as well as fish and wildlife access and vegetation growth. Higher variability in lake levels translates to increased vegetation biodiversity in coastal wetlands (Ciborowski et al. 2009) due to variable wetting and drying of sediment that creates suitable conditions to support a wide range of moisture tolerances. It is anticipated that Plan 2014 (IJC 2014), the regulation of water levels on Lake Ontario, will allow for more natural variations in levels to provide enhanced conditions for coastal wetlands (i.e., more frequent occurrence of very wet and very dry conditions) (see Section 3.4.1.1).

In Ontario, wetlands are evaluated to determine their provincial significance using the Ontario Wetland Evaluation System. The provincial evaluation determines wetland significance in terms of hydrologic function, habitat quality and socioeconomic value. In the LOISS study area, wetland evaluations are completed using the Ontario Wetland Evaluation System Southern Manual (MNRF 2014).

As noted in Section 3.6.1.1, several unevaluated coastal wetlands have been identified in the study area. CVC Ecologists completed surveys for some of these wetlands between 2012 and 2014. These wetlands are identified as "CVC Evaluated Wetlands" in Figure 3-44. Some wetlands in the study area have been identified but surveys have not yet been completed. These wetlands are identified as "CVC Field Confirmed Wetlands" on Figure 3-44. The locations and boundaries of all wetlands identified by CVC have been mapped (Figure 3-44) and are included in CVC's natural heritage mapping. Planning policy protections for wetlands are dependent on the degree of significance (provincial, local) of the wetland. CVC regulations (Ontario Regulation 160/06) take into consideration all wetlands under the Conservation Authorities Act (Section 28, R.S.O 1990).

3.7.1.3 Migratory Bird staging and stopover area surveys

The Lake Ontario shoreline serves an important role as 'stopover' habitat for a range of migratory species including bats, birds and invertebrates (e.g. odonates and lepidopterans). In a landscape scale assessment, the Iroquois Plain (includes the lowland area along the western and northern coast of Lake Ontario) was found to be one of the most important regions in Ontario for landbirds, waterfowl and shorebirds during migration (Environment and Climate Change Canada 2017).

Migratory birds are valuable indicators of ecosystem health, as they have a diversity of habitat requirements. Bonter et al. (2008) found a strong correlation between migratory bird concentrations and proximity to water and suggested that large bodies of water may act as temporary barriers to migration, resulting in concentrations in these nearshore habitats. Bonter et al. (2008) also suggested that migratory birds may use tributaries and large waterbodies as landmarks to assist in navigation, leading to concentrations in both riverine and lacustrine riparian areas.

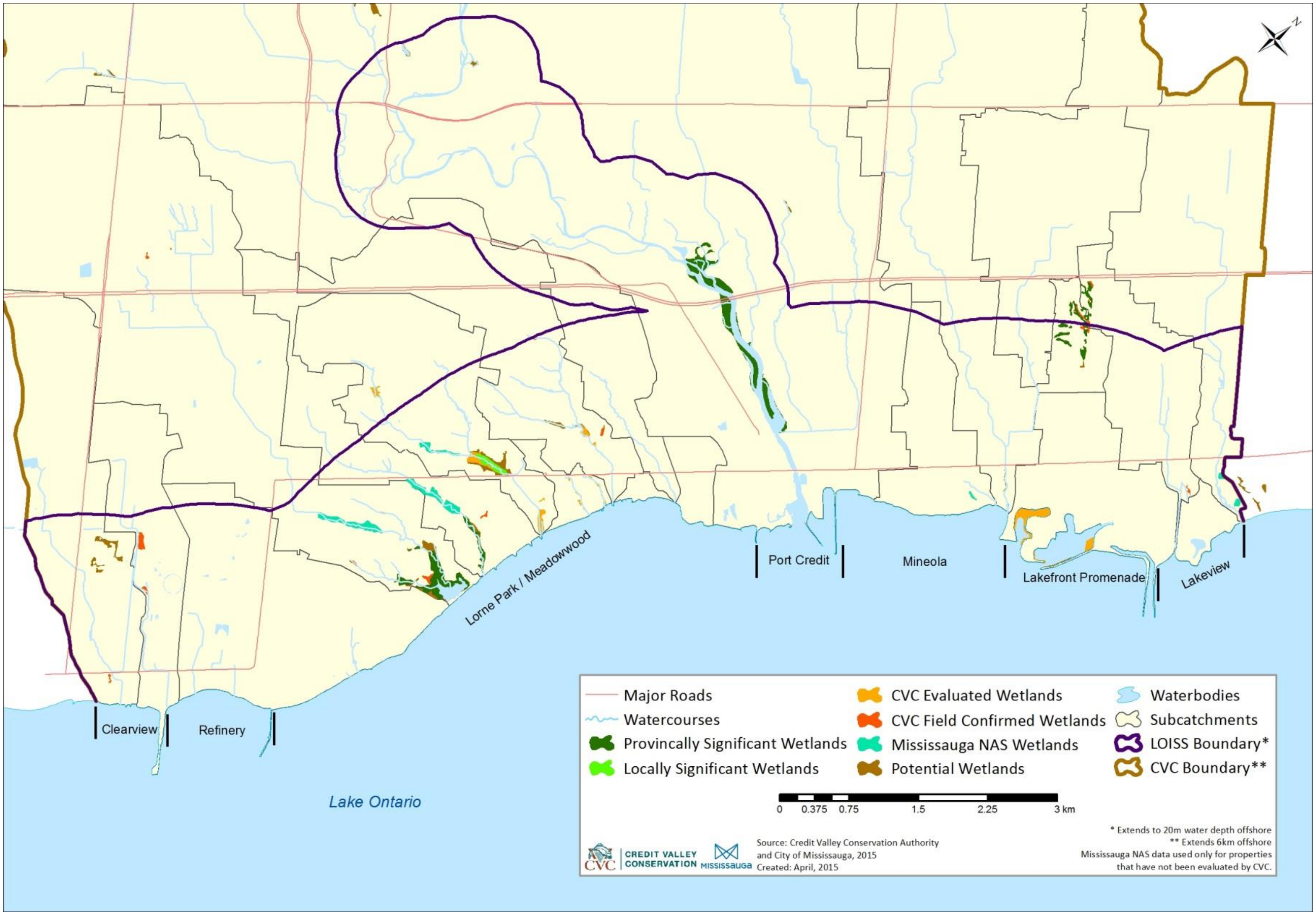


Figure 3-44: Evaluated and identified coastal wetlands.

This relationship is illustrated in satellite imagery (Figure 3-45) of the western basin of Lake Ontario, which demonstrates the take-off and landing of migratory birds from Buffalo, New York to the north shore of Lake Ontario over a 10-hour period. The yellow and red colours on the radar image indicate that birds are moving away from the radar, while the blue and green colours indicate that birds are moving toward the radar. Bonter et al. (2008) and Ewert et al. (2006) suggested that the concentrations of migratory species may be linked to food resources in these nearshore habitats and that landbirds may be concentrated within 0.4 km of the shoreline, where aquatic insect diversity is greatest. Ewert et al. (2006) summarized common stopover site attributes for birds ranging from high aquatic insect productivity to proximity to the Great Lakes.

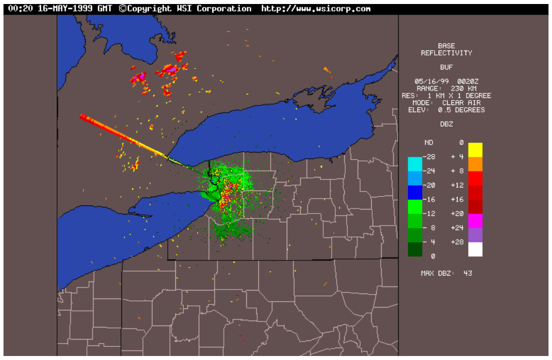
Presence surveys for migratory birds were completed by CVC along the shoreline to address the data gap identified during the Background Review (Table 3.35). Surveys were initiated to confirm habitat use by migratory species and provide a qualitative assessment of relative abundance in order to guide future monitoring. The Province of Ontario has since identified standard evaluation methodologies for some target groups (i.e., landbirds) that will provide consistency in survey effort to allow for additional ecological parameters to be assessed (i.e., year-over-year trends, comparison of significance). However, the surveys illustrate whether the sites are being used by particular species during migration, which is a parameter not previously studied. The Shannon-Wiener Diversity Index was used to compare diversity of migratory landbirds, waterfowl, and shorebirds between sites (Figures 3-46 to 3-48). The Shannon-Wiener Diversity Index (H) represents the number of species in the community and the number of individuals of each species. Higher H values are indicative of higher species diversity and more even distribution of individuals of each species. Lower H values indicate lower number of species or an uneven distribution of individuals of each species. Data collected through these surveys is summarized in Appendix C.

Migratory Landbirds

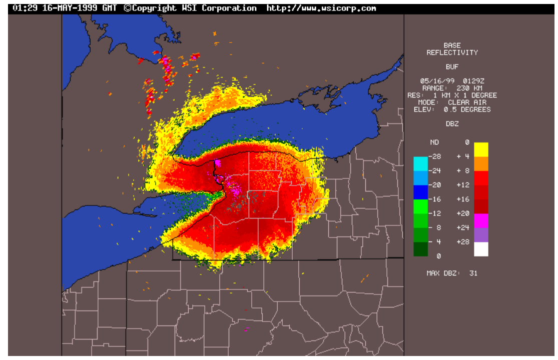
Migratory landbirds selectively forage on different plant and insect species; protein consumption is of particular importance in the spring for developing eggs and the young (Ewert et al. 2006), while lipids and carbohydrates, generally associated with the need for fruit consumption, are of greater importance in the fall to maximize fat deposits. Spring migrants show no particular preference for quality, size (Bonter et al. 2008) or surrounding landscape when they rest; small woodlands that provide food and protection from predators will suffice. Bonter et al. (2008) also found a positive correlation between urban/residential areas and concentrations of migratory landbirds; however, they speculated that this may be less about preference and more because many urban areas are located close to the Great Lakes. Fall migrant abundance is correlated with early successional forests containing high densities of fruiting shrubs and trees (Packett and Dunning 2009; Smith et al. 2007).

CVC conducted presence surveys for migratory land birds in spring (May, June) and fall (September, October, November) migration in 2012 and 2013 at 11 publicly accessible locations and private properties where permission was granted on the Mississauga shoreline of Lake Ontario. Data from these surveys is summarized in Appendix C. The diversity of migratory landbird species for surveys conducted in this time period was highest at Lakeside Park (6 - Refinery Coastal Reach), Watersedge Park, Rattray Marsh, Lorne Park Estates (5 - Lorne Park/Meadowwood Coastal Reach), and Marie Curtis Park (1 - Lakeview Coastal Reach). The number of individuals of each species at these locations was relatively evenly distributed as indicated by the Shannon Wiener Diversity Index (Figure 3-46).

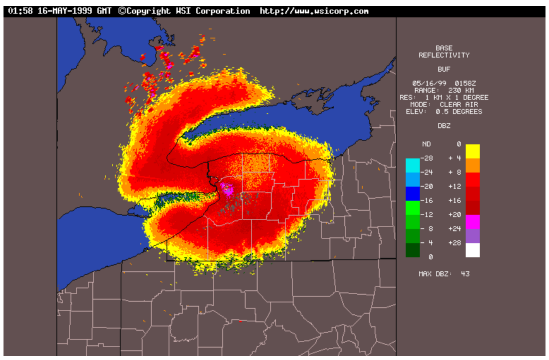
Rattray Marsh has a high diversity of habitat types, including many wetland habitats and larger forested areas that are less frequently disturbed by people, which may explain the higher number of migratory landbird species and diversity. Red Winged Blackbird (*Agelaius phoeniceus*) was the most abundant migratory landbird species recorded in the study area overall, almost double the next most abundant species, American Robin (*Turdus migratorius*).



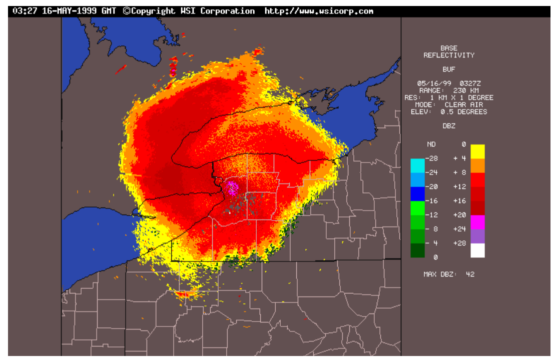
2020 hours



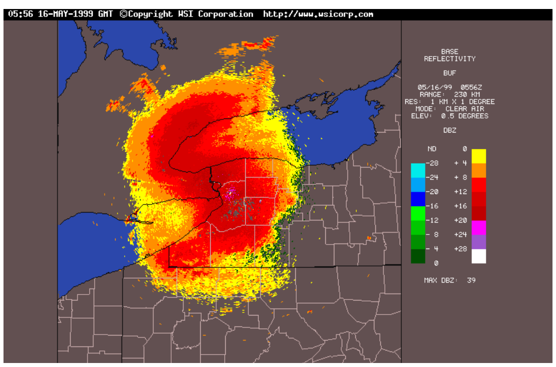
2129 hours (take off)



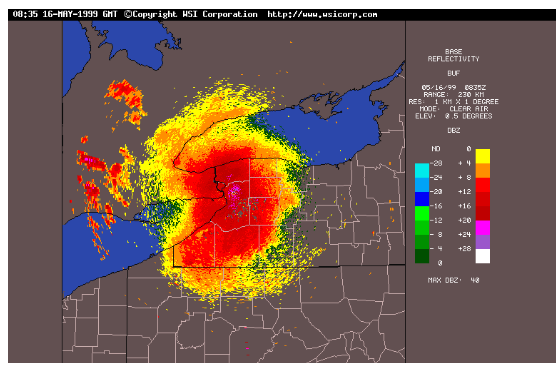
2158 hours



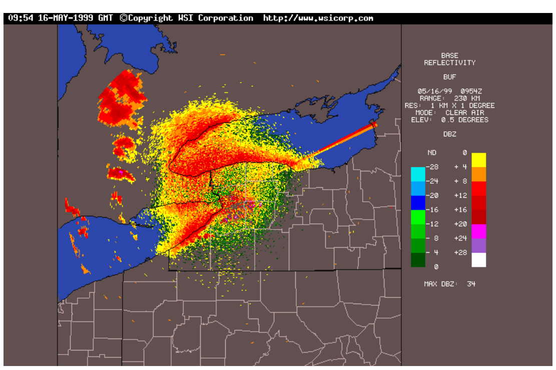
2327 hours



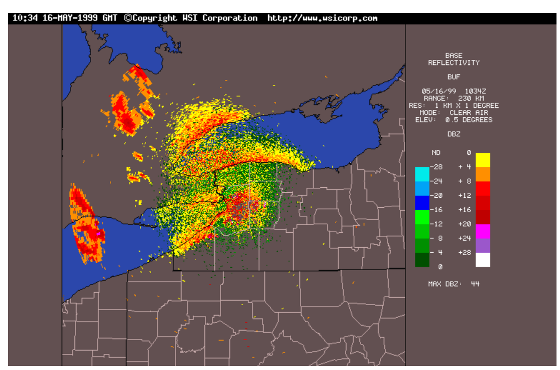
0156 hours



0435 hours



0554 hours



0634 hours

Figure 3-45: Radar image of birds taking off (2129 hours) and landing (0634 hours) along shorelines of Lake Ontario and Lake Erie. Red and yellow indicate birds moving away from the radar. Blue and green indicate birds moving toward the radar. (Source: The Weather Company).

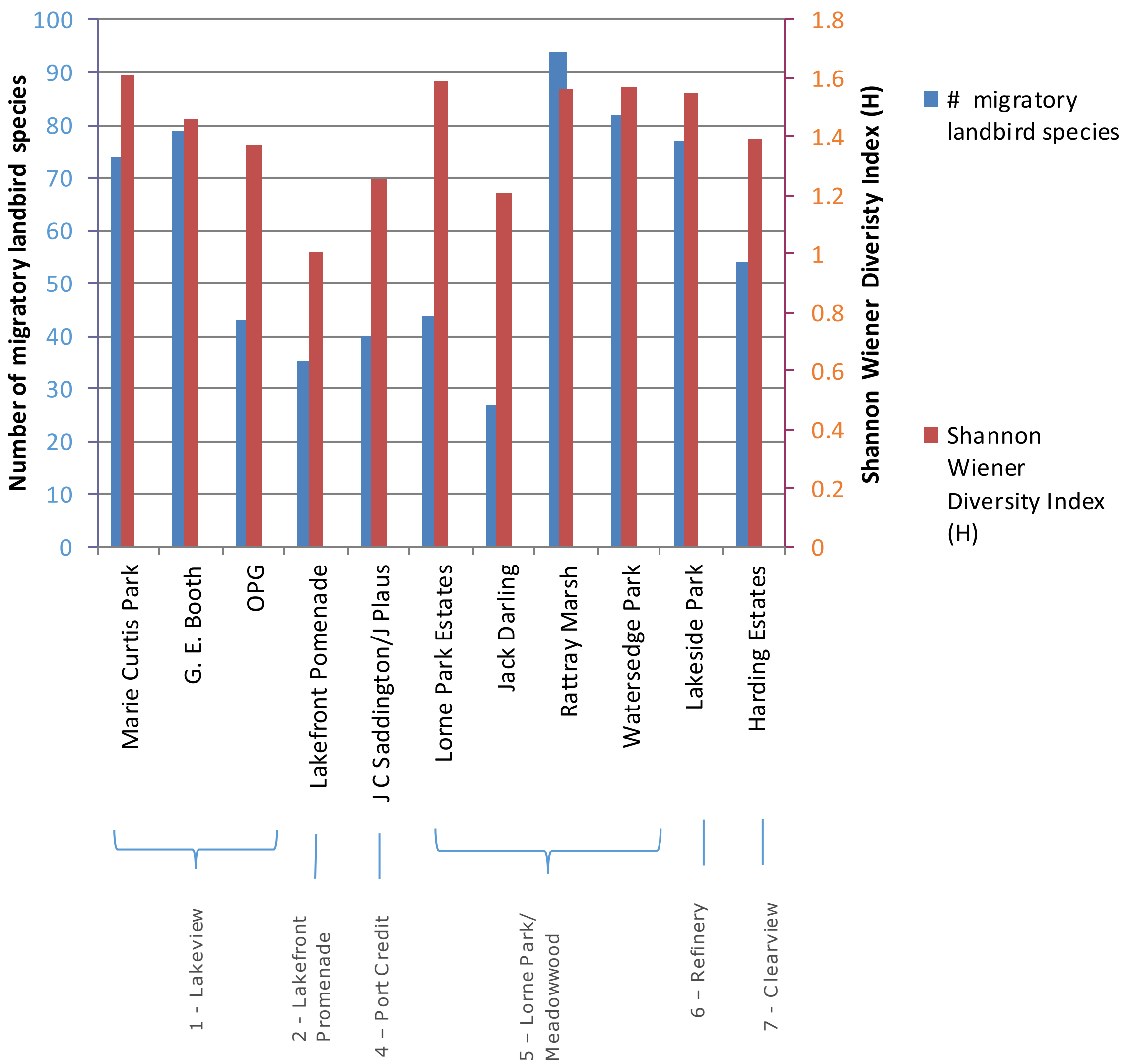


Figure 3-46: Diversity index of migratory landbirds for presence surveys conducted in 2012 and 2013.

Waterfowl

Lake Ontario west from Port Credit on the north shore to the mouth of the Niagara River on the south shore, and bounded on the west by Burlington Bar is designated as a globally significant Important Bird Area based on congregations of waterfowl.

During the narrow window of spring migration waterfowl flock in small groups and rest in small, often temporary, wetlands where insects are abundant. Typically, in the fall, waterfowl flock in larger groups, rest in larger permanent water bodies and feed on aquatic vegetation.

CVC completed presence surveys for waterfowl in spring (April, May) and fall (late August, September, October) and winter (November, December) from 2008 to 2012 at 10 publicly accessible locations and private properties where permission was granted on the Mississauga shoreline of Lake Ontario. Data from these surveys is summarized in Appendix C. Smaller groups of waterfowl were recorded in the spring (60 visits, average of 44 waterfowl per visit) than in the fall (136 visits, average 56 waterfowl per visit) and winter (45 visits, average of 53 waterfowl per visit) but not significantly so.

The diversity of waterfowl was highest at Marie Curtis Park, G.E. Booth WWTF, Rattray Marsh, and Harding Estates (Figure 3-47). Notably, Rattray Marsh (5 - Lorne Park/Meadowwood Coastal Reach) and G.E. Booth WWTF (1 - Lakeview Coastal Reach) recorded both high diversity (high number of species and even distribution of individuals for each species) and high numbers of species. While the diversity at G.E. Booth WWTF was on par with Marie Curtis Park and Rattray Marsh, the number of species recorded at G.E. Booth WWTF is highest of all the sites. This indicates that GE Booth has more species that are well represented (higher number of individuals per species) than the other locations. Credit River Marshes (4 – Port Credit Coastal Reach) shows the lowest number of species as well as the lowest diversity. This is in part due to low sampling effort at Credit River Marshes. It should be noted that both Mallards and Canada geese dominated the community composition (over 5000 individuals of each species recorded in the study area) in most locations followed by Bufflehead (*Bucephala albeola*) and Gadwall (*Anas strepera*) (approximately 900 of each species recorded in the study area). Canada Geese are monitored and managed at public beaches along the shoreline by the City of Mississauga due to their high abundance and devastating impact on water quality (due to fecal deposits) and shoreline habitats and park spaces (due to grazing).

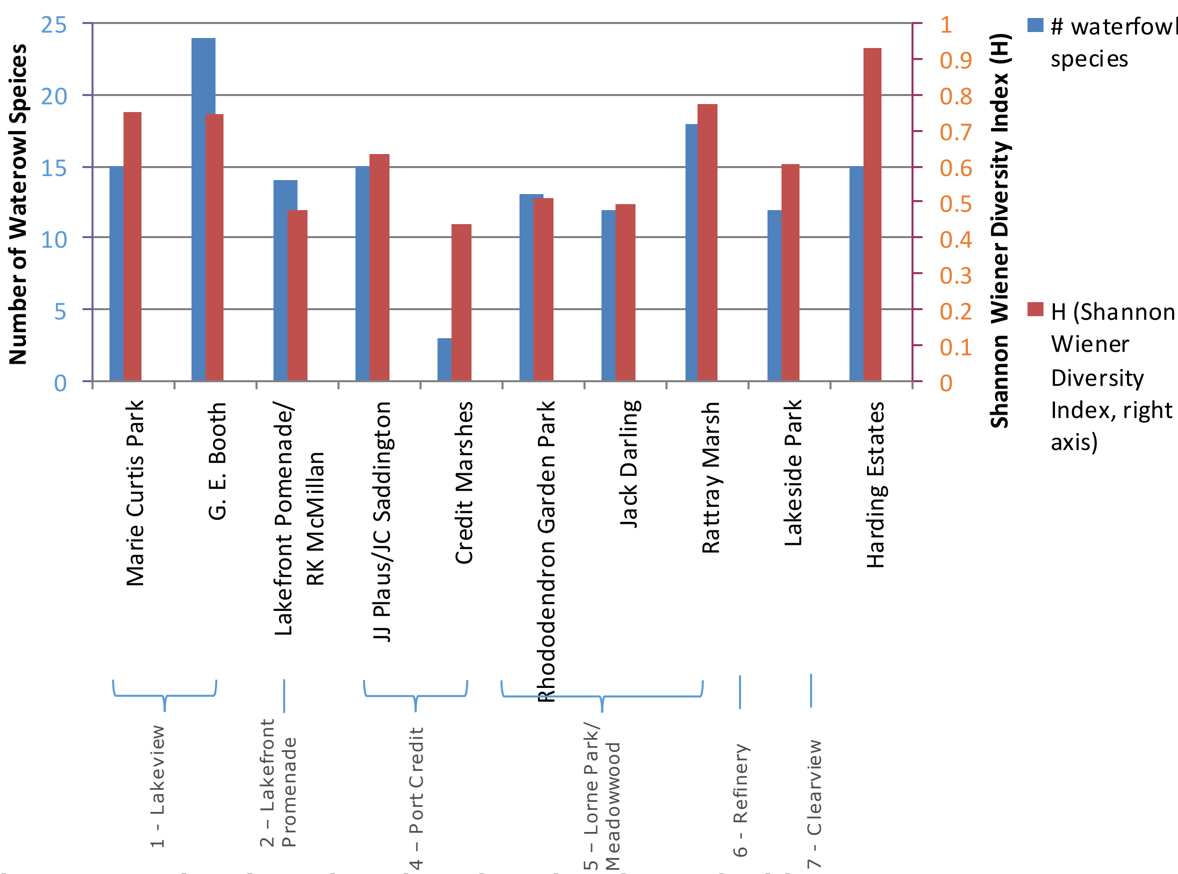


Figure 3-47: Diversity and number of species of waterfowl for presence surveys conducted from 2008 to 2012.

Shorebirds

Shorebird presence surveys were conducted by CVC in spring (April, May, June) summer (July, August) and fall (September, October, November) from 2008 to 2012 at 5 publicly accessible locations on the Mississauga shoreline of Lake Ontario. Data from this sampling is summarized in Appendix C. A total of 16 shorebird species (e.g., plovers (*Charadrius sp*.), sandpipers (*Calidris sp.*), yellowlegs (*Trainga sp*), etc.) were recorded at survey sites along the shoreline, with Rattray Marsh (5 - Lorne Park/Meadowwood Coastal Reach) and G.E. Booth WWTF (1 - Lakeview Coastal Reach) showing the highest number of species and the highest diversity among the sites surveyed (Figure 3-48). Fewer areas of suitable shorebird habitat occur along the shoreline than landbirds and waterfowl. This is in part due to shoreline hardening but also because of the prevalence of sand beaches over preferable mud flats in most natural shoreline areas. Mud flats are present in Rattray Marsh (under lower flow conditions at the mouth of Sheridan Creek) and in the ash lagoons at G.E Boothn WWTF. Killdeer (*Charadrius vociferous*) and Least Sandpiper (*Calidris minutilla*) were the most abundant species at both Rattray Marsh and G.E. Booth WWTF. All species recorded in these surveys are common in Southern Ontario.

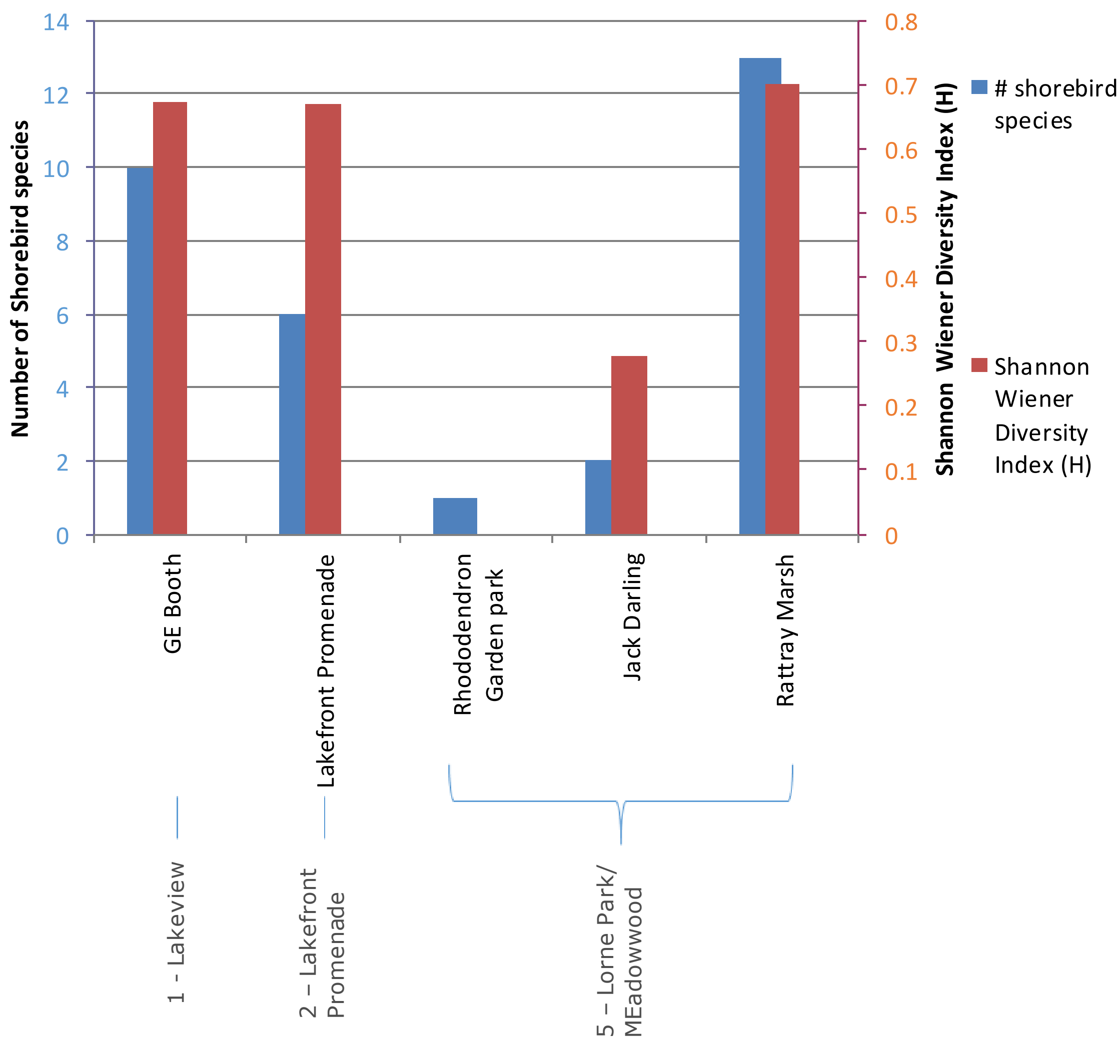


Figure 3-48: Number of species and diversity of shorebirds for presence surveys conducted from 2008 to 2012.

3.7.1.4 Butterflies and Odonates

Butterflies and odonates (dragonflies and damselflies) play an important role as both pollinators and prey in the Lake Ontario shoreline ecosystem. Butterflies and some dragonflies migrate in the spring and fall using shorelines of the Great Lakes as resting (roosting) and feeding (refuelling) grounds along their journey. Those migratory species that stay along the shoreline for the summer and those that do not migrate use the area wetlands to reproduce, with their offspring hatching out in June.

Butterflies

Shoreline areas are recognized as important areas for migratory butterfly stopover and staging. Lake shorelines, forests, fields and undisturbed open lands within 5km of Lake Ontario provide opportunities for butterflies to feed, rest and/or wait for ideal weather conditions prior to making the long flight over Lake Ontario. There are eight species of migratory butterflies recognized in the CVC jurisdiction:

Fiery skipper	*Hylephila phyleus*
Orange sulphur	*Colias eurytheme*
Monarch	*Danaus plexippus*
American lady	*Vanessa virginiensis*
Painted lady	*Vanessa cardui*
Red admiral	*Vanessa atalanta*
Question mark	*Polygonia interrogationis*
Common buckeye	*Junonia coenia*

Preliminary work by CVC and its consultants aimed to identify potential migratory butterfly habitat within the LOISS study area, evaluate suitability on-the-ground, and to undertake initial butterfly surveys to confirm presence. In 2008, Natural Resource Solutions Inc. identified four potential locations along the shoreline with low to high potential for butterfly habitat: Harding Estates, JJ Plaus, JC Saddington Park, and Marie Curtis Park (and Arsenal Lands) (Natural Resource Solution Inc. 2009).

Following up on the 2008 scoping work, William McIlveen (independent ecology consultant) conducted butterfly and odonate surveys in the LOISS study area in 2009 and 2010 on CVC's behalf (McIlveen 2009, 2010). No standard protocol exists for conducting migratory butterfly surveys for the suite of species listed above; however, a typical transect-walk survey methodology to assess presence and abundance was employed. Depending on the level of effort (time spent on a site, number of visits, number of observers) results can vary. The surveys were completed in the spring (May to June), fall (mid-August to end of October) and early winter (early November) at 19 locations (Table 3-37).

Table 3-37: Butterfly and Odonate survey locations

Location	Coastal Reach
Marie Curtis Park	1 - Lakeview
Cawthra woods	2 - Lakefront Promenade
Douglas Kennedy Headland	2 - Lakefront Promenade
RK McMillan Headland	2 - Lakefront Promenade
Lakefront Promenade	2 - Lakefront Promenade
Adamson Estates	3 - Mineola
Cooksville Creek (mouth)	3 - Mineola
Hiawatha Park	3 - Mineola
Tall Oaks Park	3 - Mineola

Location	Coastal Reach
Erindale Park	4 - Port Credit
JC Saddington Park	4 - Port Credit
Port Credit	4 - Port Credit
Jack Darling Park	5 - Lorne Park/Meadowwood
Brueckner Rhododendron Gardens	5 - Lorne Park/Meadowwood
Rattray Marsh	5 - Lorne Park/Meadowwood
Springbank Meadows Park	5 - Lorne Park/Meadowwood
Watersedge Park	5 - Lorne Park/Meadowwood
Lakeside Park	6 - Refinery
Harding Estates	7 - Clearview

These surveys were the first of their kind undertaken in the Mississauga area. Consequently, little can be concluded with respect to how typical the observations were in terms of presence and abundance. Results and observations from these studies are sumamrized in Appendix C, Table C2, and concluded:

- Migratory butterflies are present within the LOISS study area.
- Migratory butterflies were generally flying in a southwesterly direction, which is consistent with patterns in the GTA.
- Sites containing large, old-field meadow habitat with flowering plants during the migration season were found to be the most productive in terms of abundance.
- Two additional sites were identified as high potential: Arsenal Lands and the Port Credit Village Partners (formerly Imperial Oil) lands in Port Credit.

In 2015 CVC began work on standardizing survey protocols for migratory butterflies within its watershed. This will allow for future data to be comparable and to identify year-over-year trends when applied consistently across a study area. Work in 2015 also included using this protocol to survey three sites within the LOISS study area: Marie Curtis Park (including Arsenal lands), J.C. Saddington (including the waterfront trail adjacent the Port Credit Village Partners lands), and Harding Estates.

Odonates
McIlveen (2009) indicated that within the Region of Peel (and York Region) 13 species of migratory dragonfly species are known to occur. It is presumed that migratory species will generally make migratory flights in a southerly direction. This will bring migrating dragonflies to the shore of Lake Ontario. McIlveen conducted surveys for CVC in 2009 and 2010 at various sites along the lakeshore as reported above and observed three species of dragonfly that are considered to be migratory: Black Saddlebags (*Tramea lacerate*), Common Green Darner (*Anax junius*), and Twelve-spotted Skimmer (*Libellula pulchella*).

The results of these surveys are sumamrized in **Appendx C, Table C2**, and indicate:

- Common Green Darner was the most abundant migratory dragonfly species observed. The highest abundance was in the wetland areas at Cawthra Woods (2010) and Lakeside Park (2009). Inland sites like Cawthra Woods suggests that this species might not necessarily be restricting its movements to sites adjacent Lake Ontario

- Although numbers of Black Saddlebags were low across the study area, the highest abundance of Black Saddlebags was associated with Lake Ontario sites RK McMillan Park and Tall Oaks Park.
- There were two sightings of Twelve-spotted Skimmer. These were observations of single dragonflies at Harding Estates (Joshua Creek, west of CVC's jurisdiction) and at Rattray Marsh, although it is likely under reported.

3.7.1.5 Mammals

The majority of mammals known to be in the study area, including bats, mice, squirrels, Racoon (*Procyon lotor*), White-tailed Deer (*Odocoileus virginianus*), Beaver (*Castor canadensis*), Muskrat (*Ondatra zibethicus*) and Coyote are relatively resilient to the stresses and pressures experienced in urban areas. Targeted bat surveys were completed in the LOISS study area in 2009. Targeted surveys for other mammals have not been undertaken. Notes on mammals other than bats are based on incidental sightings and knowledge of the area.

Bats

Bats migrate and are assumed to use the shoreline as stopover habitat, similar to migratory birds, and provide a good link between aquatic and terrestrial habitats. In some areas of the shoreline bats may also establish hibernacula or maternity colonies. These habitats (hibernacula and maternity colonies) are considered Significant Wildlife Habitat and are afforded protected under provincial legislation (MMAH 2014) (Section 3.7.1.7). Some bats in Ontario are in decline and are designated Species at Risk.

Acoustic bat surveys were conducted at one location within the LOISS study area in 2009 and three additional locations in 2010 and 2011. The surveys aimed to document the presence of bats in the area and if they are using the area for feeding. Of eight bat species known to occur in Ontario, seven were recorded in the study area (Table 3-38): Big Brown (*Eptesicus fuscus*), Silver-haired (*Lasionycteris noctivagans*), Eastern Red (*Lasiurus borealis*), Hoary (*Lasiurus cinereus*), Little-brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*) and Tri-coloured (*Perimyotis subflavous*) bats. The last three are designated as Endangered in Ontario.

Little Brown Bat, the most common species in Ontario, was found in all areas monitored along the shoreline. Big Brown and Hoary bats are well adapted to urban environments and tend to forage in more open areas including over open water, possibly because of their larger wingspans. Bats are obligate insectivores and are known to forage along forest edges and canopies and over waterbodies; as such, their foraging patterns are similar to other aerial insectivores. Oprea et al. (2009) found that overall the amount of vegetation is a key determinant in use of corridors by bats and that in urban environments, bat activity is closely linked to matrix quality. The presence of all seven species in Rattray Marsh may be attributed to a combination of the marsh, open water and associated insects.

Table 3-38: Bat species occurrence in four surveyed locations in the LOISS Study Area 2009 - 2011

Coastal Reach	Location/ Species	Big Brown	Silver-haired	Eastern red	Hoary	Little-brown Myotis	Northern Myotis	Tri-coloured
1 – Lakeview[1]	GE Booth	√	√		√	√	√	√
5 – Lorne Park/Meadowwood[1]	Lorne Park Estates				√	√	√	
5 – Lorne Park/Meadowwood[2]	Rattray Marsh	√	√	√	√	√	√	√
6 – Refinery[1]	CRH Canada Inc	√	√	√	√	√	√	

[1] A. Adams. 2012. Bat Activity in the Credit Valley Jurisdiction. University of Western Ontario.
[2] F. Reid. 2007. Acoustic Bat Monitoring Report. Credit River Watershed

Deer

At the request of the City of Mississauga, North-South Environmental Inc. undertook a study in 2001 to identify significant wildlife issues in the Credit Valley to support future identification of Significant Wildlife Habitat relating to provincial policy (North-South Environmental Inc. 2001). The study included:

- Identification of significant wildlife species in the Credit River valley,
- Maps of wildlife habitat, and
- Identification of significant issues related to wildlife habitat and management.

The Credit Valley Wildlife Study noted abundant signs of deer north of the QEW. Although radio-telemetry surveys are needed to determine home ranges for deer, three distinct herds are thought to persist in the Credit Valley in Mississauga between the QEW and Eglinton Ave (North-South Environmental Inc. 2001). A similar analysis has not been conducted for the lakeshore; however, White-tailed Deer have been observed at the following locations:

- 1 - Lakeview Coastal Reach: Marie Curtis Park and G.E. Booth WWTF
- 4 - Port Credit Coastal Reach: Credit River Marshes
- 5 - Lorne Park/Meadowwood Coastal Reach: Rattray Marsh
- 6 - Refinery Coastal Reach: PetroCan Lubricants, Watersedge Park
- 7 - Clearview Coastal Reach: Harding Estates

These incidental sightings, along with aerial photography interpretation, suggest that deer potentially move between Joshua's Creek to the west of Study Area and Rattray Marsh, Credit River Marshes and areas within the Credit River Valley north of the marshes, and Marie Curtis Park and G.E. Booth WWTF. The City of Mississauga's Natural Areas Survey (North-South Environmental Inc. 2012) data contains records of White-tailed Deer at Jack Darling Park and within the stream corridors of Birchwood Creek, Lornewood Creek and Tecumseh Creek, upstream of Lakeshore Road. Although deer have not been recorded in the area, it is likely that passage exists between Rattray Marsh and Tecumseh Creek, and Adamson Estate and G.E. Booth WWTF based on aerial photograph interpretation.

Coyote
MNRF tracked four radio-collared female Coyotes between January 1 and 18, 2013 in Mississauga. The variability in habitat range of the tracked animals demonstrates the ability of Coyotes to move within an urban centre (confined to small local areas (i.e. golf course) and travelling over many kilometres from the Lake Ontario shoreline to Pearson International Airport area).

In general, top predators decline in urban areas due to habitat fragmentation, reduced habitat size and disturbance by humans. One of the few urban top predators, the coyote, may hunt deer in the winter when deer mobility is compromised in the deep snow but it is more apt to hunt smaller, more easily captured prey. The reduction in top predators leaves a niche for mesopredators, particularly generalist omnivores (e.g., Raccoon (*Procyon lotor*) that take advantage of human-generated food sources (e.g., garbage and cultivated foods) (Gehrt et al. 2010)

3.7.1.6 Reptiles and Amphibians

Various amphibian and reptile surveys were completed by CVC in the study area during spring of 2009 to 2012 at ten locations (Table 3-39) where habitat with the potential to support reptiles and amphibians was identified within the LOISS study area.

Table 3-39: Reptile and Amphibian survey locations

Location	Amphibian Surveys	Reptile Surveys	Coastal Reach
Marie Curtis Park	✓		1 - Lakeview
Cawthra Woods	✓		2 - Lakefront Promenade
Adamson Estate	✓		3 - Mineola
Credit River Marshes	✓	✓	4 - Port Credit
Turtle Creek Marsh	✓		5 - Lorne Park/Meadowwood
Rattray Marsh	✓	✓	5 - Lorne Park/Meadowwood
Watersedge/Meadowwood Park	✓		5 - Lorne Park/Meadowwood
Lakeside Park	✓		6 - Refinery
Harding Estates	✓		7 - Clearview

Rattray Marsh and the Credit River Marshes were the focus of reptile surveys in 2011. These locations were chosen based on suitable habitat being present and incidental observations of turtles. Results of these reptile surveys are summarized in Appendix C, table C4.

Amphibian survey sites were chosen based on the possiblility of suitable amphibian breeding habitat being present in identified wetlands. Amphibians in Cawthra Woods, Credit River Marshes and Rattray Marsh continue to be monitored through CVC's Terrestrial Environmental Monitoring Program. Amphibian surveys were completed using methods consistent with Marsh Monitoring Protocol (Bird Studies Canada, 2009). A summary of the survey results are in Appendix C, table C4. In addition, Table C3 a, b (Appendix C), summarizes amphibian records pre-2009, from various background reports.

In recent (2009-2012) surveys, Rattray Marsh showed the highest number of amphibian and reptile species and highest number of amphibian and reptile individuals of all sites surveyed. It should be noted that higher survey effort was made at Rattray Marsh than other survey sites. Of note is the presence of (provincial) Special Concern species: Snapping Turtle (*Chelydra serpentina*), Northern Map Turtle (*Graptemys geographica*), at both the Credit River Marshes and Rattray Marsh. Provincially Threatened Blandings Turtle (*Emydoidea blandingii*) was also confirmed in the LOISS study area in 2014.

3.7.2 Significant Wildlife Habitat

Significant Wildlife Habitat (SWH), as defined by provincial policy, includes habitat for wildlife that is considered "ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system" (MMAH 2014). CVC has been analyzing existing data as well as carrying out targeted field surveys in order to identify SWH throughout the Credit River watershed. This work has produced several GIS layers of confirmed and candidate SWH, as well as tools and processes to identify SWH at particular sites or within particular areas. These processes and products were used to assess the known and possible SWH within the LOISS study area (Table 3.39), as well as those types of SWH that are unlikely to occur within the area.

Identifying SWH in the Credit River watershed can be complicated by the fact that two sets of guidelines apply throughout most of CVC's jurisdiction: the MNRF's SWH Ecoregion Criteria Schedules (OMNRF 2015a, 2015b) and the Peel-Caledon Significant Woodlands and Significant Wildlife Habitat Study (North-South Environmental et al. 2009). The MNRF's Criteria Schedules are meant to identify sites that are significant at the scale of the Ecoregion, while the Peel-Caledon study is meant to identify sites at a more local scale within the Region of Peel and Town of Caledon. While the overall intent of both guidelines is similar, the criteria and thresholds used to determine whether or not an area is SWH can differ widely between the two.

There are over 45 distinct types of SWH, as defined by OMNRF (2000, 2015a, 2015b) and North-South Environmental Inc. et al. (2009). These different types of SWH are classified into four general categories: seasonal concentration areas; rare vegetation communities and specialized habitats; habitat for species of conservation concern; and, animal movement corridors. Table 3-40 lists each of these types of SWH, and indicates whether its occurrence within the LOISS study area is unlikely, possible, confirmed, or not applicable. This assessment is provided for both sets of guidelines.

Table 3-40. Summary of the types of Significant Wildlife Habitat (SWH; as defined by the MNRF SWH Criteria Schedule for Ecoregion 7E and the Peel-Caledon Significant Woodlands and Significant Wildlife Habitat Study) and their potential to occur within the LOISS study area

MNRF SWH Criteria Schedule	Peel-Caledon SWH study		Assessment of potential to occur within the LOISS study area	
Name	**No.**	**Name**	**MNRF**	**Peel-Caledon**
Deer winter congregation areas	A1	Deer wintering area	Possible: an area of candidate SWH has been identified that encompasses Rattray Marsh and surrounding woodlands (field work to confirm being conducted winter 2018)	
Deer yarding areas	-	-	NA in Ecoregion 7E	NA
Colonially-nesting bird breeding habitat (bank and cliff)	A2	Colonial bird nesting sites	Possible: a small amount of potentially qualifying habitat (natural banks and cliffs) is present in the LOISS study area, but targeted field surveys have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Colonially-nesting bird breeding habitat (tree/shrubs)			Possible: some of the listed species have been observed in the area but targeted field studies have not been done	
Colonially-nesting bird breeding habitat (ground)			Unlikely: little to no qualifying habitat (rocky islands and peninsulas) is present in the LOISS study area (common terns nesting on buildings do not qualify)	
Waterfowl nesting area	A3	Waterfowl nesting habitat	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Landbird migratory stopover areas	A4i	Migratory landbird stopover areas	Possible: listed species have been observed, but appropriate targeted surveys have not been done	Confirmed: many areas throughout LOISS study area meet size and distance requirements for SWH
Bat migratory stopover area	A4ii	Migratory bat stopover areas	No criteria and thresholds have been set for this type of SWH in either the MNRF Ecoregion Criteria Schedules or Peel-Caledon SWH study	
Migratory butterfly stopover areas	A4iii	Migratory butterfly stopover areas	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites came close to reaching the thresholds for SWH	
Waterfowl stopover and staging areas (terrestrial)	A4iv	Migratory waterfowl stopover and/or staging areas (terrestrial)	Unlikely: little to no qualifying habitat (spring flooded fields) is known from the LOISS study area, although targeted field studies have not been done	
Waterfowl stopover and staging areas (aquatic)	A4v	Migratory waterfowl stopover and/or staging areas (aquatic)	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites reached the thresholds for SWH	Confirmed, nearshore: nearshore area from the western edge of the watershed to approx. Lakefront Promenade is included in the *West End of Lake Ontario Important Bird Area*
				Unlikely, mainland: potential mainland areas have been surveyed but no sites have reached thresholds for SWH
Shorebird migratory stopover area	A4vi	Migratory shorebird stopover areas	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites reached the thresholds for SWH	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites reached the thresholds for SWH
Raptor wintering area	A5	Raptor wintering areas (i.e. used for feeding and roosting)	Possible: potential qualifying habitat (combined upland and forest sites of >20 ha) is present in the LOISS study area, but targeted surveys have not been done	
Snake/Reptile hibernaculum	A6	Snake hibernacula	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Bat hibernacula	A7	Bat maternal roosts and hibernacula	Unlikely: little to no qualifying habitat (caves, karsts, mine shafts) is present in the LOISS study area	Possible: some of the listed species have been observed in the area but targeted field studies have not been done

MNRF SWH Criteria Schedule	Peel-Caledon SWH study		Assessment of potential to occur within the LOISS study area	
Name	**No.**	**Name**	**MNRF**	**Peel-Caledon**
				Unlikely: little to no qualifying habitat (caves, karsts, mine shafts) is present in the LOISS study area
Bat maternity colonies	-	-	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	NA
-	A8	Bullfrog concentration areas	NA	Unlikely: no observations of breeding bullfrogs have been made in the LOISS study area
-	A9	Wild turkey winter range	NA	NA: Peel-Caledon guide does not provide criteria & thresholds for this type of SWH
-	A10	Turkey vulture summer roosting areas	NA	NA: Peel-Caledon guide does not provide criteria & thresholds for this type of SWH
Other rare vegetation communities	B1	Rare vegetation communities	Unlikely: no known listed rare vegetation communities are present in the LOISS study area	Confirmed: one polygon of a listed rare vegetation community occurs in the LOISS study area (FOM2-1; between CNR line and Inglewood Road)
Sand barren	-	-	Unlikely: no known sand barrens are present in the LOISS study area	NA
Alvar	-	-	Unlikely: no known alvars are present in the LOISS study area	NA
Savannah	-	-	Unlikely: no known qualifying savannahs are present in the LOISS study area (railway right of ways do not qualify)	NA
Tallgrass prairie	-	-	Unlikely: no known qualifying tallgrass prairies are present in the LOISS study area (railway right of ways do not qualify)	NA
-	B2	Forests providing a high diversity of habitats	NA	NA: Peel-Caledon guide does not provide criteria & thresholds for this type of SWH
Old growth forest	B3	Old-growth or mature forest stands	Unlikely: no known qualifying old growth forests are present in the LOISS study area	NA: Peel-Caledon guide does not provide criteria & thresholds for this type of SWH
-	B4	Foraging areas with abundant mast (i.e. nut bearing trees)	NA in Ecoregion 7E	Confirmed: several forested polygons within the LOISS study area meet the criteria for SWH
-	B5	Highly diverse areas	NA	Confirmed: several sites within the LOISS study area meet the thresholds for SWH
Cliffs and talus slopes	B6	Cliffs and caves	Unlikely: no known cliffs or talus slopes are present in the LOISS study area	Unlikely: no known cliffs or caves are present in the LOISS study area
Seeps and springs	B7	Seeps and springs	Possible: multiple seeps have been noted in forested areas near Moore Creek, but it is unclear whether this truly meets the criteria and thresholds for SWH	Possible: several seeps have been noted in the LOISS study area (Moore Creek and Sheridan Creek), but these locations have not had the necessary field surveys to establish SWH
Amphibian breeding habitat (woodland)	B8i	Amphibian breeding habitat – forested sites (e.g. vernal pools)	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Amphibian breeding habitat (wetlands)	B8ii	Amphibian breeding habitat – non-forested sites (e.g. marshes)	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done

MNRF SWH Criteria Schedule	Peel-Caledon SWH study		Assessment of potential to occur within the LOISS study area	
Name	**No.**	**Name**	**MNRF**	**Peel-Caledon**
Turtle nesting areas	B9	Turtle nesting habitat and turtle overwintering areas	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done (for both nesting and overwintering habitat)
Turtle wintering areas	-	-	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	NA
Woodland area-sensitive bird breeding habitat	B10	Habitat for area-sensitive forest interior breeding bird species	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Open country bird breeding habitat	B11	Habitat for open country and early successional breeding bird species	Unlikely: no known suitable habitat (grasslands >30 ha) is present in the LOISS study area	Confirmed: some areas of confirmed SWH for open country breeding birds have been identified near LWC; it's possible that additional areas of this type of SWH may occur in the LOISS study area
				Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Shrub/early successional bird breeding habitat	-	-	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	NA
Marsh bird breeding habitat	B12	Habitat for wetland breeding bird species	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites reached the thresholds for SWH	Unlikely: surveys have been done at potential sites within the LOISS study area, and no sites reached the thresholds for SWH
Bald eagle and osprey nesting, foraging, and perching habitat	B13i	Raptor nesting habitat – wetlands, ponds, and rivers	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
Woodland raptor nesting habitat	B13ii	Raptor nesting habitat – woodland habitats	Possible: some of the listed species have been observed in the area but targeted field studies have not been done	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
-	B14	Mink, river otter, marten, and fisher denning sites	NA	Possible: some of the listed species have been observed in the area but targeted field studies have not been done
-	B15	Mineral licks	NA	NA: Peel-Caledon guide does not provide criteria & thresholds for this type of SWH
-	C1	Species listed as END or THR by COSEWIC but not COSSARO	NA	Possible: observations for these species have not been recently assessed, but it is likely that at least some of them have been observed within the LOISS study area
Special Concern and rare wildlife species	C2	Species listed as SC on OMNR list	Confirmed: multiple SC and S1-S3 species have been observed in the LOISS study area (however, defining their habitat may prove to be more difficult)	Confirmed: multiple SC species have been observed in the LOISS study area (however, defining their habitat may prove to be more difficult)
	C3	Species listed as S1, S2, or S3 by NHIC		Confirmed: multiple S1-S3 species have been observed in the LOISS study area (however, defining their habitat may prove to be more difficult)
-	C4	Species whose populations appear to be declining substantially in ON	NA	NA: the list of species for this type of SWH has not yet been developed

MNRF SWH Criteria Schedule	Peel-Caledon SWH study		Assessment of potential to occur within the LOISS study area	
Name	**No.**	**Name**	**MNRF**	**Peel-Caledon**
-	C5	Species that have a high percentage of their global population in ON **and** are rare or uncommon in Peel	NA	NA: the list of species for this type of SWH has not yet been developed
-	C6	Species that are rare in Peel region even though they may not be provincially rare	NA	NA: the list of species for this type of SWH has not yet been developed
-	C7	Species that are the subjects of recovery programs	NA	NA: the list of species for this type of SWH has not yet been developed
-	C8	Species considered important to Peel Region based on recommendations of Conservation Advisory Committee	NA	NA: the list of species for this type of SWH has not yet been developed
Terrestrial crayfish	-	-	Confirmed: terrestrial crayfish have been observed at several sites in the LOISS study area (field studies are needed to define their habitat and the SWH)	NA
Amphibian movement corridors	D	Animal movement corridors	Possible: some of the listed species have been observed in the area but targeted field studies have not been done; in addition, guidelines for defining movement corridors are unclear	Possible: some of the listed species have been observed in the area but targeted field studies have not been done; in addition, guidelines for defining movement corridors are unclear
Deer movement corridors	-	-	NA in Ecoregion 7E	NA

Following the MNRF's Criteria Schedules, there are currently two types of confirmed SWH within the LOISS study area and an additional 16 types of SWH that may occur but where confirmation would require additional, targeted field studies. Following the Peel-Caledon SWH study provides more types of confirmed SWH – currently eight types within the LOISS study area and an additional 16 types that may occur. Of interest are also the types of SWH where appropriate surveys have been conducted, but where criteria and thresholds were not met (e.g. migratory butterfly stopover areas, marsh bird breeding habitat).

3.7.3 Invasive Species

Invasive species were not specifically assessed in the study area. The City of Mississauga and CVC in partnership with community groups such as the Rattray Marsh Protection Association undertake invasive species management in targeted locations throughout the study area. For instance, Rattray Marsh Protection Agency has undertaken Garlic Mustard (*Alliaria petiolate*) removal activities for over 20 years. More recently CVC and the City of Mississauga have completed ash tree removal in various natural areas to help control the spread of Emerald Ash Borer and remove hazard trees that have succumb to their infestation.

Two wetland species of particular concern for high quality wetlands, Rattray Marsh and Credit River Marshes, are Yellow-Floating Heart (*Nymphoides peltatum*) and *Phragmites* sp. These species are escapees from garden plantings. They both spread to form dense monoculture mats that compete with native plants reducing plant diversity and reducing availability of native food sources for birds, fish and other wildlife.

3.7.4 Synthesis of Terrestrial Natural Heritage

Overall, terrestrial habitats west of the Credit River are relatively well connected with larger parcels of intact woodlands and meadows compared to areas east of the Credit River. While potential corridors in the LOISS study area have been identified based on connectivity of natural and semi-natural spaces, it is likely that most urban wildlife, those species that can live and thrive in urban environments (e.g., Raccoon, Opossum (*Didelphis virginiana*), etc.) also use urban pathways (trails, roads, backyards) regularly to travel between natural areas.

Shannon-Weiner Diversity Index values for Rattray Marsh are high for landbirds, shorebirds and waterfowl. Habitat quality including habitat patch size and food sources for migratory birds is poor in the study area due to fragmentation of habitats that provide cover and presence of non-native and invasive species that provide lower nutritional value.

The lagoons and shoreline at G.E Booth WWTF have a relatively high number of migratory bird species and S-W Diversity Index values, making G.E. Booth WWTF an important stopover area for migratory landbirds, waterfowl and shorebirds, and a staging area for waterfowl. Sheltered embayments and wetlands at G.E. Booth WWTF and Rattray Marsh appear to be important habitats for waterfowl in the study area as evidenced by the higher species abundance in these areas. Low numbers of species and diversity values in other areas may be a result of poor habitat quality and/or quantity, and/or disturbance by people. Further investigation and site exploration are necessary to determine the source of impact, which may vary between sites.

Of the areas studied, Rattray Marsh has been identified as having the highest number of bat species and a variety of amphibians. Rattray is also well-connected to wildlife movement corridors to the east and west. Rattray Marsh is clearly an important natural heritage feature within the LOISS study area and has been identified as a Centre for Biodiversity by CVC. The Credit River Marshes have also been identified as a Centre for Biodiversity, and also likely support a large number of migratory birds and other wildlife; however, more intensive confirmatory surveys are required.

The lagoons and shoreline at G.E. Booth WWTF have a relatively high number of migratory bird species and moderate S-W Diversity Index values, making G.E. Booth WWTF an important stopover area for migratory landbirds, waterfowl and shorebirds, and a staging area for waterfowl. Low numbers of species and diversity values in other areas may be a result of poor habitat quality and/or quantity, and/or disturbance by people. Further investigation and site exploration are necessary to determine the source of impact, which may vary between sites.

Significant Wildlife Habitat has been confirmed within the LOISS study area along with a number of locations where potential Significant Wildlife Habitat may exist. Confirmed Significant Wildlife Habitat includes:

- Migratory landbird stopover areas (Peel-Caledon SWH study)
- Migratory waterfowl stopover and/orstaging areas (aquatic) (Peel-Caledon SWH study)
- Rare vegetation community (Peel-Caledon SWH study)
- Foraging areas with abundant tree masts (i.e. nut bearing trees) (Peel-Caledon SWH study)
- High diverse areas (Peel-Caledon SWH study)
- Habitat for open country and early successional breeding bird species (Peel-Caledon SWH study)
- Special Concern and rare wildlife species (MNRF)
- Species listed as SC on OMNR list and species listed as S1, S2, or S3 by NHIC (Peel-Caledon SWH study)
- Terrestrial crayfish (MNRF)

Further detailed investigations are necessary to inform decision-making at the site-scale.

Recommendations and next steps for Terrestrial Natural Heritage are summarized in Table 3-41.

Table 3-41: Summary of Terrestrial Natural Heritage Next Steps and Recommendations

Action	Location	Priority (High, Medium Low)	Lead Agency
Ecological Land Classification Mapping	Throughout LOISS study area	Low	CVC/City of Mississauga
Completion of wetland evaluations	Throughout LOISS study area	Medium	MNRF
Implementation and protection of	Throughout LOISS study area	High	City of Mississauga

Action	Location	Priority (High, Medium Low)	Lead Agency
natural heritage system			
Increase wetland cover to support migratory landbirds, shorebirds, and waterfowl	Throughout LOISS study area	Medium	CVC/City of Mississauga
Increase terrestrial habitat cover to support migratory landbirds, bats and butterflies	Throughout LOISS study area	Medium	CVC/City of Mississauga
Improve linkages between habitats (including between aquatic and terrestrial habitats) to support movement of urban wildlife and migratory landbirds	Throughout LOISS study area	Medium	CVC/City of Mississauga
Wildlife surveys	Credit River Marshes	Low	CVC
Butterfly and odonate surveys using standardized protocols to determine abundance	Throughout LOISS study area including identified new sites (Arsenal Lands, Port Credit Village Partners Lands)	Low	CVC
Landbird, waterfowl, and shorebird surveys using standardized protocols to determine abundance.	Throughout LOISS study area	Low	CVC
Migratory bird habitat quality improvements	Throughout LOISS study area	Medium	CVC/City of Mississauga
Assessment of identified significant Significant Wildlife Habitat	Throughout LOISS study area	High	CVC
Management Plans for natural areas	Throughout LOISS study area	Medium	CVC
Continue to implement CVC's	Throughout LOISS study area	High	CVC/City of Mississauga

Action	Location	Priority (High, Medium Low)	Lead Agency
and the City of Mississauga’s Invasive Species Management strategies including control of Phragmites and Yellow-Floating Heart			

3.8 OUTREACH, EDUCATION AND COMMUNICATIONS

An understanding of human dimensions of shoreline management was identified as one of the key knowledge gaps in the LOISS Background Review. Research characterizing the local residents and visitors' use of the shoreline, their values and concerns, and their interest in protection and restoration was identified as a priority to address this gap. It was also recognized that this information would provide a valuable basis upon which to develop and implement a strategic communications strategy.

In summer 2011, as part of the Characterization phase, CVC developed and administered a survey aimed at gaining a better understanding of human use and perspectives of the shoreline. The objective of the survey was to gain a better understanding of users in the study area, their concerns and attitudes towards various natural features and restoration/management practices (LURA 2012).

3.8.1 Survey Results

Of the 675 surveys completed, 305 were in-park, 175 were door-to-door and 195 were online, with some differences between the in-person and on-line survey questions. A detailed analysis is found in LOISS: Shoreline Uses, Attitudes and Perceptions of Restoration Options (LURA 2012).

Respondents identified which of the parks in the study area they used most often. While the results of the online and in-person surveys vary, overall, Jack Darling Memorial Park, Rattray Marsh, Port Credit Harbour, J.C. Saddington Park and Lakefront Promenade Park were identified as the most frequently visited parks by the majority of respondents in both online and in-person surveys (Figure 3-49).

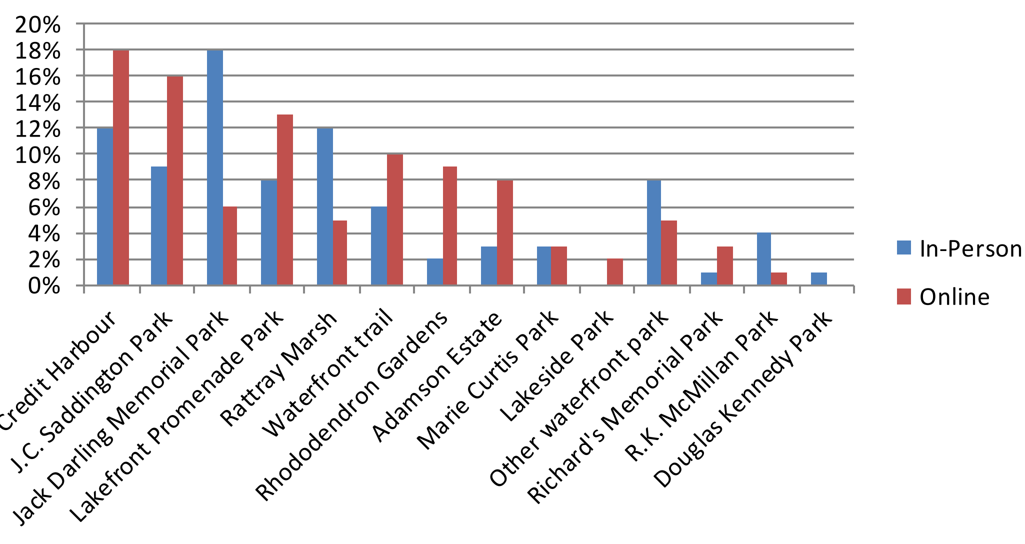


Figure 3-49: Park Visitation: On-Line and In-Person Survey

The most common reason for visiting the parks within the shoreline study area was 'physical exercise/activity', with the most common activities including hiking/walking/running, scenery viewing/photography and dog walking.

Most respondents said the 'lake and water' were important for their use and enjoyment, although very few people identified participating in water-based activities such as fishing, swimming, kayaking or canoeing. The lake and water are therefore more closely linked with 'scenery viewing' and other activities pertaining to the appreciation of natural elements.

Many people also placed importance on 'trees and meadows', 'forest and trees' and 'herbaceous green spaces'. Sixteen percent (16%) of the respondents also stated that wildlife was an important shoreline element, with more frequently mentioned wildlife categories including birds (e.g., ducks, swans and migrating birds) and wildlife in general (e.g., 'animals' and 'fauna'). Insects, reptiles and amphibians were mentioned by only a few respondents. Finally, 'walking trails' and 'water quality' were of importance to respondents.

For most survey respondents, 'wetlands' were not considered important for use and enjoyment. This does not suggest that wetlands are not important to people but that they are not important for use and enjoyment of the shoreline. It may also be because there are few wetlands in the study area or that their functions (e.g., storm flow mitigation, habitat, etc) are poorly understood.

Overall, the respondents were satisfied with the condition of the shoreline's natural elements; however, the least satisfaction was associated with water quality for a variety of reasons including the smell of lake water, problems with algae and being unable to swim in the lake. When asked what they thought contributed to this condition, the most common responses stated urban development (73%) and pollution from industry (72%). Overuse (48%), invasive species (47%) and breakwalls (31%) were less common answers.

Many respondents provided other answers for what they thought contributed to their dissatisfaction with aspects of the natural shoreline. Common themes identified in the other answers were (1) overpopulation/population density (e.g., 'Too many people trying to make use of too little green space') and (2) maintenance issues (e.g., 'Need to keep beaches clean').

Approximately 79% of respondents felt there was a need for projects that would create a more natural shoreline, indicating general support for the LOISS in the community.

Those who said they did not see a need for natural shoreline projects were asked to indicate why. The following list shows the percentage of respondents who chose each of the provided options:

- Money could be better spent on other issues (such as maintaining existing facilities) (10%)
- I need more information about management/restoration projects to answer this question (3%)
- I am not interested in shoreline natural areas (2%)
- I do not believe that this will benefit shoreline residents/visitors (1%)

Initiatives for improving water quality and providing more habitats for wildlife are likely to motivate individuals and communities to support and participate in shoreline projects. 'Opportunities for recreation' was a common second choice. 'More natural areas for relaxation and spiritual enjoyment' and 'more natural areas that will be available for your children and grandchildren' were popular third choices, with 98% of the individuals who chose the latter as their top priority believing in the need for shoreline projects. Further to this, the study found that females were most likely to support shoreline projects.

This finding suggests a connection between caring about the future of the shoreline and supporting shoreline projects, suggesting that shoreline outreach should help people understand the long-term implications of shoreline projects.

3.8.1.1 Interpretation of survey results

The results of the LOISS: Shoreline Uses, Attitudes and Perceptions of Restoration Options (LURA 2012) survey provide valuable information about the people who use the parks, their concerns and attitudes towards various natural features and restoration/management practices. Organized by theme, the following points provide an overview of the report's key findings and their implications for LOISS.

1) Management of shoreline areas and accommodating user preferences

- A good trail system is essential for accommodating park-users; need to accommodate various user-types and frequent use of trails.
- Physical activity, particularly walking, hiking and cycling are very popular activities in the shoreline parks and natural areas. These areas should provide ample opportunities for such activities.
- Dog walkers are frequent users of shoreline parks, especially R.K. McMillan Park and Jack Darling Memorial Park. Environmental management strategies should consider the size of the population that use the parks for this reason.
- The needs of the aging population should be considered in the management of shoreline parks and trails, as hiking and walking are popular among older age groups.

2) Direction for CVC's communication strategies and restoration options, particularly those associated with LOISS

- Because of the popularity of physical exercise, communication strategies should help people to make the connection between shoreline health and opportunities for exercise and maintaining good health.
- Water quality, trees and meadows, hiking and walking trails, and the presence of wildlife were the most important natural elements according to survey respondents. These are concepts that people understand and feel connected to. CVC should leverage the importance of these concepts to encourage individuals and communities to participate in shoreline projects and restoration programs.
- Education and awareness is needed regarding fishing opportunities and local sport fish species and to a certain extent about wetlands, as many people are not aware of their importance.

- The outcomes and benefits of shoreline projects should be clearly communicated to the public and used to gain public-buy in, as cost was a concern for some people.
- Communication strategies should consider the connection between caring about the state of the shoreline for future generations and being supportive of shoreline projects. Shoreline outreach could help people understand the long-term implications of shoreline projects.
- Concerns about urban development and pollution from industry should be addressed in CVC's communication materials to help ease public concerns and showcase what can be done to address the issues. More education may be needed about the other issues, such as pollution from homes and invasive species.
- To gain support for LOISS and encourage communities to get involved in shoreline projects, it may be more effective to start with females, as they are more likely to support shoreline projects.
- When determining the location of specific shoreline projects, CVC should consider focusing their efforts in less-naturalized parks (i.e. Douglas Kennedy, R.K McMillan and Lakefront Promenade Park), as there is a slightly stronger desire for restoration projects among those who use these parks most often.

3.8.2 Communications strategy

The need for a comprehensive communications strategy for the LOISS was identified early in the planning process, with the general approach to communications including the development and implementation of annual tactics that build on the previous year's findings and the results of the survey. Completed tactics have included workshops designed to better understand perspectives from corporate and individual stakeholders, quarterly 'Living by the Lake' newsletters profiling individual and corporate landowners, key messaging about the study area, to news releases and outreach at key events such as the Mississauga Waterfront Festival. This early engagement has broken down perceived barriers, created new relationships and developed important local initiatives with homeowners and corporate landowners. Local government partnerships and cooperation have also been strengthened.

A number of activities have been undertaken to engage with the local community about LOISS throughout the Characterization phase. Redbrick Communications was retained in 2011 to prepare a Communications Strategy and updated to reflect the summary recommendations in Section 3.8.1.1 (LURA 2012).

Table 3-42 below summarizes the outreach and communications initiatives implemented through this phase. Details of these activities are provided in Appendix D

Table 3-42 Summary of outreach and communications activities undertaken between 2011-2018 for the LOISS Characterization Phase

Activity	Description	Quantity
Stakeholder research	Formal surveys and feedback	1
Display materials	Display panels, fact sheets	2
Newsletters	Corporate and general newsletters focused on shoreline health	9
Video	"The Lake Ontario Shoreline – Under Stress" narrated by Robert Bateman	1

Activity	Description	Quantity
Presentations	Presentations on LOISS for conferences, public meetings, stakeholders, etc.	16
Stakeholder outreach events	Various events geared towards LOISS stakeholders, including targeted groups such as Clarkson Mothers Group to respond to LURA recommendations	9
Public outreach events	Outreach events open to the general public	4
News releases	Based on key themes identified in communications strategy (e.g. invasive species, water quality, etc)	3
Frontliner Program	The following presentations and tours were undertaken by Frontline volunteers promoting LOISS-related themes: 2016: 9 Frontliners engaged 290 youth (theme: migratory birds). 2017: 10 Frontliners engaged 378 youth (theme: stream health in urban settings). 2018: The final number of people engaged and number of Frontliners participating in 2018 will be confirmed in June (theme: wetlands).	

A large effort was put forth to engage with stakeholders through the local Ratepayer Associations in each coastal reach. Presentations and outreach events completed for Ratepayers Associations are summarized in Table 3-43.

Table 3-43: Summary of presentations and outreach events for Ratepayer Associations in the LOISS Study Area

Ratepayer Name	Coastal Reaches	Year of Presentation or Outreach
Birch Glen Residents' Association	5 – Lorne Park/Meadowwood	-
Clarkson Fairfields South Ratepayers Assoc.	6 – Refinery	2011
Cranberry Cove Ratepayers Association	4 – Port Credit, 5– Lorne Park/Meadowwood	2011; 2012
Credit Reserve Association	3 - Mineola, 4 – Port Credit	-
East Collegeway Ratepayers Assoc. Inc.	4 – Port Credit	-
Erindale Village Associates	4 – Port Credit	-
Gordon Woods Homeowners Association	4 – Port Credit	-
Lakeview Ratepayers Association (Annual Picnic)	1 - Lakeview, 2 – Lakefront Promenade, 3 - Mineola	2013; 2015; 2016
Lorne Crest Community Association	5 – Lorne	-

Ratepayer Name	Coastal Reaches	Year of Presentation or Outreach
	Park/Meadowwood	
Lorne Park Estate Association	5 – Lorne Park/Meadowwood	2011; 2013
Lorne Park Watercolours Residents Association	4 – Port Credit, 5 – Lorne Park/Meadowwood	-
Meadow Wood - Rattray Ratepayers Association	5 – Lorne Park/Meadowwood, 6 – Refinery	2011; 2012
Mississauga - Kane Rds. Ratepayers Association	4 – Port Credit, 5 – Lorne Park/Meadowwood	-
Mississauga Oakridge ratepayer's Association	4 – Port Credit, 5 – Lorne Park/Meadowwood	-
Mississauga Road Sawmill Valley Drive Ratepayer's Association	4 – Port Credit	-
Owenwood Residents Association	5 – Lorne Park/ Meadowwood	-
Parkland Area Residents Association (PARA)	5 – Lorne Park/ Meadowwood	-
Park Royal CA		2011; 2012
Port Credit Village RA	4 – Port Credit	2011
Sherwood Forest Residents' Association	4 – Port Credit	-
Sir John's Homestead Ratepayers Association Inc.	4 – Port Credit	-
Tecumseh Area Ratepayers Association	4 – Port Credit, 5 – Lorne Park/Meadowwood	2011
Town of Port Credit Association (TOPCA)	3 - Mineola, 4 – Port Credit, 5 – Lorne Park/ Meadowwood	2011
Whiteoaks Lorne Park Community Association	5 – Lorne Park/ Meadowwood	2011; 2014

3.8.3 Synthesis of Outreach, Education and Communications

The following outreach, education, and communications opportunities should be explored in greater detail through the Implementation report:

Action	Location	Priority (High, Medium Low)	Lead Agency
Continue to advance recommendations from the Urban Recreational Fishing Strategy (MNRF 2015) including promoting urban fishing	Lakefront Promenade, mouth of Credit River, JC Saddington Park, Jack Darling Park, Lakeside Park, JJ Plaus Park, Marina Park, Memorial	Medium	MNRF/CVC/City of Mississauga

Action	Location	Priority (High, Medium Low)	Lead Agency
opportunities	Park, Brueckner Rhododendron Park, Richard's Memorial Park, RK McMillan Park, Watersedge Park, Tall Oaks Park.		
Continue to advance recommendations in the Great Lakes Nearshore Framework (Lakewide Management Annex Nearshore Framework Task Team 2016) including promoting concept of links between nearshore habitat health and human health, social learning and increased awareness	Throughout LOISS study area	Medium	CVC/City of Mississauga
Increase profile of CVC as partner and technical experts rather than only regulatory body	Throughout LOISS study area	High	CVC
Advance communications that respond to widespread stressors such as water quality impacts including use inappropriate disposal of pharmaceuticals and personal care products, use on non-native invasive species in landscaping, etc, and water quantity including Low Impact Development.	Throughout LOISS study area	High	CVC/City of Mississauga
Continue to advance the Frontliners program focused on peer-to-peer outreach	Throughout LOISS study area	Medium	CVC
Continue to foster relationships and to undertake targeted presentation to ratepayer groups, building on completed efforts	Throughout LOISS study area	Low	CVC
Focus restoration efforts through CYC etc on less-	Throughout LOISS study area	Medium	CVC

Action	Location	Priority (High, Medium Low)	Lead Agency
naturalized parks.			
Engaging community and corporate volunteers in restoration opportunities including tree, shrub and wildflower plantings and invasive species management on public lands.	Throughout LOISS study area	Medium	CVC/City of Mississauga
Provide educational opportunities including interpretive signage along Credit Valley Trail linked to Lake Ontario shoreline.	Credit River	Medium	CVC
Build upon Riverwood/CVC Native Plant Propagation program to increase supply of locally sourced native plant seeds and plants.	Throughout LOISS study area	Low	CVC/City of Mississauga
Partner with Great Canadian Shoreline Clean Up to engage community in the state of our shorelines and build support for shoreline projects.	Credit River and public spaces along Lake Ontario shoreline	Medium	CVC/City of Mississauga
Lake Ontario Learning Centre at Adamson - public engagement programs and events, including partnership with Blyth Academy and other community agencies	Adamson Estates	Low	CVC
School outreach education – regional targeted program focusing on specific school-based or residential intervention(s) e.g. butterfly or bird habitat	Throughout LOISS study area	Low	CVC
Teacher professional development – focused on key issues or interventions	Throughout LOISS study area	Low	CVC

Action	Location	Priority (High, Medium Low)	Lead Agency
Multicultural Outreach with local newcomer and social service agencies – offering experiential education services to residents in the region	Throughout LOISS study area	Medium	CVC

4 INTEGRATION: COASTAL REACHES

This section integrates the detailed information from the individual disciplines (Section 3) by coastal reach, considering their interrelationships in terms of existing features and associated processes and functions.

The results of the discipline-by-discipline analysis points to the need for five priority actions:

- Manage stormwater quality and quantity
- Improve habitat quality
- Manage existing habitats
- Connect habitats
- Outreach, communications, and education

Manage stormwater quality and quantity: Improved stormwater management should be a priority for the LOISS study area. Reducing the amount of stormwater runoff that reaches natural waterways would improve flow conditions and help to restore streams' natural form and function, increasing their capacity for supporting robust ecosystems, reducing erosion, and mitigating flood risk. Improved stormwater quality controls would help to meet federal and provincial water quality targets, allowing greater access to the lake for recreation and improving pre-treatment drinking water quality.

Improve habitat quality: The LOISS study are is marked with poor quality habitats that lack the structural complexity and native food sources to support native and migratory birds, fish, and wildlife. Imrpoving habitat quality entails creating physical habitat structure, ensuring appropriate features are present that will contribute to ongoing and future development of habitat complexity and replacing poor quality food sources with native flowering and fruiting plant species to sustain birds and wildlife through all seasons.

Manage existing habitats: Many of the natural and semi-natural areas in the study area require ongoing management to ensure their health and compatibility with surrounding land uses. Management activities may include control or management of invasive species, establishment of policies to ensure protection or compatibility of natural areas with development, or undertaking studies to inform management decisions.

Increase habitat connectivity: Where feasible, both aquatic and terrestrial isolated habitats should be connected. Many barriers prevent fish from accessing LOISS streams from the lake or from moving from one stretch of stream to another. Again, public works projects can proceed concurrently with efforts to remove barriers to fish movement. Culvert works completed by the City of Mississauga in 2018 on Serson Creek and Applewood Creek at Lakeshore Road included improvements to fish passage as an objective to be achieved in the culvert design. Improvements to fish passage at these locations will open approximately 3000 m (collectively) of stream to fish.

Outreach, communications, and education: Existing outreach initiatives, such as CVC's Your Green Yard, Greening Corporate Grounds and Frontline programs, have shown positive and far reaching effects in fostering connections between people and the environment.

The following coastal reach characterizations are proceeded by recommendations specific to each coastal reach and are arranged according to the action themes presented above.

4.1 1 - LAKEVIEW COASTAL REACH

1 - Lakeview Coastal Reach extends from the eastern limits of the LOISS and CVC's jurisdictional boundaries to the pier at the mouth of Serson Creek (Figure 4-1). Terrestrial vegetation and bird surveys in Marie Curtis Park and the Arsenal Lands east of the study area have been included, since the terrestrial features within 1 - Lakeview Coastal Reach extend onto these lands. Inclusion of these lands increases our understanding of the functions of the natural areas within this reach. Due to the proximity of Etobicoke Creek to the study area boundary and potential flow spill from this stream into the Applewood Creek watershed, effects of Etobicoke Creek have been considered. However, no in-depth research or studies have been conducted on Etobicoke Creek for the purposes of this study, as it is outside Credit Valley Conservation's jurisdiction.

Limited access to private lands in the Serson Creek and Applewood Creek watersheds has prevented in-depth studies of their terrestrial habitats. However, aerial photo interpretation indicates a very low percentage of natural cover in the 1 - Lakeview Coastal Reach relative to other coastal reaches but a fairly high percentage of cultural meadow cover.

The breakdown of land cover in the 1 - Lakeview Coastal Reach is listed below. The majority of this coastal reach is residential and, to a lesser degree, commercial and open space land uses (Figure 4-1):

Open Space	21.6%
Natural	14.1%
Wetland	0.1%
Woodland	4.0%
Cultural Meadow	4.6%
Cultural Savannah	1.6%
Cultural Thicket	1.0%
Cultural Woodland	2.8%
Commercial	20.3%
Residential	39.7%
Other	3.6%

Terrestrial, Wetland, and Riparian Habitat

Use of poor quality habitats (e.g., G.E. Booth Waste Water Treatment Facility ash lagoons) by migratory birds is evident in the 1 - Lakeview Coastal Reach. Bird guilds requiring open spaces for hunting and feeding, such as birds of prey, aerial insectivores, and gulls and terns, are commonly found at Marie Curtis Park, G.E. Booth WWTF and along the shoreline where cultural woodlands and meadows dominate. The banks of the incinerated ash lagoons at G.E. Booth WWTF provide suitable substrate for Bank Swallows (*Riparia riparia*) to create nesting burrows. Waterfowl also use the calm waters and surrounding vegetation in the G.E. Booth WWTF lagoons and between the Ontario Power Generation piers. The armoured berms around the WWTF limit access between the lake and tableland habitats, although some waterfowl come to shore to rest on the lower banks between the large rocks or under shrubs close to the water's edge.

Bird survey records concentrated at the G.E. Booth WWTF lagoons show this area to be a hotspot for a diversity of shorebirds. Sandpipers such as the Dunlin (*Calidris alpina)* and Sanderling (*Calidris alba*) were found as well as a few species of Dowitchers (*Limnodromus spp*.) and yellowlegs (*Tringa spp*.). Further, six of seven bat species recorded in the study area have been found at G.E. Booth WWTF. The mudflats and shallow waters of the lagoons likely provide sufficient foraging grounds for these species. However, this habitat is not considered optimal.

The lake shoreline and stream banks, in the southern and eastern areas of this coastal reach, are dominated by deciduous and cultural woodlands and cultural meadows, both of which are heavily impaired by invasive species. North-south terrestrial connections are limited to the stream corridors. Multiple east-west terrestrial connections exist between 1 - Lakeview Coastal Reach and the neighbouring watersheds (Cawthra Creek and Etobicoke Creek), though they are are confined to the southern ends of these watersheds.

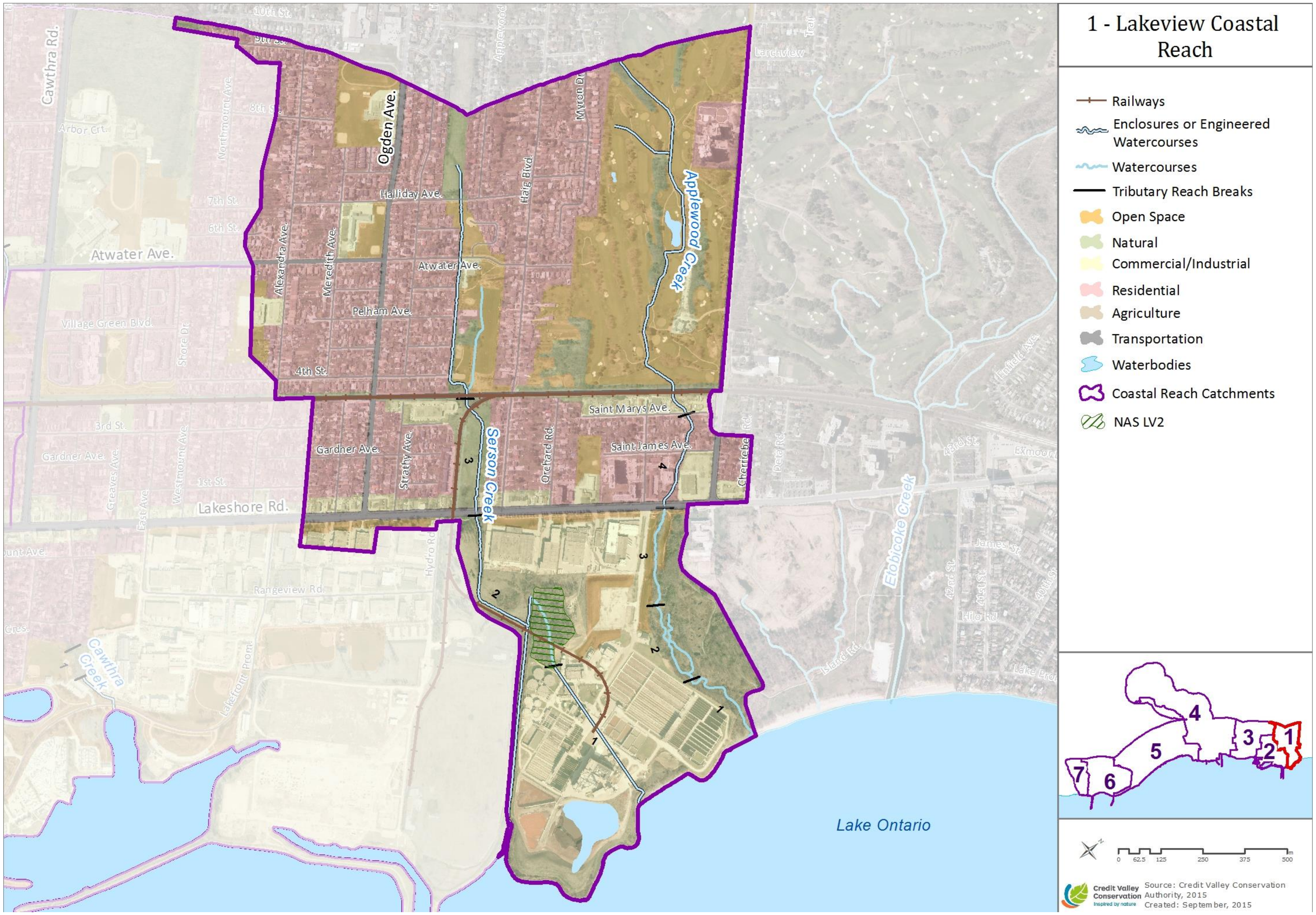


Figure 4-1: 1 - Lakeview Coastal Reach: Land Use (Source: CVC)

Terrestrial habitats within Marie Curtis Park straddle the Etobicoke Creek and Applewood Creek watersheds, providing suitable connection for many species. The golf courses on either side of Dixie Road north of Lakeshore Road may provide adequate connection between Applewood Creek and Etobicoke Creek watersheds for mammal movement, as suggested by recent MNRF radio collar Coyote surveys (MNRF unpublished 2013). However, the resident Coyote in this area tend to stay within the Toronto Golf Club lands with very little movement beyond. In other areas, the Coyote tracking showed that individuals traversed major roadways and highways, indicating very few barriers to movement within the urban landscape for this species.

To the west, Mississauga Natural Areas Survey (NAS) LV2 (Figure 4-1) cultural woodland north of the G.E. Booth WWTF provides an east-west terrestrial linkage between Serson Creek watershed and Applewood Creek watershed. Linkages between Serson Creek west to Lakefront Promenade Park are low quality with a lack of cover or small stepping stone patches through the open retired industrial lands at Ontario Power Generation (OPG; see Section 4.2). Note these retired industrial lands are scheduled for redevelopment.

Serson Creek

Serson Creek has one of the highest incidences of flooded structures (Table 3-7, pg. 39) in the LOISS study area, the majority of which are located upstream of the rail tracks. Seven structures are flooded in storms less than the 5-year event (6.7m^3/s). At the lake, Serson Creek discharges into 1 - Lakeview Coastal Reach at two locations, with the flows split south of Lakeshore Road. Storm flows discharge through a constructed channel west of the G.E. Booth WWTF. The mouth of the storm channel is blocked by large woody material and flotsam. Flows from the storm channel are insufficient to push this debris jam out into the lake to maintain access to the channel. Further, the channel is frequently dry through much of its length since it only conveys higher flow events (greater than 2–year storm, 1.40 m^3/s). Baseflows in Serson Creek recorded above the flow diversion were in the order of 0.001 m^3/s (1 l/s) (Table 3-1, pg. 31). Midsummer instream water temperatures (average 20^oC, Table 3-2, pg. 32) suggest potential groundwater contributions to Serson Creek. Lakeview Waterfront Connection, currently under construction, will divert low flows (under the 5-year storm event) in Serson Creek down the existing storm channel to improve the hydraulic connection with Lake Ontario. This will allow fish to access Serson Creek

Low flows in Serson Creek currently discharge through a corrugated steel pipe under the WWTF to the east of the facility. The low flow pipe is perched above the normal water levels for the lake, preventing fish access into the stream. This particular barrier to fish passage will be maintained through Lakeview Waterfront Connection, though fish will be able to access the creek through the storm channel. However, local stormwater flows from G.E. Booth WWTF and surrounding developed areas will continue to flow into newly created wetlands associated with Applewood Creek.

Downstream of the flow diversion, Serson Creek is naturalized through a cultural woodland that provides large woody material along the banks and instream. In this location, the stream, which had been previously straightened, is now showing signs of developing meanders. Undercutting and slumping of the sand banks are evident in the upper portions of Tributary Reach 2, upstream of the diversion. Tributary Reach 3, north of Lakeshore Road, flows through a hydro corridor. Previously straightened, bank slumping in this stream reach is also recreating meanders. Channel stability in

Tributary Reaches 2 and 3 is considered 'fair'. However, analysis of other geomorphic parameters (instream habitat, water quality, riparian habitat, biological indicators) resulted in an overall geomorphic condition (Rapid Stream Assessment Technique) of 'poor' for Serson Creek.

Water quality monitoring identified exceedances of provincial of federal guidelines for total phosphorus, *E. coli*, and nitrates. As previously noted, phosphorus (which exacerbates algae growth) and *E.coli*, can contribute to impaired water for drinking and recreation. High nitrate levels can be toxic to aquatic life and impair drinking water.

No fish have been captured in Serson Creek. Although habitat within both the main channel and the storm flow channel are poor (low density woody riparian cover, homogenous channel form and instream habitat structures), suitable habitat for tolerant warmwater species exists. The piped section of stream under the G.E Booth WWTF and noted lack of appropriate flows in the storm flow channel both constitute barriers to fish movement. The culvert at Lakeshore Road may also be a barrier to fish passage under certain flows. Fish likely once inhabited Serson Creek, but it is unknown when or why they disappeared. With no water quality parameters (Table 3-20, pg.85) or Probable Effects Limit (Table 3-11, pg. 52) suggesting water quality or sediment quality, respectively, as limiting factors for supporting aquatic life, access is the likely reason why fish have not recolonized this stream. These barriers to fish movement are scheduled to be removed through work at Lakeview Waterfront Connection and culvert modifications at Lakeshore Road.

Applewood Creek

Flows in Applewood Creek are double that of Serson Creek, with 2-year event flows of $9.57m^3/s$. Applewood Creek receives flows from neighbouring Etobicoke Creek under larger storm events; this recent discovery has not yet been quantified. Etobicoke Creek may also contribute to water quality exceedances (*E.coli*) in the area.

Although a variety of engineered bank stabilization methods (e.g. riprap, gabion baskets) have been installed along Applewood Creek, its well-vegetated riparian zone provides woody material and overhanging vegetation to enhance instream fish habitats. Applewood Creek discharges over a sand beach into Lake Ontario. Flows from Applewood Creek, waves, and lake water levels influence how the mouth of Applewood Creek forms through the dynamic sand beach at Marie Curtis Park. The geomorphic assessment of Applewood Creek identified a backwater effect from Lake Ontario in Tributary Reach 1, influencing both a wetland and a treed beach ridge that is bisected by the stream near its mouth. CVC staff confirmed that the treed beach ridge on the west side of Applewood Creek is no longer directly affected by coastal processes due to water level regulations and is succeeding to an upland forest (Sampson pers. com. 2013). The treed beach ridge on the east side of Applewood Creek is still being influenced by coastal processes sufficient to maintain the treed beach ridge community. This community is dominated by invasive species.

Applewood Creek flows through a well-vegetated woodland (Tributary Reach 1), providing woody material to the stream to diversify habitat and provide some buffering from adjacent land uses. Upstream of Lakeshore Road, the banks of Applewood Creek are negatively affected by erosion protection measures such as gabion baskets, which limit bank habitat diversity along the banks of the stream. Moderately deep pools, point bars and diverse substrates contribute to channel bed diversity. Substrates are well sorted on the bed, with the various substrates (sand, gravel, cobble, etc) grouped together. However, riffles are embedded in some areas. Note that screening level sediment surveys, completed by Environment and Climate Change Canada (2003), indicated Probabability Effects Level (PEL) exceedances of 10 compounds (Table 3-11, pg. 52) in Applewood Creek. However, turbidity monitoring indicated that Applewood Creek has the lowest Total Suspended Sediment concentration of all the monitored LOISS tributaries. Potential sources of these contaminants include agricultural activity and fossil fuels . Further, high conductivity levels in water quality sampling, which indicate chlorides from road salt, reflect the influence of urbanization on this watershed.

The warmwater fish community assemblage in Applewood Creek (including White Sucker, Longnose Dace (*Rhinichthys cataractae*), Blacknose Dace, Creek Chub and Fathead Minnow (*Pimephales promelas*) are typical of urban tributaries. Longnose Dace and Blacknose Dace sampled in Applewood Creek prefer small tributaries with rocky or gravelly bottoms. Longnose Dace can also be found in the shallow shores of lakes. Blacknose Dace feed on benthic invertebrates and on algae, while Longnose Dace feed on crustaceans and mollusks. Migratory White Suckers have been observed in Applewood Creek in some years up to Lakeshore Road (Jon Clayton pers. comm 2014), where the design of the road crossing prevents upstream access. White Sucker feed on aquatic insects, molluscs, crustaceans and plants on the stream bed. Creek Chub and Fathead Minnow are omnivores, feeding on invertebrates and plants, including algae.

The presence of Lake Chub and the migratory run of White Sucker in Applewood Creek indicates that fish are able to access the lake under certain conditions. However, their access is variable and dependent on the barrier beach at the mouth of the stream. A previously identified barrier to fish passage at Lakeshore Road has recently been mitigated through culvert works undertaken by the City of Mississauga. Since completion of these works, White Sucker have been observed upstream of Lakeshore Road providing strong evidence that this barrier has been mitigated.

Lake Ontario

The open coast habitat in the 1 - Lakeview Coastal Reach is exposed to the waves and currents from the east. Shoreline habitat along this reach includes sand-cobble beach (27%, Figure 3-15) found at Marie Curtis Park. Despite the proximity of the Marie Curtis Park forest to the shoreline, limited woody material along the coast appears to originate from this forest. That is, there are few fallen trees along the forest edge adjacent to the shoreline. Rather, woody material is transported down tributaries and dispersed through wave action along the shoreline. Large woody material from Marie Curtis Park Beach and Etobicoke and Applewood Creeks accumulates at the mouth of Serson Creek storm channel and low flow channel outlet (Tributary Reach TR1, Figure 3-6b, pg. 36) by waves and current from the east. Much of the shoreline has been hardened with treatments including armour stone revetment and concrete piers (Table 3-16, pg. 70; Figure 3-17, pg. 72). 1-Lakeview Coastal Reach is undergoing restoration (Section 3.4.1.5), including creation of a new shoreline consisting of armourstone revetment, cobble beach, and three large islands.

Littoral transport in the CVC jurisdiction occurs from east to west across the shoreline. The piers at OPG are the first barrier to littoral drift in CVC's jurisdiction, halting the movement of sediment from the Toronto shoreline and from contributing tributaries. An anticyclonic current is created when the waves from the east reflect off the OPG piers. This current redistributes much of the sediment trapped by the piers by pushing the sediment back out to the open water in front of Marie Curtis Park beach. Waves from the east push this sediment back towards the shoreline. This anticyclonic process causes erosion and deposition of sand at Marie Curtis Park beach and contributes to its status as a dynamic beach.

As noted, the beach at Marie Curtis Park is dynamic in part due to the anticyclonic current and may meet the Province of Ontario's definition of a dynamic beach (SEL 2014). However, the City of Toronto maintains this beach by adding sand and performing regular grooming (Chapman pers. comm. 2013). The sand and cobble beach extends into the nearshore waters where the dominant substrate is bedrock with a veneer of sand and silt. The nearshore substrates in the 1 - Lakeview Coastal Reach are likely of lowest diversity along the LOISS shoreline, with bedrock and a veneer of sand and silt dominating the area (Table 3-15, pg. 69).

Recorded levels of Total Phosphorus and Nitrate-Nitrogen exceeding Provincial Water Quality Objectives 1.5 km offshore of Applewood Creek may be influenced by discharge from Etobicoke Creek or G.E. Booth WWTF. High *E. coli* closer to shore in front of Applewood Creek likely reflects high *E. coli* concentrations from Etobicoke Creek discharge that moves along the shore by waves and current.

Detailed bathymetric (i.e. underwater depth/topography) surveys in this area reveal a deep drowned valley feature, a shallow submerged shelf, and a steep drop off in this coastal reach providing some bathymetric relief and roughness. It is relatively deep directly in front of the G.E.Booth WWTF and shallower to the east, with the accumulation of sand in the nearshore at the foot of the beach. The open coast environment and lack of protection by piers or headlands to the east of this coastal reach results in harsh environmental conditions that limit the area's ability to support a resident fish community.

Fish surveys have identified an abundance of Emerald Shiner in this coastal reach. Low numbers of Spottail Shiner (*Notropis hudsonius*), Alewife and Longnose Dace have been recorded, and transient species such as White Sucker, Common Carp, and Smallmouth and Largemouth Bass have also been caught occasionally. Fish sampling in the 1 - Lakeview Coastal Reach shows the lowest number of fish species in the study area (Figure 3-35, pg. 113). Fish biomass (by year) at open coast sites in the 1 - Lakeview Coastal Reach ranged from 78 g to 94,449 g (including Common Carp) between 2008 and 2014 (Figure 3-36, 113).

Etobicoke Creek likely plays an influential role in species occurrence and use of the 1 - Lakeview Coastal Reach. The dynamics between Etobicoke Creek and the study area are beyond the scope of this study. However, it is likely that fish species within Etobicoke Creek would be suitable for re-colonizing Serson Creek once access is re-established. Fish movement along the shoreline is interrupted at the OPG piers. Fish must move into deeper and colder waters to get around the piers, potentially increasing their exposure to prey species. This makes it unlikely that fish could re-colonize Serson Creek without assistance.

Chironomids and dreissenid mussels are also likely ingested by the Long-tailed Duck (*Clangula hyernalis*), Common Goldeneye (*Bucephala clangula*) and Bufflehead (*Bucephala albeola*) recorded in this coastal reach.

Summary

Habitat quality and connectivity are key issues in the 1 - Lakeview Coastal Reach, both on land and in the lake and tributaries. The creation of “sinks” (i.e., dead-ends for wildlife movement) should be avoided (or mitigated) to reduce human-wildlife conflicts. Existing linkages from the lake to Marie Curtis Park, between Serson Creek and Applewood Creek through LV2, and between Applewood Creek and Marie Curtis Park should be maintained and invasive species managed to improve habitat quality. Improved terrestrial connectivity to Lakefront Promenade Park is needed. Terrestrial habitat improvements should address stopover needs of migratory birds.

With Serson Creek having one of the highest number of flood-vulnerable structures of the tributaries assessed in the LOISS study area and with wetland not well represented, this Coastal Reach requires improved retention through water management. Introducing wetlands will help to both retain water, reducing flood-risk and increasing habitat. The benefits of green infrastructure implementation to manage storm water increase the further up into the watershed they are located. Conversely, habitat benefits from wetland creation will increase depending on connectivity between complementary habitat types.

The following opportunities should be explored in greater detail for 1-Lakeview Coastal Reach through the Implementation report:

Opportunities: 1-Lakeview Coastal Reach	**Notes**
Improve Habitat Quality	
• Create higher quality nesting habitat for Bank Swallows currently using ash lagoons at G.E. Booth WWTF	Bank Swallow nesting habitat has been included in the design for Lakeview Waterfront Connection
• Create higher quality foraging habitat for shorebirds currently using mud flats at G.E. Booth WWTF ash lagoons.	Mudflats (foraging habitat for shorebirds) may be available for use at Lakeview Waterfront Connection during some seasons depending on water levels in the marshes.
• Create higher quality foraging habitat for bats currently using G.W. Booth WWTF ash lagoons	Wetlands at Lakeview Waterfront Connection will provide a source of insects once established
• Improve instream habitat in Serson and Applewood Creeks by increasing diversity of structures and bed form as appropriate.	Instream habitat diversity is included in the design for Serson Creek and Applewood Creek works associated with Lakeview Waterfront Connection
• Increased diversity and cover of riparian zone on Serson and Applewood Creeks. Softer, natural bank treatments should be implemented where feasible.	Diverse planted riparian zones are included in the design of the creek works associated with Lakeview Waterfront Connection
• Create in-water fish habitat (e.g. substrate, structures, etc.) in the nearshore of 1 – Lakeview Coastal Reach where bedrock dominates.	Fish habitat features (e.g., cold water shoals, wetlands, cobble substrate, reefs, etc.) have been incorporated in the design of Lakeview Waterfront Connection
• Increase cover of wetlands in the coastal reach	Three coastal wetlands are being created through Lakeview Waterfront Connection

Manage Existing Habitats	
• Manage invasive species in deciduous and cultural woodlands and cultural meadows in the southern and eastern areas of the coastal reach.	
• Manage invasive species on treed beach ridge on east side of Applewood Creek.	
Connect Habitats	
• Maintain existing terrestrial connectivity between Serson Creek, G.E Booth woodland (LV2), Applewood Creek, and Marie Curtis Park.	
• Maintain connectivity between Lake Ontario and beach and forest at Marie Curtis Park.	
• Improve wildlife connectivity along the shoreline between Lakefront Promenade Park and Marie Curtis Park and Lake Ontario	Wildlife connectivity will be improved through habitat creation associated with Lakeview Waterfront Connection
• Improve cover and small stepping stone habitat to create terrestrial connectivity between Lakefront Promenade Park and Serson Creek.	
• Improve fish passage from the lake to the upper reaches of Serson Creek for spawning, feeding and rearing.	Access from the lake to Serson Creek will be improved through Lakeview Waterfront Connection and proposed changes to crossing at Lakeshore Road.
• Undertake feasibility study regarding improvements to longshore movement of fish and substrates to and from adjacent coastal reaches	
Manage Stormwater quality and quantity	
• Reduce flooding of structures in Serson Creek through improved flow conveyance and other methods (e.g. improve stormwater management, remove structures, etc.).	
• Continue real-time stream flow monitoring on Serson Creek and Applewood Creek	
• Implement stormwater management quality controls on Serson and Applewood Creeks to reduce impacts of phosphorus, *E. coli* and nitrates in the nearshore of Lake Ontario.	
• Undertake a study to determine the extent and effect of flood spill from Etobicoke Creek to adjacent watersheds.	Currently under discussion between CVC, TRCA and City of Mississauga
Outreach, Education, Communications	
• Efforts should focus on stormwater management for residential landowners, including Low Impact Development for water quantity control and water quality	

improvements (particularly regarding Phosphorous, *E. coli*, and Nitrates).	

4.2 2 - LAKEFRONT PROMENADE COASTAL REACH

2 – Lakefront Promenade Coastal Reach encompasses the former OPG lands from the eastern breakwater and west bank of Serson Creek storm flow channel to the west side of RK McMillan Park (Figure 4-2). Atwater Avenue constitutes the northern boundary of this coastal reach, truncating the original watershed boundary of Cawthra Creek. Cawthra Creek upstream of Atwater Ave now flows into Cooksville Creek in 3 – Mineola Coastal Reach.

The breakdown of land cover in the 2 - Lakefront Promenade Coastal Reach is as follows:

Open Space	12.1%
Natural	17.3%
Cultural Meadow	12.2%
Cultural Savannah	3.0%
Cultural Thicket	1.1%
Cultural Woodland	1.1%
Commercial	37.6%
Residential	29.6%
Other	3.2%

The majority of the coastal reach is dominated by a combination of mostly commercial and some residential land uses (Figure 4-2).

Terrestrial, Wetland, and Riparian Habitat

Although habitat quality is generally poor (e.g. non-native species with low species diversity) along the shoreline in the coastal reach, the public parks between Cooksville Creek and Lakefront Promenade provide unimpeded east-west access through much of the 2 - Lakefront Promenade Coastal Reach. Industrial lands at the eastern edge of this reach may prevent some species from migrating east along the shoreline to the 1 - Lakeview Coastal Reach due to lack of cover or stepping stone habitat.

Residential development impedes north-south linkages to the higher quality habitat in Cawthra Woods, now considered part of Coastal Reach 3 – Mineola. A narrow band of vegetation along Cooksville Creek to the west may be suitable for species to migrate north. Connections between Cooksville Creek and Cawthra Creek through Lyndewood and Dellwood Parks are considered inadequate for most species to reach Cawthra Woods. There are no woodlands in 1 - Lakefront Promenade Coastal Reach. The few areas of upland habitat (e.g. cultural meadow) are of poor quality, providing little in the way of cover and food sources for wildlife.

The sand, gravel and cobble beaches of the constructed beach in the Lakefront Promenade Park 'thumb basin' (Figure 4-2) provide barrier-free access between the lake and upland areas. Waterfowl and shorebirds have been observed using this area for nesting, wading and feeding. However, species numbers and diversity are relatively low (Figure 3-47, pg. 140; Figure 3-49, pg. 149). This may be caused by the presence of people rather than the availability of suitable habitat. Landbird surveys reflect a similar condition (Figure 3-37, pg. 116). While little is known about the use of this area by amphibians and reptiles, it is unlikely these groups are present in significant numbers, if at all, due to the highly altered condition of the surrounding tableland. These tablelands adjacent to the thumb basin consist of high use recreational parks including sports fields and marinas.

The Lakefront Promenade basin, created by the wave breaks around the marina, is deeper and more disturbed by boat traffic compared with the 'thumb basin'. The shoreline of this area is also disconnected from the tableland by armoured walls and wave breaks. These characteristics also prevent the establishment of aquatic vegetation through most of the basin.

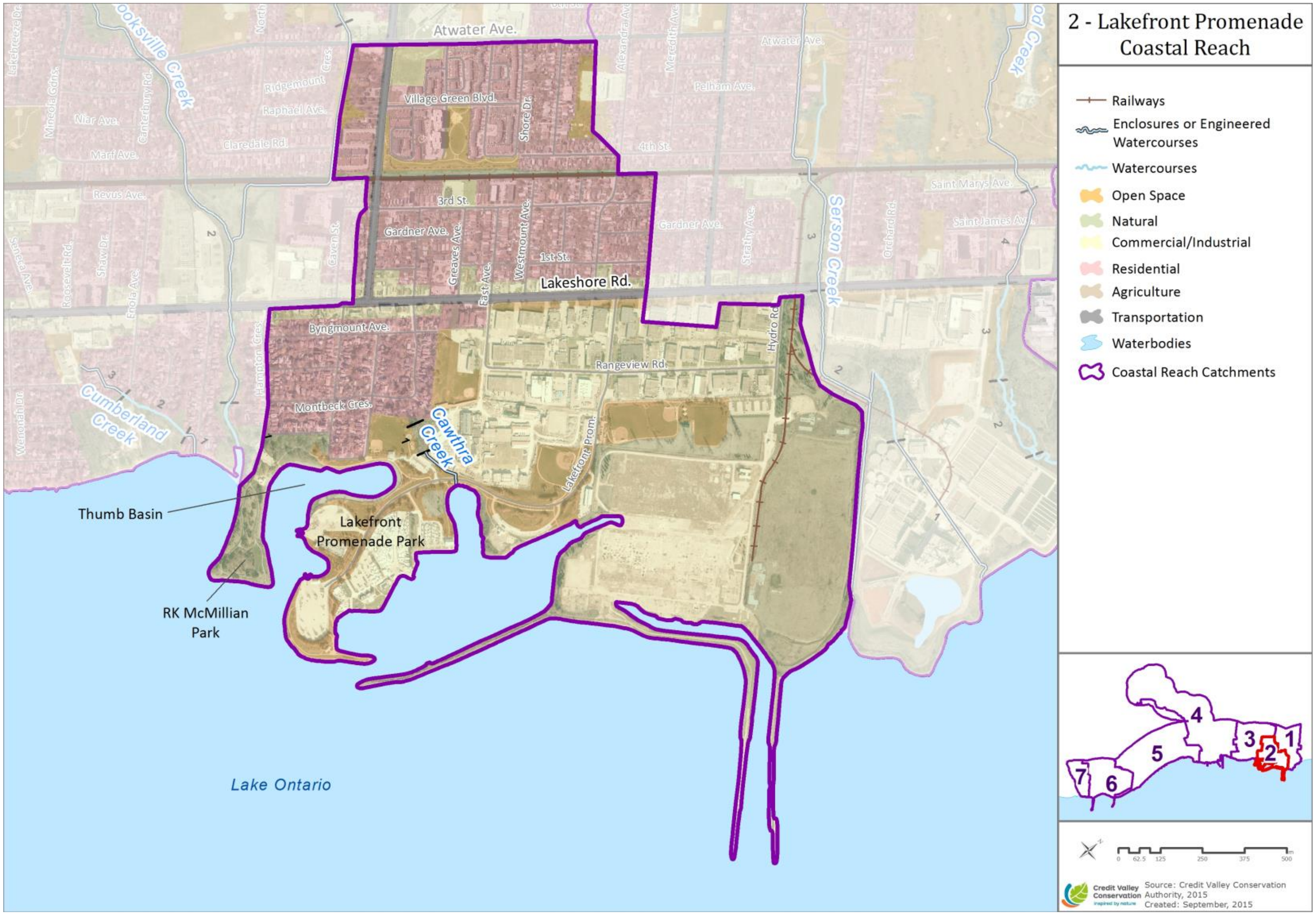


Figure 4-2: 2 - Lakefront Promenade Coastal Reach: Land Use (Source: CVC)

Cawthra Creek

Given the diversion of the Cawthra Creek watershed north of Atwater Ave. to Cooksville Creek, the Cawthra Creek watershed considered to be in 2 - Lakefront Promenade Coastal Reach is only a portion of its original watershed.

In the remnant channel of Cawthra Creek, flows less than 20m^3/s (below the 100-year event) are conveyed through sewer pipes. This stream is intermittent, flowing only during storm events. Cawthra Creek is above-ground through A.E. Crookes Park (Figure 2-2) and is piped again under Lakefront Promenade Road and discharges into the protected embayment of Lakefront Promenade Marina. This 95-m open stream reach of Cawthra Creek is undergoing planform (meander geometry) adjustment and has been straightened through a 10-m vegetated corridor. The piped stream reach discharging to the lake prevents fish migration into the channel. The fish and benthic macroinvertebrate habitat within the channel is poor, with very little structure and substrate variation.

Lake Ontario

Approximately 14% of this shoreline is in a naturalized state, largely due to the constructed sand beach at Lakefront Promenade Park. The remaining shore is hardened with armourstone, rip rap, and concrete walls. The shoreline structure assessment identified areas within the Lakefront Promenade Marina and R.K McMillan Park that are deficient and will need maintenance in the future. Opportunities to integrate fish habitat structures with shoreline protection works in the Lakefront Promenade Marina and thumb basin were identified in the study.

Two protected embayments, the thumb basin and Lakefront Promenade Marina embayment, are isolated from many nearshore processes and conditions. Protection from the long eastern breakwater prevents sediment from entering the marina, making dredging an infrequent occurrence. The wave breaks and headlands protect the basins from prevailing current from the east, reducing circulation of water between basin and lake, creating a more static erosion and deposition regime within the basins. However, in the absence of significant stream discharge, water levels in the basins depend entirely on lake levels. These basins are one of the few places in the LOISS study area where ice forms.

The calm, shallow waters of the 'thumb basin' created by the Lakefront Promenade Marina and the R.K. McMillan Park headland allow the water to warm up, and protection from waves provides suitable conditions for the establishment of aquatic plants and creation of a shallow water wetland. Given the rocky revetment along most of the water's edge, the managed nature of the sand-and-gravel beaches and overgrazing by geese, little emergent and wetland fringe vegetation has established along the sand, gravel and cobble shoreline. Further, the presence of geese at this location may contribute to higher levels of phosphorous in the water during rain events. The 75th percentile for total phosphorous concentration (0.036mg/L) for the thumb basin is slightly elevated over the Provincial Water Quality Objective (PWQO) of 0.03 mg/L.

The fish community assemblage in the basin includes Northern Pike, Large and Smallmouth Bass, Yellow Perch, Rock Bass (*Ambloplites rupestris*), Emerald Shiner, and Alewife, most of which are typical of warmwater, lentic environments. Rock Bass, Smallmouth Bass and Yellow Perch have similar habitat requirements including cool, calm waters, with rocky substrates and large cover structures including docks and piers. Northern Pike require aquatic vegetation for camouflage, hunting and reproduction. The embayments in 2 - Lakefront Promenade Coastal Reach meet the diverse habitat requirements of the fish species present; however, the thermal regime of the embayments is not well understood. All indicators suggest that the embayments functions as warmwater fish habitat however, coldwater upwellings that occur periodically on the lake through summer months may penetrate into the embayments creating thermal regimes outside the tolerable ranges for warmwater fish. Potential areas of refuge from such thermal changes are also unknown. Habitat enhancement projects within the basin have created micro-niches that complement the existing wetland and shallow bay habitat. These enhancements have increased the amount of cover and rocky substrates desired by fishes in the embayments. Two small wetlands have been identified in the western area of the marina, and the fish community assemblage within the marina is similar to that of the thumb basin.

The average fish biomass (by year) in the Lakefront Promenade embayment (average 50,725 g; range: 25,059 g to 76,077 g) was more than three times that of open coast sites (average 14,445 g; range: 875 g to 43,508 g) in the coastal reach between 2008 and 2011.The embayment is highly productive relative to open coast.

Very little is known about aquatic habitat characteristics beyond the Lakefront Promenade breakwater. This area is considered open coast habitat and likely supports transient fish and coldwater fish that use the shoreline for spawning and feeding.

Summary

Terrestrial habitat quality is poor in 2 - Lakefront Promenade Coastal Reach, although wildlife connectivity to adjacent coastal reaches appears unobstructed. Aquatic habitat in the basin and marina is diverse and supports Fish Community Objectives for Lake Ontario (Stewart et al. 2013) target species for nearshore embayment habitats such as pike, bass, sunfish, and perch. The hardened shoreline through much of this coastal reach is an impediment to wildlife movement between the lake and upland habitats. Opportunities to enhance upland habitat quality (particularly for amphibians, reptiles, and migratory birds) and transitional habitats (between the lake and uplands) should be explored. The condition of fish habitat enhancements previously implemented is needed to determine the need for additional habitat improvements. Embayments and wetlands are highly productive fish habitats and should be optimized to the extent feasible.

The following opportunities should be explored in greater detail for 2 - Lakefront Promenade Coastal Reach through the Implementation report:

Opportunities: 2-Lakefront Promenade Coastal Reach	Notes
Improve Habitat Quality	
• Improve terrestrial habitat quality (cover and food sources) by increasing diversity of native species in upland areas connecting Cooksville Creek and Lakefront Promenade.	
• Increase cover of woodlands throughout this coastal reach.	

• Create fish habitat (e.g., spawning, rearing, feeding, cover) along existing shoreline erosion structures. Incorporate fish habitat features in design for repair and replacement structures.	
• Increase diversity of aquatic plants (i.e., emergent, floating, etc.) in thumb basin and other protected areas of Lakefront Promenade basin.	
• Conduct a study to determine thermal refuge areas within the Lakefront Promenade basin to inform fish species targets.	
• Increase diversity of open water habitats (e.g., cover, vegetation, shoals, etc.) for suitable target fish species (to be determined based on future study of thermal regime).	
• Investigate habitat conditions beyond the Lakefront Promenade breakwater (e.g., substrate type, size and coverage, unique features, existing fish usage).	
Manage Existing Habitats	
• Investigate potential to isolate areas of Lakefront Promenade basin from boat traffic to encourage aquatic plant growth and use by fish.	
• Investigate potential to create isolated (i.e., no human presence) nesting, wading and feeding habitats for waterfowl, shorebirds and landbirds.	
• Continue to support the City of Mississauga in implementation of the Canada Goose Managment program, including habitat modification as a deterent.	
Connect Habitats	
• Maintain connection between Cooksville Creek and Lakefront Promenade Park	
• Improve terrestrial connection between Lakefront Promenade Park and 1-Lakeview Coastal Reach by increasing cover and creating stepping stone habitat.	
• Maintain Cawthra Creek from Lakefront Promenade Marina through A.E. Crookes Park as stormwater management.	
• Maintain connection between existing naturalized beach at Lakefront Promenade Park and Lake Ontario	
Manage Stormwater quality and quantity	
• Investigate potential to implement stormwater quality control on private lands draining to Cawthra Creek discharging through A. E. Crookes Park to Lakefront Promenade Marina.	
• Repair or replacement of priority shoreline erosion structures at Lakefront Promenade Park (see Table 3-17).	
Outreach, Education, Communications	

• Efforts should focus on impacts of feeding geese, recreational fishing opportunities, interpretive signation at Lakefront Promenade Park, lot-level stormwater management, and urban residential support for migratory birds, bats, and butterflies.	

4.3 3 – MINEOLA COASTAL REACH

3 – Mineola Coastal Reach extends from Port Credit Village Marina at the mouth of the Credit River to the west side of R.K. McMillan Park and encompasses the Cumberland Creek and Cooksville Creek (with Cawthra Creek diversion) watersheds. 3 – Mineola Coastal Reach has the least amount of natural cover along its shoreline and provides little in the way of connections between the Credit River and higher quality habitats to the east.

The breakdown of land cover in 3 – Mineola Coastal Reach is as follows; the majority of this coastal reach is dominated by residential land uses (Figure 4-3):

Open Space	6.9%
Natural	10.7%
Wetland	0.1%
Woodland	5.8%
Cultural Meadow	1.4%
Cultural Savannah	0.1%
Cultural Thicket	0.3%
Cultural Woodland	3.0%
Commercial	11.5%
Residential	67.9%
Other	3.0%

Terrestrial, Wetland, and Riparian Habitat
There are few west-east linkages in 3 – Mineola Coastal Reach connect 4 – Port Credit Coastal Reach to 2 – Lakefront Promenade Coastal Reach. Private property and hardened shorelines likely impede west-east migration, particularly for larger mammals (e.g., White-tailed Deer, Coyote). With the exception of the beach at Cooksville Creek and a small cobble beach adjacent to Tall Oaks Park, totalling about 5% of the shoreline, 3 – Mineola Coastal Reach is dominated by hardened shoreline including riprap, concrete and steel sheetpile walls along a portion of St. Lawrence Park.

The narrow Cooksville Creek corridor provides the only north-south terrestrial linkage in this coastal reach. Although Cooksville Creek receives flows from neighbouring Cawthra Creek, the terrestrial linkage between these watersheds is limited, reducing the ability of mammals and other wildlife to access Cawthra Woods. Cawthra Woods supports higher quality habitat than many of the urban woodlands in Mississauga, including deciduous forest, swamps, and vernal pools.

No landbird, waterfowl, or shorebird surveys were conducted in the reach since suitable habitat is limited.

Cumberland Creek
The Cumberland Creek watershed has been highly altered by development, so the creek primarily conveys flows from storm sewers. The upper stream reach of Cumberland Creek is piped under a residential subdivision. The middle stream reach remains open and confined in a small vegetated valley before entering a pipe under another residential development and discharging to Lake Ontario. Fish are unable to access this stream from Lake Ontario, as the mouth of the stream is a perched pipe.

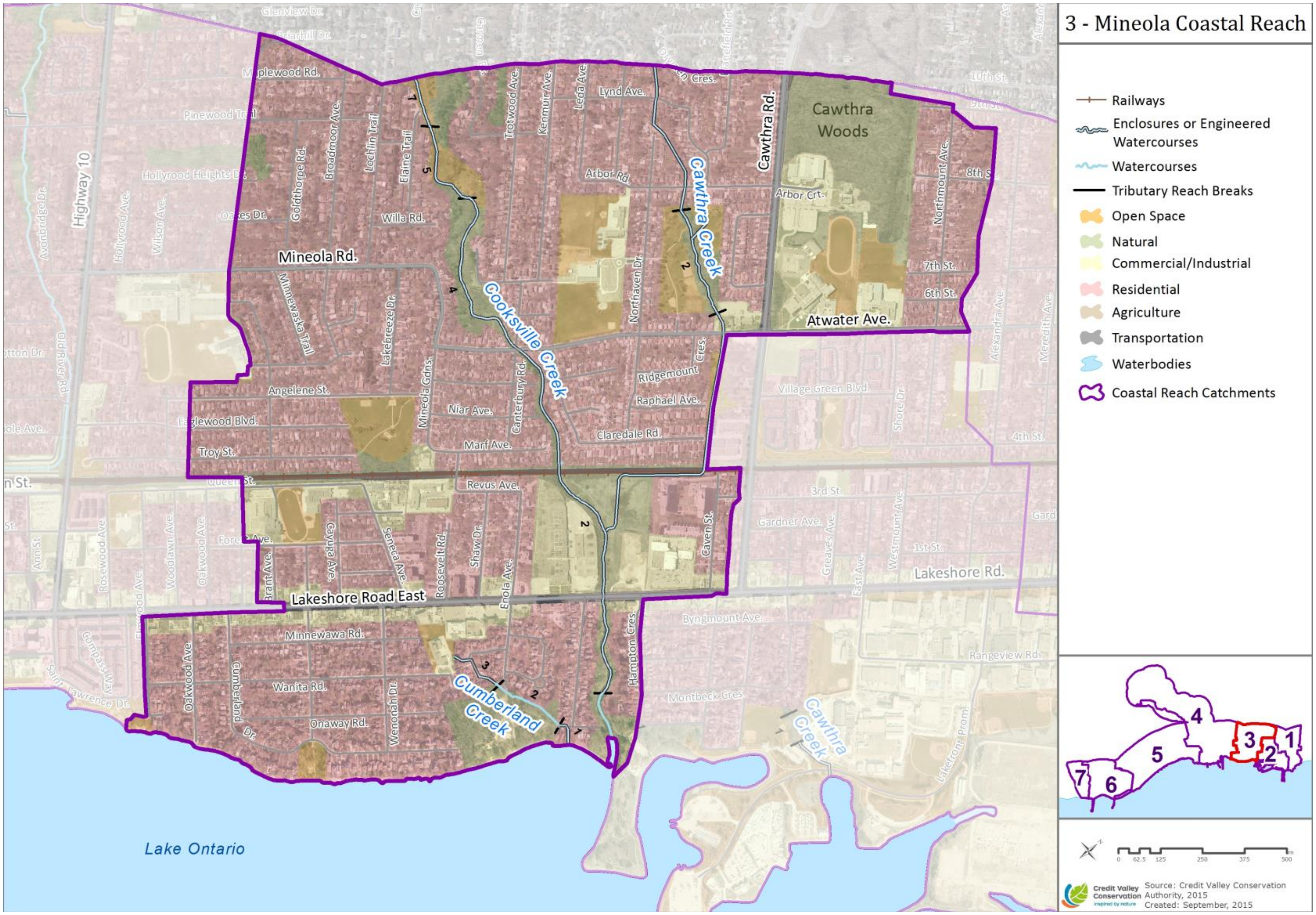


Figure 4-3: 3 – Mineola Coastal Reach: Land Use (Source: CVC)

Cooksville Creek

Cooksville Creek was not studied as part of the LOISS due to the extensive existing studies on this stream. However, information from these studies has been incorporated in this report as needed to provide context and information related to the occurrence of species and associated functional relationships.

Upstream diversions of flows from adjacent watersheds, including Cawthra Creek, have increased the drainage boundary and flows of Cooksville Creek. The 2-year event flow for Cooksville Creek is 80 m^3/s. This, combined with the highly developed nature of the Cooksville Creek watershed right up to the banks (i.e. development within the floodplain), has resulted in Cooksville Creek having the highest number of flood-vulnerable structures (133 structures) of all tributaries in the LOISS study area (Figure 3-5).

Cooksville Creek in its present-day form is channelized over most of its length (92%) (Table 4-1) through a variety of methods and materials, including gabion baskets, concrete, rip-rap, armourstone and grass lining. Few natural stream sections exist in this watershed. Engineered channel has been installed to increase stability and reduce flooding. Fairly well-vegetated banks provide shade and organic inputs to the stream.

Table 4-1: Summary of Creek Bed Materials

Channel Lining Material	Watercourse Length	% of Total Length
Gabion Baskets	3.5 km	24 %
Concrete	1.7 km	11 %
Natural (eroded)	1.2 km	8 %
Armourstone	2.4	16 %
Grass – Trapezoidal	6.4	41 %
Total	14.9 km	100 %

Cooksville Creek is actively adjusting through erosion on its bed and banks (i.e. degradation and widening). These two processes have combined to create an over-sized cross-section to accommodate urbanized peak flow events but, for most of the year, Cooksville Creek supports minimal baseflows. The *Tier 2 Credit River Source Protection Area* (AquaResources 2009) report suggested Cooksville Creek may receive groundwater contributions. This has not been supported by baseflow and water temperature field studies. These two primary modes of channel adjustment have also resulted in the extensive failure of bank and bed protection throughout the stream due to undermining and outflanking. Existing and historic land use practices and channel modifications within the Cooksville Creek watershed have combined to create a watercourse that is not stable in the long term.

Cooksville Creek is considered sediment starved (CVC, 2010 unpublished) due to the heavily armoured bed and banks that reduce natural erosion and deposition. What sediment it does carry has a high pollutant load. Screening level sediment quality studies identified sediment from Cooksville Creek exceeded Probable Effect Limits for total DDE, Phenanthrene, Pyrene, Benz(a)anthracene (Table 3-11). The sources of these compounds are likely agricultural activity, fossil fuels. As a result, only low quantities of very fine sediment are transported from stream sources to Lake Ontario. Conversely, runoff from developed areas increases the suspended sediment in the stream during rainfall events due to limited stormwater management. In turn, Cooksville Creek is also noted as having the highest modelled contribution of total phosphorus per unit area (1.11 kg/ha) in the study area. Monitoring revealed *E. coli* concentration in Cooksville Creek exceed provincial objectives and specific conductivity is high, which indicates chorlide (road salt) presence and reflects the influence of urban land use.

Cooksville Creek likely provides spawning habitat for some lake resident forage species such as Lake Chub, Alewife and Emerald Shiner. It also has a large run of migratory White Suckers in the spring and sees a small number of migratory salmonids enter the stream in the spring and fall. Access for most lake species ends at a barrier located at the rail tracks upstream of Lakeshore Road, with some jumping species making it up to Atwater Avenue and a few making it further upstream.

Lake Ontario

The almost entirely engineered shoreline in 3 – Mineola Coastal Reach is heavily exposed to the erosive forces of waves from the east. Erosion protection structure on the west side of RK McMIllan headline have been identified as needing repair (Table 3-17). Substrate sampling in transects perpendicular to the shoreline in this coastal reach reveal the presence of cobble nearshore substrates of unknown source. One of the only natural shoreline areas in the coastal reach is a sand beach at the mouth of Cooksville Creek. Although it acts like a dynamic beach, it does not meet the length criteria to meet the Province of Ontario's definition of a regulated "dynamic beach" (SEL 2011). Although the sediment from Cooksville Creek likely adds to this formation, a counter-clockwise current between Crozier Court, R.K. McMillan Park, shallow water which reduces erosion from waves, and protection of the R.K McMillan headland to the east enables formation and maintenance of this beach. Larger storm events from Cooksville Creek periodically push the beach substrate further out into the lake only to be caught in the prevailing current and pushed back to reform the beach. Over time, substrate is lost to littoral movement to the west and to depths beyond the zone of the local current (Davidson-Arnott pers. Comm. 2012). This dynamically stable sand beach west of the mouth of Cooksville Creek transitions to the predominantly cobble and bedrock dominated nearshore. There is also a small sand beach at Tall Oaks Park and sand accumulation downdrift of St. Lawrence Park in this coastal reach.

It is unlikely that this high-energy (e.g., wind and waves) open coast environment provides suitable habitat conditions for a resident fish community, suggesting that fish found here are transitory. Alewife and Emerald Shiners were relatively abundant in all sampling events. An assemblage of benthic fish species has also been recorded including Brown Bullhead, Common Carp, White Sucker and Round Goby. The most diverse assemblage of fish species in 3 – Mineola Coastal Reach exists between the seawall (sheetpile wall) and gazebo at Tall Oaks Park at the west end of this coastal reach. Salmonids are regularly found here, and the uncommon Longnose Sucker and Longnose Gar were also captured here. The bathymetry may be part of the reason why uncommon species for the LOISS shoreline are found in this area. Wave analysis suggests that a deeper valley formation in this area may provide unique habitat for fish that are rare in the shallow bedrock dominated nearshore waters of the study area (R. Davidson-Arnott pers. Comm, 2012). This deep valley area may be used as a refuge for pelagic species more commonly found in deeper areas of Lake Ontario.

Fish biomass (by year) for the open coast sites in 3 – Mineola Coastal Reach ranged from 1,903 g to 56,685 g (from 2008 to 2014). The station at the mouth of Cooksville Creek is a major contributor to the coastal reach biomass.

Summary

There is very little terrestrial habitat in 3 – Mineola Coastal Reach, with the exception of Cawthra Woods. East-west connectivity to adjacent coastal reaches is limited along the shoreline as well as inland. North-south linkages are confined to Cooksville Creek corridor. Opportunities to enhance habitat for migratory birds in municipal parks should be explored. Fish habitat, both in the lake and streams, has been highly impacted by erosion protection structures. Fish habitat enhancements to mitigate impacts of hardened shorelines and stream beds and banks should be pursued. Flooding in Cooksville Creek remains a high priority for mitigation efforts.

The following opportunities should be explored in greater detail for 3 – Mineola Coastal Reach through the Implementation report:

Opportunities: 3-Mineola Coastal Reach	Notes
Improve Habitat Quality	
• Create habitat (e.g., foraging, spawning, rearing) for fish along hardened Lake Ontario shorelines (e.g., rip rap and concrete structures, steel sheet pile walls)	
• Improve instream fish habitat (e.g., cover, woody material, diverse bed form, softer bank treatments, etc.) in Cooksville Creek using natural channel principles.	
• Identify opportunities to create wetlands throughout this coastal reach	
• Identify opportunities to increase forest cover throughout this coastal reach (e.g. Cawthra Woods).	
• Investigate opportunities to enhance open coast habitat for coldwater fish species (e.g., enhance existing habitats at the mouth of Cooksville Creek and in front of St. Lawrence Park)	
Manage Existing Habitats	
• Maintain existing beaches at mouth of Cooksville Creek, Tall Oaks Park and downdrift of St. Lawrence Park.	
• Maintain Cumberland Creek as stormwater management.	
• Study fish use of the nearshore at St. Lawrence Park to inform habitat enhancement and/or protection.	
• Continue to support the City of Mississauga in implementation of the Canada Goose Management program, including habitat modifications as a deterrent.	

• Continue monitoring hydrology at Cawthra Woods Provincially Significant Wetlands and identify enhancement opportunities	
Connect Habitats	
• Expand and improve the quality (e.g., increase native species, reduce hardened surfaces, etc.) of riparian areas of Cooksville Creek to improve connectivity from Lake Ontario to Cawthra Woods.	
• Examine opportunities to create east-west linkages to connect Lakefront Promenade Park to the Credit River.	
• Mitigate fish barrier at CN tracks on Cooksville Creek to improve fish passage from Lake Ontario.	
Manage Stormwater quality and quantity	
• Reduce flooded structures on Cooksville Creek by improving conveyance, removing structures from flood prone areas, reconnecting Cooksville Creek to its floodplain and other methods.	
• Continue real-time flow monitoring on Cooksville Creek	
• Conduct geomorphic study of Cooksville Creek to provide recommendations to improve channel function.	
• Create stormwater management and creek restoration master plan to address current and future stormwater quantity and erosion impacts to Cooksville Creek.	
• Implement stormwater management to reduce impacts of phosphorus, and *E. coli* on Cooksville Creek.	
• Monitor, repair and replace priority erosion structure at mouth of Cooksville Creek and RK McMillan headland (Table 3-16).	

Outreach, education, communications	
• Efforts should focus on supporting migratory birds, bats, and butterflies, water quality controls including Low Impact Development in residential areas draining to Cooksville Creek	Consider Community-based Social Marketing to engage shoreline (private) landowners

4.4 4 - PORT CREDIT COASTAL REACH

4 - Port Credit Coastal Reach consists primarily of the mouth of the Credit River. New studies on the Credit River were not undertaken as part of LOISS; however, the ecological functions and habitats within 5 km upstream of the mouth of the Credit River were included to identify contributions and functional relationships between the river and Lake Ontario.

The majority of this coastal reach is dominated by residential land uses (Figure 4-4):

Open Space	11.9%
Natural	23%
Wetland	0.3%
Woodland	11.7%
Cultural Meadow	5.5%
Cultural Savannah	1.2%
Cultural Thicket	0.7%
Cultural Woodland	3.6%
Commercial	7.6%
Residential	50.2%
Other	3.6%

Terrestrial, Wetland, and Riparian Habitat

Terrestrial linkages between the Lake Ontario shoreline and the Credit River are weak on both east and west sides of the river. Low density residential subdivisions and armoured banks of the Credit River provide little cover and access for wildlife between JC Saddington and JJ Plaus Parks and upstream to the forested areas of Credit River valley. Development also reduces terrestrial linkage and wildlife corridor functions between this coastal reach and 5 - Lorne Park/Meadowwood and 3 - Mineola coastal reaches to the west and east, respectively.

The terrestrial natural areas within the coastal reach are dominated by deciduous forest and cultural woodlands. Of note is the Stavebank Oak Forest and Tallgrass Prairie near the southern end of the Credit River Marshes includes prairie indicator species such as Black Oak (*Quercus velutina*), Indian Grass (*Sorghastrum nutans*) and Big Bluestem (*Andropogon gerardii*) (CVC 2014).

JC Saddington Park at the mouth of the Credit River is fairly isolated from other natural or semi-natural areas. Although high concentrations of migratory landbirds were recorded in the park (Figure 3-47), the armoured shoreline and harsh conditions from waves makes it unsuitable for waterfowl or terrestrial species that require access to water. A small constructed pond in the park provides some species access to water. The City of Mississauga has completed an update to the Master Plan for JC Saddington Park.

Shallow depths due to sedimentation upstream of the CN Rail bridge to just upstream of the QEW overpass has provided suitable conditions for the establishment of the Credit River Marshes coastal wetland complex. These wetlands comprise eight wetland units and are designated as provincially significant by MNRF and as a Centre for Biodiversity by CVC. The marshes themselves support a diverse complex of habitat types, their location, access and structure provide unique habitat for turtles, snakes, amphibians and birds (including waterfowl). The Credit River Marshes rival Rattray Marsh in quality and species richness, providing habitat for reptiles and amphibians including Eastern Milksnakes (*Lampropeltis triangulum*), Common Watersnakes (*Nerodia sipedon*), Snapping Turtles (*Chelydra serpentine*) and Map Turtles (*Graptemys geographica*).

Yellow Floating Heart (*Nymphoides peltata*), an invasive aquatic plant, has been identified in the wetlands. When it forms dense mats, it can shade out other plant species and can cause stagnant, anoxic conditions, driving out fish and other aquatic fauna that need oxygen to survive. Few wetlands exist within the study area upstream of the Credit River Marshes.

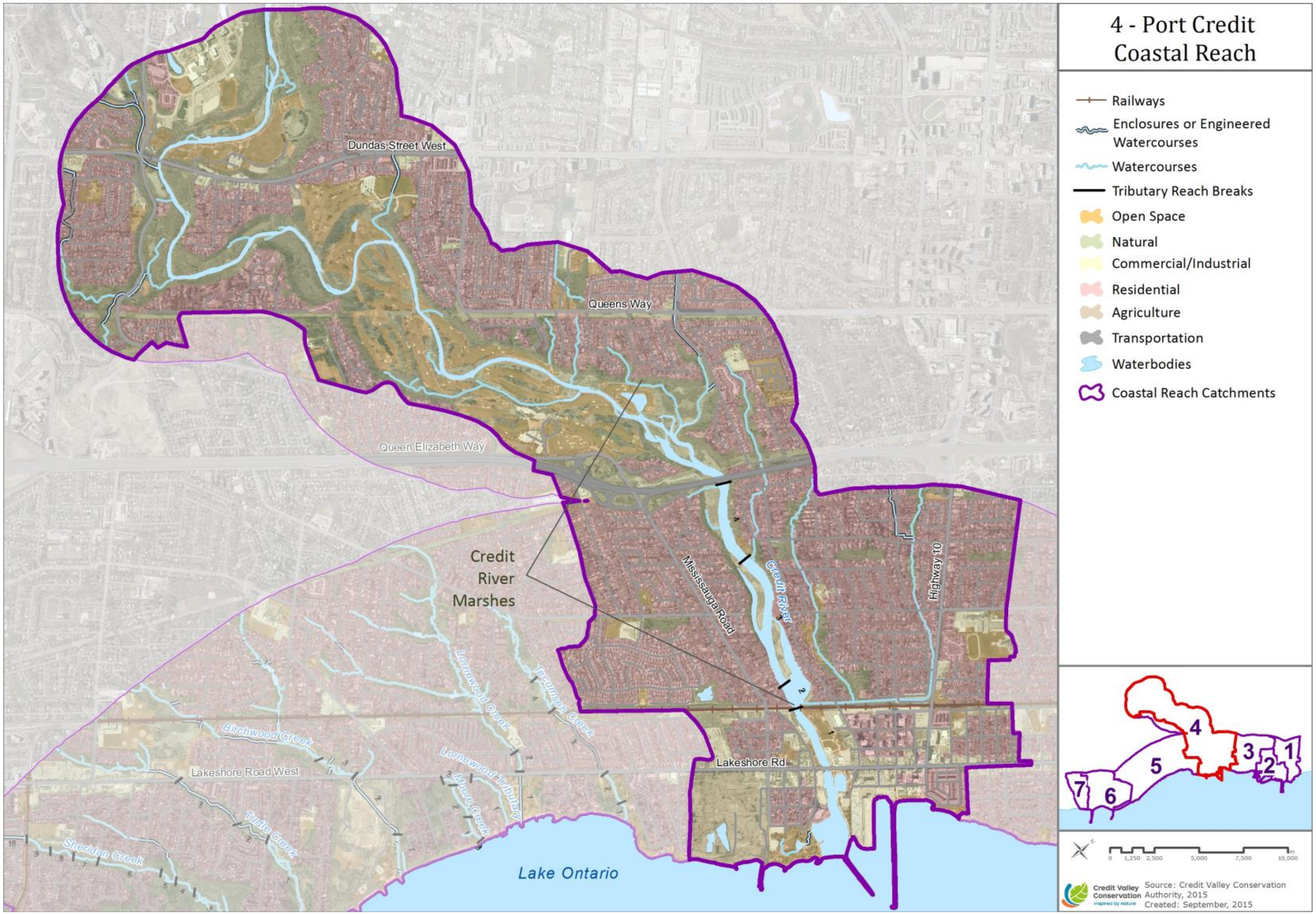


Figure 4-4: 4 - Port Credit Coastal Reach: Land Use (Source: CVC)

As with the broader study area, large numbers of waterfowl, gulls and terns are found in sheltered areas of this coastal reach. In fact, a colony of Common Tern (*Sterna hirundo*) was found at the mouth of the Credit River nesting on the roof of the Port Credit Harbour Marina. This colony represents approximately 20% of the Great Lakes population (Moore, pers. comm., 2014). The Canadian Wildlife Service undertook the creation of some artificial nesting platforms on the Ridgetown, a sunken lake freighter located at the mouth of the Credit River, in an attempt to attract some of the Common Terns to a location where there would be fewer conflicts with marina users. To date success has been limited, likely because the habitat on the roof of the Port Credit Harbour Marina is still accessible to the terns.

Credit River

The banks of the Credit River are armoured (e.g., armour stone, steel seawall) up to and slightly beyond Lakeshore Road, reducing riparian habitats, functions and access (for fish as well as floodwaters) to the floodplain. Upstream of Lakeshore Road to the CN Rail tracks, the banks are predominantly natural with the exception of a few private docks and minor riprap bank stabilization.

Interactions between lake and river are evident in this area. River depth becomes shallower towards the mouth, as sediment transported from upstream meets slower moving waters from the lake and begins to settle out. Ice formation in the river provides some protection from wave propogation from the lake into the river in the winter. Deposition of materials at the mouth of the Credit River means a regular need for navigation dredging to maintain boat access to the marina. The Credit River Harbour Sediment Study (Geomorphic Solutions, 2012b) classified sediment in the mouth of the Credit as sand and silt, although dominant underlying substrate at the mouth of the Credit River is predominantly shale.

Despite the settling (i.e. deposition) of finer sediment at the mouth of the Credit River, monitoring and modelling revealed the Credit River as the largest contributor of total suspended solids in the study area with a modelled annual contribution of 226,676 tonnes. Unsurprisingly, the Credit River also contributes the highest concentration of total phosphorous. Particulate phosphorus can bind to sediment, enabling it to become mobile. Elevated chloride concentration at the Credit River creates conditions where the total phosphorous plume reaches deeper into the lake; up to 14 m depth, approximately 1.5 km offshore. The Credit River is one of the largest contributors of phosphorous in western Lake Ontario.

The rivermouth (between Queen Elizabeth Way and Lake Ontario) habitat of the Credit River is unique in the LOISS study area, providing a diversity of habitats in a relatively small area for a wide variety of fish species at different life stages. The Port Credit Harbour Marina is one of only a few areas along the shoreline with aquatic vegetation and associated aquatic refuge areas.

The Credit River Marshes upstream of the CN Rail tracks support Largemouth and Smallmouth Bass, Northern Pike, Rock Bass, Pumpkinseed and Yellow Perch. The calm shallow waters of the Credit River Marshes also provide suitable spawning, rearing and nursery habitat for warmwater migratory and resident fish species. The Credit River Marshes are one of only eleven Centres of Biodiversity identified in CVC's jurisdiction.

Two constructed riffles create turbulent water and deep pools upstream of the Credit River marshes which have the potential to support spawning by Walleye (*Sander* *vitreus*) and Lake Sturgeon (*Acipenser fulvescens*) (Jon Clayton Pers.Com 2017). Lake Sturgeon rarely appear in the Credit River and Walleye are occasional observed or caught in the Credit River mouth. Since these species typically return to the same location to spawn, stocking may be required to re-establish these species in the Credit River.

Many salmonid species have been recorded at the river mouth. Lake species found at the mouth include American Eel (*Anguilla rostrata*), Freshwater Drum (*Aplodinotus grunniens*), Smallmouth Bass, Alewife, Emerald Shiner and Spottail Shiner. Species uncommon to tributaries in the Greater Toronto Area of note that use the Credit River to spawn include Greater and Shorthead Redhorse (*Moxostoma macrolepidotum*), White Bass (*Morone chrysops*) and Rosyface Shiner (*Notropis rubellus*). Total Fish biomass for the open coast site in 4 - Port Credit Coastal Reach ranged from 2,534 g to 58,477 g between 2008 and 2014. In comparison, the rivermouth and embayment fish biomass ranged from 13,763 g to 95,874 g. The total biomass for the rivermouth and embayment sites is largely driven by the biomass of embayment sites which on average constitutes 12% to 80% of the annual total biomass.

Lake Ontario

The shoreline of 4 - Port Credit Coastal Reach is highly engineered, with only 1% left in a natural state. Shoreline protection consists primarily of rock armouring. However, an old transport ship (the Ridgetown) has been installed as a breakwater to protect the marina. Erosion protection structures are under high stress from large waves that break at the shoreline due to deep bathymetry in this area. Waves that would typically break on the shallow lake bottom, thereby dissipating their energy, are breaking on the shoreline structures with greater force. Ice formation at the mouth of the Credit River and in the marinas provides additional erosion protection from winter storms. Erosion protection structures at JC Saddington Park have been identified as priority areas for repairs, maintenance or replacement.

Upon entering the lake (past the marina breakwater), flows and sediment (predominantly silts) from the Credit River are transported to the west past JC Saddington Park, settling as far away as the mouth of Tecumseh Creek. Watershed contributions of sediment and particle-bound phosphorus exceed PWQO guidelines, reducing water quality in the mouth of the Credit River and nearshore of Lake Ontario. Chloride due to road salting is a concern during winter months. Chloride decreases the buoyancy of water in the Credit River increasing potential for plumes to delivery nutrients towards the bed of the lake, which would then be available for Cladophora algae to uptake. Warmer temperatures and nutrient-rich waters of the Credit River estuary also assist algae growth at the mouth of the Credit River and in its flow path into Lake Ontario.

Fisheries research at Port Credit in 1929 recorded 5000 lbs of Burbot (Ling, *Lota lota*) caught in one Lake Whitefish (*Coregonus clupeaformis*) net (Clarkson 1977) and until 1944, 250,000 lbs of Herring (*Coregonus artedi*) were landed in Port Credit each year (Clarkson 1977). Burbot and herring are very uncommon sightings in Port Credit today. Wetlands and sheltered embayments play a key role in reproduction of these species. Aerial photography dating back to 1954 shows the Faulkner Marsh on the east bank of the Credit River estuary extending from the Lake Ontario shoreline to the current CN rail line. The loss of the Faulkner Marsh at the mouth of the Credit River may have reduced spawning of these species in this area.

Shoals have been recorded offshore at the mouth of the Credit, where Lake Trout were known to spawn (Ozolins, pers. comm. 2014). Bull (1934) references a newspaper article from 1927 mentioning how a local fisherman captured a 32.5 lb Lake Trout off Port Credit. Goodyear (1982) also referred to two shoals located offshore of Port Credit where Lake Trout spawned. The status and exact location of these shoals is currently unknown.

Summary

Hardened shorelines in 4 - Port Credit Coastal Reach limit movement of species between aquatic and terrestrial habitats. The narrow band of terrestrial habitat confined to the Credit River Valley limits east-west linkages to adjacent coastal reaches. Opportunities to improve connectivity within and to adjacent areas of this coastal reach should be explored as development occurs.

Impacts from upstream are evident in the water quality modeling results with high chloride, total suspended solids, and phosphorus resulting from cumulating impacts from practices throughout the watershed. Watershed-scale mitigation including agricultural best management practices, winter road maintenance best management practices, and stormwater management controls should be implemented to improve the water quality conditions in the reach.

The following opportunities should be explored in greater detail for 4 – Port Credit Coastal Reach through the Implementation report:

Opportunities: 4-Port Credit Coastal Reach	Notes
Improve Habitat Quality	
• Conduct seasonal fish studies to inform management and restoration of Credit River estuary and embayments	
• Conduct wildlife studies at Credit River Marshes to enhance understanding of habitat functions and usages.	
• Implement terrestrial habitat quality improvements, particularly to support migratory birds, bats and butterflies, including wetland enhancement (Credit River Marshes) and potential wetland creation.	
• Enhance habitat for migratory birds, bats and butterflies at JC Saddington Park	
• Increase diversity of habitats (e.g., cover, vegetation, shoals, etc.) for suitable target fish species (to be determined based on future study of thermal regime) in the Credit River estuary, embayments and open coast.	

• Relocate and improve quality of common tern nesting habitat at Credit Harbour Marina.	
• Investigate feasibility to create shoals off Credit River mouth to enhance existing and historic Lake Trout/Whitefish habitat.	
• Investigate suitability to restore Walleye and Lake Sturgeon habitat at Credit River mouth.	
• Create habitat at mouth of Credit River to support Burbot and Cisco.	
• Create fish habitat (e.g., spawning, rearing, feeding, cover) along existing shoreline erosion structures. Incorporate fish habitat features in design for repair and replacement structures.	
• Pursue recommendations from the Credit River Estuary: Species at Risk Research Project (CVC 2014)	
Manage Existing Habitats	
• Manage Yellow Floating Heart in Credit River Marshes and other invasive species.	CVC initiated discussions with MNRF in 2015. MNRF will not be taking action at this time.
• Protect and enhance important and uncommon habitats (e.g., Stavebank Oak Forest and Tallgrass Prairie, Huron Park Oak Savannah).	
• Continue to support the City of Mississauga in implementation of the Canada Goose Management program including habitat modification as a deterrent.	
• Develop stewardship plan for Credit River Marshes Centre of Biodiversity	Expand on findings of CVC's Credit River Estuary report (2014)
Connect Habitats	
• Examine opportunities to create terrestrial east-west linkages to connect Lakefront Promenade Park to the Credit River	
• Expand and improve the quality (e.g., increase native species, reduce hardened surfaces, etc.) of riparian areas of Credit River to improve wildlife connectivity from Lake Ontario to Credit River Marshes and riverine riparian habitat improvements.	
Manage Stormwater quality and quantity	
• Install a realtime water quality station in Lake Ontario.	

• Conduct year round water temperature monitoring on Credit River and Lake Ontario.	
• Conduct temperature and algae resurgence correlation study on Lake Ontario.	
• Conduct watershed wide sediment and total phosphorus source study and identify opportunities for reduction.	Hot spot Implementation Tool Model under development by CVC. Models priority areas for non-point sources of phosphorus
• Monitor, repair and replace priority erosion structure on Lake Ontario at JC Saddington Park, Port Credit Village Partners Lands, and Credit River Harbour Marina.	
• Continue real-time stream flow and water quality monitoring on the Credit River.	
Outreach, education, communications	
• Efforts should focus on invasive species, healthy stream shorelines, recreational fishing opportunities, water quality best management practices (particularly concerning chloride and phosphorous), support for migratory birds, bats, butterflies, and interpretive signage (e.g., Credit Valley Trail)	

4.5 5 – LORNE PARK/MEADOWWOOD COASTAL REACH

Coastal Reach 5 – Lorne Park/Meadowwood extends from east of Cranberry Cove to the Suncor lands west of Meadowwood Park. This reach is the longest stretch of uninterrupted shoreline in the study area and includes six watersheds: Sheridan Creek (including Rattray Marsh), Turtle Creek, Birchwood Creek, Moore Creek, Lornewood Creek and Tecumseh Creek, as well as a small portion of the Lakeside Creek drainage area.

The majority of this coastal reach is made up of residential land use (Figure 4-5):

Open Space	5.4%
Natural	22.2%
Wetland	2.4%
Woodland	13.1%
Cultural Meadow	2.1%
Cultural Savannah	0.4%
Cultural Thicket	0.3%
Cultural Woodland	3.9%
Commercial	5.3%
Residential	63.1%
Other	3.5%

Terrestrial, Wetland, and Riparian Habitat

The 5 – Lorne Park/Meadowwood Coastal Reach has a high diversity of terrestrial ecosystems. However, some habitat areas are too small to be mapped or have limited functions due to size and shape. The diverse range of habitat types (woodlands, wetlands, open aquatic areas) supports the most diverse assemblage of terrestrial species in the study area, including White-tailed Deer, Muskrat, Beaver, Coyote, Mink, bats, turtles, amphibians and representatives from all studied bird groups, largely due to the presence of Rattray Marsh.

5 – Lorne Park/Meadowwood Coastal Reach has the highest woodland cover of all coastal reaches in the study area. Connected woodlands consisting of deciduous, coniferous and mixed forests, cultural woodlands, swamps and plantations extend across most of the coastal reach south of Lakeshore Road. Its terrestrial features are higher in quality but are threatened by invasive and non-native plant species (e.g. Garlic Mustard (*Alliaria petiolata*), European Buckthorn (*Rhamnus cathartica*), Japanese Knotweed (*Reynoutria japonica var. japonica*), etc.) common to urban areas in the Greater Toronto Area. Invasive and non-native species offer lower quality food sources and decrease resilience of the communities they inhabit.

Natural terrestrial connections along the shoreline are interrupted at Watersedge Park on the west end of this reach, where shoreline access by urban wildlife from the west (6 – Refinery Coastal Reach) transitions to residential development, extending to the shoreline edge. The park provides natural cover to funnel terrestrial wildlife north (away from residential areas), where east-west connections are re-established, providing access to Rattray Marsh. Shoreline connections continue to the east, terminating at the eastern edge of Lorne Park Estates.

The bird species present in the surveyed open country and grassland habitats are not typical of these habitats, which may in part reflect the small size of most grassland habitat in this coastal reach, the use of this area as stopover habitat rather than permanent nesting grounds, or lack of access for surveys in bigger tracts of grasslands in this coastal reach.

The 5 – Lorne Park/Meadowwood Coastal Reach also has the highest wetland cover within the study area. This may be due to higher groundwater in the area supporting natural heritage features, particularly upstream of lakeshore Road. Rattray Marsh, Fudgers Marsh, Turtle Creek Marsh and the various wetland pockets along the riparian area of many of this reach's tributaries all provide habitat for species that require both terrestrial and aquatic environments to complete their life processes. High groundwater in Birchwood Creek is evidenced by the presence of skunk cabbage as the dominant ground cover in the valley upstream of Lakeshore Road. These riverine wetlands are primarily located south of the rail line, so their role in flow attenuation is lessened due to proximity to the lake. However, the existing wetlands provide other functions important to ecosystem health and water quality, including sediment retention, erosion control, nutrient retention and habitat diversity.

Sand and cobble/gravel beaches extend across much of the reach. The sand beach on the PetroCan Lubricants property connects with beach at Watersedge Park linking the 5 – Lorne Park/Meadowwood Coastal Reach to The 6 – Refinery Coastal Reach. Small bluffs identified in some areas were likely much more prevalent historically including a large bluff associated with Lorne Park Estates that was documented to provide habitat for bank swallows (Weeks 1993). The active erosion of this bluff was curtailed significantly sometime in the late 1970s with the placement of significant amounts of construction debris at the toe of the slope (R. Davidson-Arnott pers. comm. 2012) likely limiting their use by Bank Swallows. These natural shoreline types provide unobstructed access between lake and tablelands. The sand, cobble and gravel substrates, which extend into the nearshore, provide a habitat for fish.

Historic records state that Sheridan Creek once ran into a pond with little vegetation, and that significant amounts of soil accumulated around 1850, resulting in conditions necessary for what is now Rattray Marsh (Dietermann 2002). Rattray Marsh is one of only eleven Centres of Biodiversity identified in CVC's jurisdiction. Its complex of diverse terrestrial and aquatic habitats supports a vast array of bird and wildlife species. It also has the highest number of shorebird species (as well as the highest Shannon-Weiner Diversity Index value) in the study area, including sandpipers, Dunlin, Killdeer and plovers. Evidence suggests these birds predominately use the interior of Rattray Marsh rather than the beach along the lake, although they use beach, wet mudflats and shallow water (0–5 cm) as primary foraging sites (Potter et al. 2007).

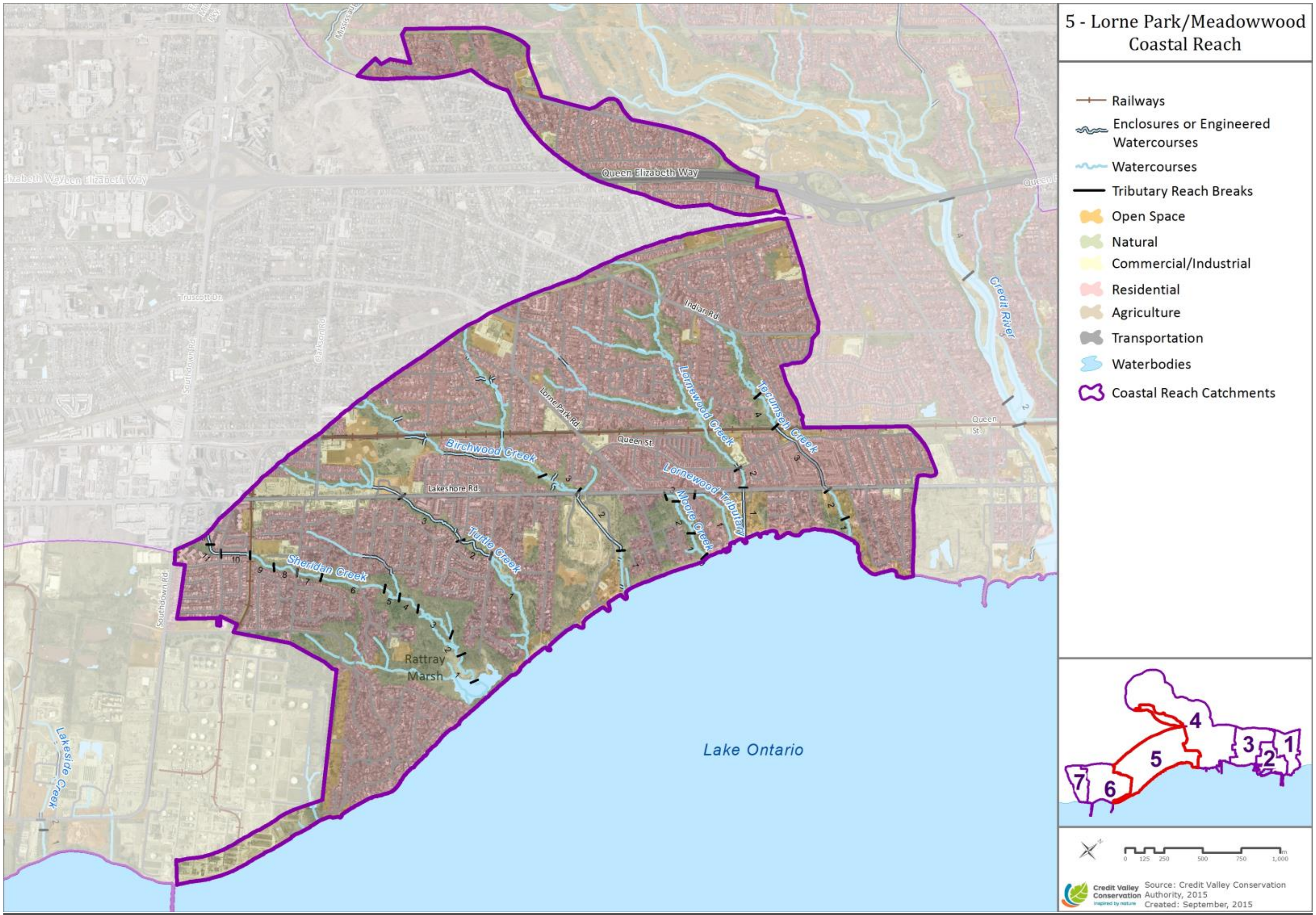


Figure 4-5: 5 – Lorne Park/Meadowwood Coastal Reach Land Use (Source: CVC)

Sheridan Creek

Sheridan Creek was not evaluated as a part of the LOISS due to the extensive studies already conducted on this stream. However, it is important to include some details on the functions and processes of Sheridan Creek and their effect on Lake Ontario.

There are limited headwater channels left in the Sheridan Creek watershed. Most reaches upstream of Clarkson Road South have been straightened, confined, and hardened in some way. This has limited the supply of sediment to reaches downstream, resulting in bank erosion and downcutting, which separates the channel and its floodplain. Total suspended sediment (and subsequently total phosphorus and *E.coli.)* in Sheridan Creek exceeds provincial water quality guidelines. In addition to direct modifications of the channel during development of the watershed, urbanization of the watershed has also changed the character of flow in the channel to be more flashy with limited infiltration.

Sheridan Creek supports a warmwater fish community both in Rattray Marsh and the stream proper. The presence of Rattray Marsh at the mouth of the Creek diversifies habitat available to a variety of fish species. The barrier beach at the mouth of Sheridan is regulated by flows in Sheridan Creek and waves in Lake Ontario. Prior to restoration dredging in Rattray Marsh, the substrates in the marsh and the lower stream reaches of Sheridan Creek were gravel, sand and silt. Dredging in Rattray Marsh in 2014 and 2015 increased depth in the open water areas of the marsh. The exposure of native organic soils and seedbank within has increased the diversity and cover of aquatic vegetation in these areas. Further upstream, substrate sizes increase to include cobbles. Large woody material in the upper stream reaches and overhanging vegetation in lower stream reaches and marsh provide cover and refuge. Undercut banks are present throughout the stream, with partial engineered treatment of banks near Bexhill Road.

A cobble beach along the shoreline, lake water levels, wave direction and height, and flows from Sheridan Creek determine the form of the mouth of Sheridan Creek through to the barrier beach at the shore. This dynamic nature of the barrier beach can affect the composition of the fish community in the marsh at any time of the year. Access by lake fish species is evident by the presence of lake fish species in the marsh and Sheridan Creek (Lake Chub, White Sucker, Common Shiner, Emerald Shiner, Alewife, Northern Pike, Gizzard Shad, Freshwater Drum and Rainbow Smelt (*Osmerus mordax*). CVC has installed exclusion fencing in Rattray Marsh in efforts to control Common Carp as they continue to be problematic in the marsh (e.g., uprooting vegetation, increasing turbidity).

Turtle Creek

Turtle Creek has some of the most diverse instream habitat in the study area, including a wetland upstream of the mouth, a well-vegetated corridor and a diversity of substrates. Overall, the geomorphic assessment ranked instream habitat in Turtle Creek as 'fair'. Site descriptions identify the presence of well-vegetated banks, instream large woody material, a meandering channel and undercut banks. Sand, cobble and gravel are the dominant substrates in the pools and riffles of the studied reaches.

The diversity of substrates and instream structures (e.g. pools, riffles, large woody material) along with the presence of the wetland in Tributary Reach 1 suggests a potential to support a range of fish and benthic macroinvertebrate species. Turtle Creek supports a warmwater fish community typical of urban streams including Brook Stickleback (*Culaea inconstans*), Fathead Minnow and Creek Chub. However, baseflow and temperature surveys indicate that Turtle Creek may be influenced by groundwater contributions, although they are unlikely significant enough to support cool or coldwater species. No fish were captured upstream of Lakeshore Rd where the stream has been piped for approximately 220m.

Turtle Creek has the third largest number of overtopped structures (58 structures) including infrastructure and buildings in the study area, 60% of which are flooded at the 5-year event or lower. Many of these structures are upstream of the rail line.

Turtle Creek discharges to Lake Ontario over a sand beach. A backwater effect from the lake has been identified for Turtle Creek extending through much of the wetland in Tributary Reach 1. As water levels in the lake, wave action and flows from Turtle Creek determine the formation of the stream mouth, access by fish into Turtle Creek is variable. Unlike Sheridan Creek, which has a large migratory white sucker run in the spring, white suckers do not appear to be using Turtle Creek. The reason for this is unknown but likely the small discharge and/or the location of the entrance to the stream (adjacent to a pier) is not drawing White Sucker to this area.

Birchwood Creek

Baseflow and temperature surveys indicate that Birchwood Creek may be influenced by groundwater contributions, providing some thermal stability for fish. Overhanging vegetation is noted in both Tributary Reaches 1 and 3. Tributary Reach 1 of Birchwood Creek is lined with gabion baskets, and instream habitat in Tributary Reach 3 includes undercut banks. Tributary Reach 2 is enclosed in a pipe associated with the water treatment facility in Jack Darling Park. This piped section of the stream is considered a barrier to fish movement. Upstream of the highly impacted Tributary Reaches 1 and 2, Birchwood Creek is relatively natural with diverse instream habitat including a well-vegetated corridor, Fudger's Marsh, and meandering form. Two online ponds upstream of the studied stream reaches in East Birchwood Creek are also barriers to fish movement. A gabion basket barrier is located on west Birchwood Creek upstream of lower Kos Boulevard.

The fish community in Birchwood Creek is likely isolated upstream of Lakeshore Road due to the barrier at the piped section through Jack Darling Park. Blacknose Dace and Creek Chub have been found upstream of Lakeshore Road in Tributary Reach 3, suggesting the presence of gravel deposits, which are the preferred spawning substrate of both species. Hundreds of Creek Chub were found in the west branch of Birchwood Creek between Kos Boulevard and Birchwood Drive in spring of 2014 by CVC staff. Fudgers Marsh likely provides suitable habitat for Common Carp spawning, an invasive species that typically uses shallow, weedy or grassy waters.

Under direction from the MNRF, CVC relocated fish species upstream of the barrier ponds in the east branch of Birchwood Creek for reindroduction purposes:

- June 8th 2011 – Black/Longnose Dace, White Sucker, Creek Chub and Brook Stickleback.
- June 25th, 2012 – Black/Longnose Dace, White Sucker, Creek Chub, Brook Stickleback Common Shiner and Fathead Minnow.

The habitat in Birchwood Creek upstream of the ponds is suitable for supporting a resident warmwater fish community. However, sampling conducted in the summer of 2014 resulted in 'no catch' (only Common Carp caught in the pond). These poor results may be caused by access impediments to the ponds where fish may be seeking refuge.

Birchwood Creek discharges over a sand beach into Lake Ontario. Access from the lake to this stream is open but low flows may limit fish access. Use of this stream by lake species is presumably further limited by the barrier resulting from the enclosure in Tributary Reach 2 in Jack Darling Park.

Water quality monitoring of Birchwood Creek identified NO_3-N exceedances of the PWQO targets. The source of NO_3-N is unknown but may be linked to area septic systems. Further, *E.coli* sampling at the beach at Jack Darling Park showed exceedances of the PWQO target, the second highest of the beaches sampled.

Moore Creek

Moore Creek has been highly altered due to development. Flows in Moore Creek have been diverted in sewers to neighbouring Lornewood Creek, reducing Moore Creek drainage area to 8 ha. Fluvial geomorphic studies undertaken by Aquafor Beech Ltd. (2014) identified severe erosion downstream of Lakeshore Road, and net sediment accumulation in the downstream reaches. Small pools and riffles are present throughout Moore Creek within Lorne Park Estates. Undercut banks and exposed roots are noted and evidence of groundwater is apparent along the stream in the form of iron staining and seepage areas.

Moore Creek discharges over a cobble and sand beach into Lake Ontario. A concrete bridge and dam structure has been constructed at the mouth of the stream with a small opening in the dam to permit flow to discharge to the lake. The purpose of the dam is unknown. Lorne Park Estates is seeking to improve the bridge in the near future. Fish access to Moore Creek is open despite the concrete bridge. However, it is unlikely the flows in this stream are sufficient to support migratory or resident fish populations under normal conditions.

Aquafor Beech (2014) identified an erosion area downstream of Lakeshore Road in need for stabilization. Low flows present significant limitations to the ecological restoration of Moore Creek. In 2018, the City of Mississauga identified they have no plans to divert more water to this stream.

Lornewood Creek

Lornewood Creek is piped from the mouth to Lakeshore Road (Tributary Reach 1) which is likely a barrier to fish movement under lower flows and due to a metal trash gate located on the upstream side of the culvert, which may limit fish passage as debris builds up. Upstream of Lakeshore Road this stream flows through a small wetland (Tributary Reach 2). The formerly straightened channel is showing signs of channel adjustment and improvements to instream habitat with the formation of meanders and undercut banks. The riparian area upstream of Lakeshore Road is well vegetated, providing a source of large woody material to the stream to diversify habitat. Records from 2011 only identified Blacknose Dace, Creek Chub, Fathead Minnow and Longnose Dace upstream in Tributary Reach 2, which may be because the piped section downstream forms a barrier to fish movement or because of a change in habitat (substrate) within the sampled reach. Of the fish species collected, most prefer cool, clear waters with gravel substrates for spawning.

In 2018, investigations by CVC were underway to determine if the piped portion of the creek can be replaced with a natural channel. The culvert at the CN tracks likely also limits most upstream movement.

Lornewood Creek water quality sampling showed high levels of both nitrate-nitrogen and *E.coli*, suggesting storm and wastewater systems may be cross-connected or leakage from area septic systems. Further, sampling for *E.coli* at Richard's Memorial Park beach, where Lornewood Creek discharges to Lake Ontario, showed exceedances of the PWQO for *E.coli*.

A separate small stream is found between Moore Creek and Lornewood Creek on the Lorne Park Estate and is locally known as 'Orient Creek' but identified as "Lornewood Creek Tributary One" in a fluvial geomorphic study completed by Aquafor Beech in 2011. Site observations identify the origin of this stream as a storm sewer south of Lakeshore Road which discharges over the Richard's Memorial Park beach. The channel is poorly defined but well connected to its floodplain. The lower channel passes through a swamp prior to discharging to Lake Ontario. This stream possibly only flows during storm events. However, the flows are typically insufficient to create a passable channel over the sand beach for fish to access this stream. Further research is necessary to confirm these assumptions.

Tecumseh Creek

Instream water temperature surveys suggest that Tecumseh Creek may be influenced by groundwater, although it is unclear to what extent the piped portion of the stream from the CN tracks to Lakeshore Road moderates its water temperature.

Based on the results of the geomorphic assessment, Tecumseh Creek possibly has the highest quality physical structure in the study area. In areas where the channel is open, a narrow band of vegetation provides enhanced riparian habitat along much of its length. Tecumseh Creek is recognized as having 'good' channel stability and a balanced channel scour and deposition regime. Meanders, undercut banks, riffles and pools provide instream habitat structures through the studied stream reaches. A variety of substrates are noted in the riffles and pools including sand, gravel, cobble boulders and silt. Generally, Tecumseh Creek is well connected to its floodplain. However, the stream is piped under a subdivision for 550 m from Lakeshore Road north to the rail line, which likely impedes fish access to the upper portions of the stream (Tributary Reach 3).

Sampling downstream of Lakeshore Road in Tributary Reach 2 resulted in the capture of Lake Chub, Blacknose Dace and Longnose Dace. No fish were captured in the sampling of Tecumseh Park (Tributary Reach 4), upstream of the rail line above the enclosure. The presence of Lake Chub downstream of Lakeshore Road indicates fish access from Lake Ontario. Tecumseh Creek discharges over a gravel and cobble beach into Lake Ontario. The form of the outlet is likely dictated by conditions in the lake. The low numbers of fish caught in the stream (4 individuals) suggests no resident fish population in this stream.

Historically a cranberry marsh was present at the mouth of Techmseh Creek in what is now Breuchner Rhododenron Gardens. The reason for and timing of its removal is unknown.

Lake Ontario

5 – Lorne Park/Meadowwood Coastal Reach, the longest stretch of uninterrupted shoreline in the study area, is highly exposed to lake processes. Substrates within the nearshore of the reach range from boulders to sand overlaying bedrock. The long stretch of exposed open coast provides little shelter or relief to maintain smaller substrates in the nearshore. Shoreline erosion monitoring sites have been established at Rattray Marsh, Jack Darling, Richard's Memorial, Brueckner Rhododendron Gardens to determine the changes due to erosion at these beaches over time.

Shoreline treatments for the reach include the lowest linear extent of hardened shoreline; about 40% of this coastal reach. The more natural areas of the shoreline include a combination of cobble and sand beach and bluff habitat, and five dynamically stable beaches (PetroCan Lubricants, Richard's Memorial, Jack Darling, Rattray Marsh and Lorne Park Estates). Shoreline erosion monitoring stations have been established at Rattray, Jack Darling, Richard's Memorial, and Brueckner Rhododendron Gardens. Annual monitoring at these stations is recommended.

Small groyne structures (approximately 50 m in length) have been constructed to protect some beach areas from erosion. Natural sand sources to replenish beaches are not apparently available from shore erosion or stream sources. Significant amounts of rock and gravel on the lakebed are assumed to have been removed through stonehooking. Still, the 5 – Lorne Park/Meadowwood Coastal Reach has the highest diversity of substrates based on transect findings (GHD 2011).

Protection of the Brueckner Rhododendron Garden beach from eastern waves is provided by the Cranberry Cove 'headland'. As noted in the Coastal Processes section (Section 3.4.1.5), the water depth to the west of Cranberry Cove is relatively shallow, causing waves to break further out from the shore, thus providing additional protection to the natural shore. This protected cove at the mouth of Tecumseh Creek provides a unique habitat in this coastal reach. The headland created by Cranberry Cove protects the beach at the mouth of Tecumseh Creek and creates an isolated circulation pattern that re-circulates much of the substrate within the cove. Woody material accumulation has been observed in this location.

Erosion protection structures at Turtle Creek, Rattray Marsh and Ben Machree Park have been identified as needing repairs or removal (in the case of the old pump station at Rattray Marsh) to ensure continued protection of the shoreline.

Nearshore fish sampling in 5 – Lorne Park/Meadowwood Coastal Reach identified a diverse assemblage of fish in this coastal reach representing different trophic levels. Alewife and Emerald Shiner are regularly present in large quantities but their numbers are dependent on the status with the lake-wide population. These species typically use nearshore areas seasonally and nocturnally. Lake Chub and Spottail Shiner migrate into tributaries to spawn, as is evident by their presence in stream fish surveys. Top predators such as salmonids are common occurrences but are considered transient. A variety of benthic fish species, including Brown Bullhead, Common Carp, Round Goby and White Sucker, are also common in the nearshore of the reach. The total fish biomass (average: 19,190 g) in this reach is fairly high compared to other open coast areas (range: 2,638 g to 20,319 g). However, there are more sampling sites in this coastal reach than others.

Summary

Terrestrial habitats in 5 – Lorne Park/Meadowwood Coastal Reach are well connected east and west adjacent to the lake as well as north and south through stream corridors. Terrestrial communities are diverse and support a diversity of wildlife species in large part due to Rattray Marsh. Aquatic communities are typical of urban centres supporting common warmwater fish species. Aquatic connectivity between the lake and tributaries is poor providing limited opportunities for lake fish species to move into tributaries for spawning or other life processes.

The following opportunities should be explored in greater detail for 5 – Lorne Park/Meadowwood Coastal Reach through the Implementation report:

Opportunities: 5-Lorne Park/Meadowwood Coastal Reach	Notes
Improve Habitat Quality	
• Terrestrial habitat quality improvements in Jack Darling Park, Richard's Memorial Park. Bruekner Rhododendron Garden Park, Meadowwood Park and Ben Machree Park, particularly to support migratory birds, bats and butterflies, including wetland enhancement and potential creation.	
• Improve in-water habitat diversity in tributary reach 1 and upstream of Kos Blvd. on Birchwood Creek using natural channel design principles.	
• Create riverine wetlands associated with Lornewood and Tecumseh Creeks to replicate historic wetland features and provide habitat for migratory birds, bats and butterflies and fish.	
• Improve nearshore aquatic habitat and riparian habitat diversity.	
Manage Existing Habitats	
• Manage terrestrial invasive species throughout natural areas and increase native plants for higher quality food sources for wildlife in this coastal reach.	
• Continue to manage for Emerald Ash Borer at Rattray Marsh and associated restoration of impacted habitats.	
• Continue to support City of Mississauga in implementation of Canada Goose Management program including habitat modification as a deterrent.	
• Continue to manage Common Carp in Rattray Marsh to protect aquatic vegetation and water quality. Open discussions regarding long-term management options with appropriate agencies	
• Continue to monitor sediment Rattray Marsh sediment accumulation, invasive species (e.g. *Phragmites*), and vegetation re-establishment	
• Investigate need to stock warmwater fish in Turtle Creek upstream of Lakeshore Road to establish diverse resident warmwater fish community.	
• Pursue detailed inventories of Turtle Creek Marsh and Fudgers Marsh and Lornewood Creek marsh. Develop management plans for long-term sustainability of these habitats.	
• Protect and enhance bluff habitats at Lorne Park Estates and Petro-Canada lands.	
• Regularly remove collection of debris on trash grates on Lornewood Creek and Birchwood Creeks to ensure fish passage is maintained.	
• Protect dynamically stable beaches at Petro-Canada, Richard's Memorial Park, Jack Darling Park, Rattray Marsh and Lorne Park Estates.	

• Update Rattrray Marsh Master Plan including developing Rattray Marsh – Turtle Creek Centre of Biodiversity Management Plan	
Connect Habitats	
• Enhancement of east-west terrestrial habitat linkages to connect this coastal reach to JC Saddington Park and the Credit River to the east and Lakeside Park and Harding Estates to the west.	
• Improve fish passage from Lake Ontario to the headwaters of Sheridan Creek, Birchwood Creek and Lornewood Creek.	
• Reconnect downcutting streams to their floodplains to relieve flooding, improve water quality and channel morphology, and enhance aquatic habitat.	
Manage Stormwater quality and quantity	
• Identify sources of NO_3-N and *E.coli*, particularly in Lornewood Creek and Richard's Memorial Park beach.	
• Explore opportunities to implement green infrastructure to mitigate stormwater quantity and to improve its quality, particularly in the headwaters.	
• Implement stormwater quality methods to improve water quality, particularly Total Phosphorus and *E.coli* in Sheridan Creek, Turtle Creek, and Lornewood Creek. Continuous monitoring for Nitrate-Nitrogen and *E. coli* in Lornewood Creek and Richard's Memorial Park is recommended.	
• Reduce flooding of structures in Turtle Creek.	
• Protect Infrastructure and development from erosion in Moore Creek downstream of Lakeshore Road.	
• Conduct study to ensure conveyance infrastructure downstream of stream diversions and piped section of creek (e.g., Turtle Creek, Birchwood Creek, Lornewood Creek, Tecumseh Creek) are appropriate for climate change scenarios.	
• Continue shoreline erosion monitoring at Rattray Marsh, Jack Darling Park, Richard's Memorial Park, and Brueckner Rhododendron Gardens.	
• Monitor, repair and replace priority shoreline erosion protection structures at Turtle Creek, RK McMillan Park, Rattray Marsh and Ben Machree Park (Table 3-17)	
• Continue real-time flow monitoring on Turtle Creek and Sheridan Creek	

Outreach, Eduction, Communications	
• Efforts should focus on stormwater management controls including Low Impact Development (particularly concering the Turtle Creek watershed), invasive species (particularly adjacent to natural areas), septic system care and best management practices, healthy stream shorelines, the impacts of feeding geese, and interpretive signage at Rattray Marsh	

4.6 6 - REFINERY COASTAL REACH

Coastal Reach 6 – Refinery is bounded by the CRH (formerly known as Holcim Canada Inc.) pier to the west and PetroCan Lubricants Pier to the east. This reach extends landward to the northern extent of the Lakeside Creek and the Avonhead Creek drainage areas within the LOISS study area boundary (two kilometers inland). The Lakeside Creek drainage area to the east of the Suncor pier has been included in 5 – Lorne Park/Meadowwood Coastal Reach (Figure 4-6) due to terrestrial connectivity between these coastal reaches and low aquatic influence on Lakeside Creek.

The majority of this coastal reach is made up of commercial and residential land uses (Figure 4-6):

Open Space	7.8%
Natural	23.6%
Wetland	0.3%
Woodland	4.8%
Cultural Meadow	11.6%
Cultural Savannah	1.9%
Cultural Thicket	1.1%
Cultural Woodland	3.9%
Commercial	56.1%
Residential	9.5%
Agriculture	1.6%
Other	1.4%

Terrestrial, Wetland, and Riparian Habitat

The cultural woodlands, cultural savannahs and grasslands at Lakeside Park provide habitat for birds of prey, aerial insectivores, and gulls and terns. Eleven species of grassland and shrubland birds were observed in the savannah and cultural meadow complex at Lakeside Park. Six species of aerial insectivores were also recorded in this complex. A range of Lepidoptera (e.g., butterflies and moths) and mammals typical of urban environments have been recorded in Lakeside Park.

A small, but highly altered, bluff exists on the eastern side of Lakeside Park. There is also some evidence of a former bluff in the vicinity of the PetroCan Lubricants site that is now largely covered over by hardened materials (e.g. broken concrete, bricks). Due to the highly altered nature of the bluff, it is unlikely this area is suitable for use by species such as Bank Swallow without extensive restoration intervention or experimental design of constructed nesting burrows. Evidence of Bank Swallow nesting has not been observed during field surveys, although they were found foraging in proximity to the 7 - Clearview Coastal Reach.

Woodlands and successional fields in the middle of this coastal reach were inaccessible for in-depth study. These areas likely provide stepping stone habitat, resting areas for migratory birds, and hunting grounds for birds of prey and urban mammals (e.g. coyotes, foxes, etc.). Interpretation of aerial photography identifies these areas as consisting of deciduous woodlands, cultural meadows, and cultural thickets.

Lakeside Creek's woodland corridor contains the only known wetlands in the 6 – Refinery Coastal Reach. These wetlands consist of swamp and riparian wetland communities that are too small to map accurately. However, they do increase the diversity of available habitats, as evidenced by the stopover use in May 2011 by a pair of Provincially and Federally Endangered Prothonotary Warblers (Appendix C - Cranford 2011).

The shoreline in the 6 - Refinery Coastal Reach provides a good east-west linkage between 7 - Clearview Coastal Reach and 5 - Lorne Park/Meadowwood Coastal Reach. The eroded and broken clay pipes along the beach at Lakeside Park is not a significant obstacle for most birds and mammals. North-south access to the shoreline from the terrestrial habitats in the centre of Lakeside Creek and Avonhead Creek watersheds has all but been eliminated. The upland habitats in Lakeside Park transition to a cobble beach via a small artificial bluff. There is open access along the beach and Waterfront Trail from 7 - Clearview Coastal Reach to the west and 5 - Lorne Park/Meadowwood Coastal Reach to the east. However, the high bluff likely presents a challenge for some mammal and reptile (e.g. turtle) movement.

The number of waterfowl species in the 6 - Refinery Coastal Reach is relatively low. However, individuals recorded in this area are well distributed among species. Conversely, the number of migratory landbirds in the reach is high but the Shannon-Weiner Diversity Index value is low, indicating an uneven distribution of individuals across the species. With limited natural cover in the areas surveyed (Lakeside Park and shoreline) it is assumed that most species recorded are passing through to other stopover habitats before continuing their migration.

Avonhead Creek

Avonhead Creek's drainage boundary has been altered by a number of diversions. It is unclear whether the flow rates and volumes downstream of the diversions are sufficient to meet the amount needed to move sediment effectively in Avonhead Creek. Flows for the 2-25 year events are being modelled in 2018. Baseflows for Avonhead Creek indicate very little groundwater input into this stream. Modelling of the diversion structures capacity to perform under climate change scenarios should be considered.

Geomorphic assessments (RSAT) of Avonhead Creek indicate that conditions within the lower stream reaches are generally 'fair'. However, Tributary Reach 1 was not assessed, as it is almost entirely piped. These results are not surprising given the high degree of manipulation, including channelization, in these reaches.

Fish have not been found in this stream with the exception of the outlet of Tributary Reach 1, downstream of the piped section of Avonhead Creek. An armoured riffle/beach maintains a small and shallow embayment at the mouth of Avonhead Creek which is accessible by fish from the lake. A diverse assemblage of fish has been sampled in this pool, although the higher diversity in this area may also reflect the lack of cover and refuge habitat within and adjacent to the rest of the reach. Based on the reduction in the watershed area under high flow conditions, no fish species are expected to exist in this stream. However, if sufficient flows and water depth exist under low flow conditions, this stream could potentially support migratory lake species (Lake Chub, Bluntnose Minnow, Emerald Shiner) or a resident urban fish population, once barriers are removed.

Terrestrial habitats in Avonhead Creek watershed consist primarily of cultural woodland in the middle of the watershed. This area is small and shows signs of regular disturbance. Nearby agricultural fields and small open areas likely provide a habitat complex suitable for some bird types, including birds of prey and aerial insectivores that require open fields for feeding.

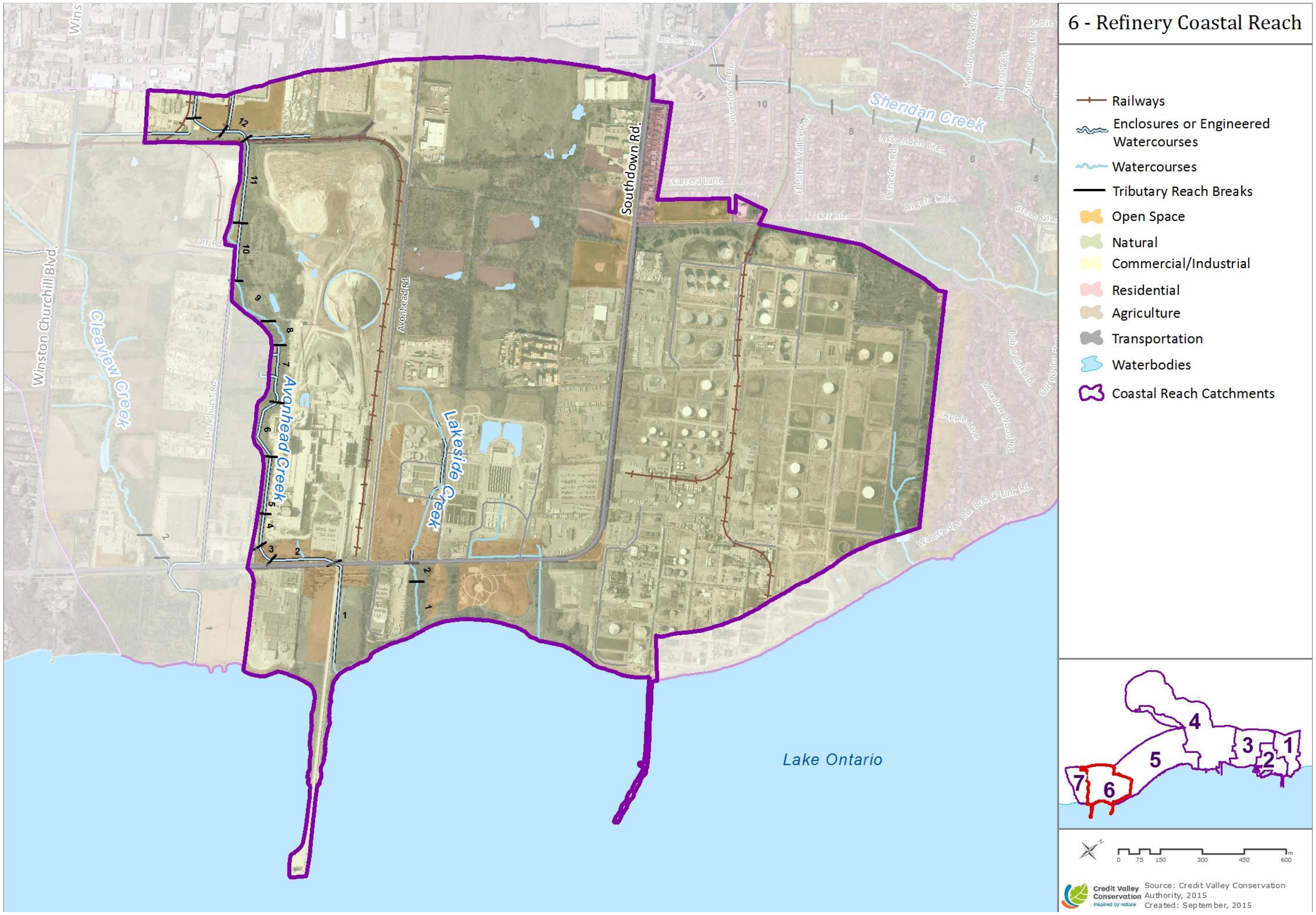


Figure 4-6: 6 - Refinery Coastal Reach: Land Use

Lakeside Creek
The majority of Lakeside Creek is piped, leaving only Tributary Reaches 1 and 2 open to the south of Lakeshore Road. Baseflows, surficial geology and instream temperature measurements for Lakeside Creek indicate potential groundwater inputs. However, it is unclear to what extent the instream temperature is influenced by the enclosure of Tributary Reach 3 north of Lakeshore Road, since this may moderate water temperatures prior to discharging into the open channel.

Lakeside Creek is influenced by backwater from the lake. However, this influence is limited, only affecting about 10 m upstream of the beach. Access to this stream may be compromised at times due to the formation of a natural cobble barrier beach. The geomorphic assessment of Lakeside Creek indicates 'good' instream habitat and riparian habitat downstream of Lakeshore Road (Tributary Reaches 1 and 2), suggesting the presence of diverse habitat structure, meandering channel form, pool-riffle formation and sand bar formation. Substrates within Lakeside Creek include cobble, sand and gravel in pools and riffles.

Longnose Dace and Lake Chub are found in the beach riffle at the mouth of Lakeside Creek. However, access beyond the first culvert (under the walking path) may be limited because it is perched (Portt et al. 2007). Substrates within the stream are suitable for spawning by Longnose Dace and Lake Chub which prefer gravel and large rocks, respectively.

Lake Ontario
Piers on either end of 6 - Refinery Coastal Reach offer some protection from waves and prevailing current from the east. Sand and cobble (weathered clay pipes) beach material extend into the lake and provide a diversity of substrates sizes along the shore. The eastern pier interrupts littoral transport of sediment from 5 - Lorne Park/Meadowwood Coastal Reach. The local current in the 6 - Refinery Coastal Reach is counter-clockwise, confining the larger substrates tight to the shoreline. The prevailing current pushes the cobbles and woody material from the bluff at the east end of the park to the mouth of Avonhead Creek to the west. Similar to the CRH Canada pier to the west, the PetroCan Lubricants pier at the east end of the reach may also interrupt fish movement along the shoreline and into adjoining coastal reaches.

This shoreline includes a long stretch of beach made up of clay pipes that has now eroded into a more natural form similar to cobble beaches found in areas such as Rattray Marsh. As the bluff located at the east end of the coastal reach erodes, the clay pipe is exposed and washed into the lake. The tumbling action of the waves in the nearshore has shaped the broken clay into flat, cobble-sized substrate that now covers the beach, particularly towards the west, suggesting that this area is less protected from the pier and receives more direct wave action. The beach, which meets the definition of 'dynamic' (MMAH 2005), is restrained by the bluff and bank. The cobble beach extends into the lake where dominant substrate is bedrock with a thin veneer of sand and silt. Because this clay pipe beach is acting much like a natural cobble beach, it has been classified as natural hence only about 20% of this coastal reach is designated as hardened.

Very little aggregate (e.g. larger substrate materials) is available from Avonhead and Lakeside Creeks or from shoreline erosion to provide nearshore substrate. The substrate in this coastal reach is dominated by bedrock with only a thin layer (<3 cm) of fine sediment and silt. Cobble and broken rock are present in small quantities.

The lack of larger substrate materials in the nearshore likely limits the use of this zone by fish or benthic macroinvertebrates for cover, refuge, nesting and rearing. Under higher lake levels, the beach substrate may provide some fish habitat for spawning and substrate for benthic species; however, this has not been confirmed. The semi-protected areas created by the piers and stream mouths likely provide refuge from the prevailing current and waves, although the pool at the mouth of Avonhead Creek appears to provide the greatest refuge in this coastal reach. While Alewife, Emerald Shiner and Lake Chub are present consistently in this coastal reach (Appendix B), top predators are absent from the sampling records. White Sucker and Round Goby are the only benthic (i.e. bottom-dwelling) fish species found in some frequency. Total fish biomass for open coast sites in the 6 - Refinery Coastal Reach was relatively high in 2008, amounting to 27,955 g (excluding Common Carp). Since 2008, biomass has dropped to between 727 g and 5799 g in the five most recent sampling events.

Summary
North and south connectivity in the 6 - Refinery Coastal Reach is poor for both aquatic and terrestrial ecosystems. Terrestrial communities are isolated within a highly industrialized landscape. East-west connections are maintained along the shoreline connecting 7 - Clearview Coastal Reach to the west with 5 - Lorne Park/Meadowwood Coastal Reach to the east. Tributary habitat is limited due to the enclosure of Lakeside Creek and Avonhead Creek. The eroding clay pipes from the bluff east of Lakeside Park have created a unique, naturalized sand and cobble beach which extends into the nearshore waters.

The following opportunities should be explored in greater detail for 6 – Refinery Coastal Reach through the Implementation report:

Opportunities: 6-Refinery Coastal Reach	Notes
Improve Habitat Quality	
• Rehabilitate bluff habitat on eastern side of Lakeside Park and Petro-Canada lands for use by bank swallows.	
• Investigate opportunities in increase wetland cover in 6 – Refinery Coastal Reach.	
• Investigate opportunities to improve north-south terrestrial connectivity to connect the Lake Ontario shoreline to the rail line and beyond.	
• Increase habitat diversity and improve habitat quality for migratory landbirds, particularly at Lakeside Park and the cultural woodland central to the Avonhead Creek watershed.	Four acres of terrestrial habitat enhancements for migratory birds have been completed at CRH Canada Group Inc.
• Undertake feasibility study regarding improvements to longshore movement of fish and substrates to and from adjacent coastal reaches	
• Improve diversity of aquatic habitat in	

Lake Ontario nearshore between the piers in 6- Refinery Coastal Reach.	
Manage Existing Habitats	
• Maintain open field foraging habitat for aerial insectivores and birds of prey.	
• Manage invasive species, particularly along the shoreline at Lakeside Park and cultural woodlands central to the Avonhead Creek watershed.	
• Maintain large woodlands central to Lakeside and Avonhead Creek watershed.	
• Continue to support City of Mississauga in implementation of Canada Goose Management program, including habitat modification as a deterrent.	
Connect Habitats	
• Remove Avonhead Creek from pipe from Lake Ontario to Lakeshore Road to improve channel morphology and fish passage into Avonhead Creek watershed.	
• Investigate opportunities to improve fish passage in Avonhead Creek upstream of Lakeshore Road.	
• Improve fish passage at the waterfront trail on Lakeside Creek.	
Manage Stormwater quality and quantity	
• Monitoring and potential repair and replacement of priority shoreline erosion protection structure at Lakeside Park.	
• Continue to monitor erosion on the shoreline at Lakeside Park	
• Initiate study to determine if diversion structures on Avonhead Creek are suitable under climate change scenario.	
• Investigate feasibility for stormwater management in Avonhead Creek to control flow diverted to Clearview Creek.	
Outreach, education, communications	
Efforts should focus on supporting migratory birds and impacts of feeding geese	

4.7 7 - CLEARVIEW COASTAL REACH

7 – Clearview Coastal Reach extends from the CRH pier to the western CVC watershed boundary and encompasses the full extent of Clearview Creek watershed within the LOISS study area boundary. This Coastal Reach also encompasses the western portion of Avonhead Creek watershed that has been diverted into Clearview Creek.

7 – Clearview Coastal Reach is the largest remaining greenfield areas in the LOISS study area. The City of Mississauga Official Plan shows the agricultural areas in the Clearview Creek watershed are scheduled for development to primarily industrial. Current land uses in this Coastal Reach are as follows:

Open Space	3.9%
Natural	38.3%
Wetland	1.4%
Woodland	5.7%
Cultural Meadow	16.8%
Cultural Savannah	3.3%
Cultural Woodland	11.1%
Commercial	26.9%
Residential	0.3%
Agriculture	26.9%
Other	3.5%

Terrestrial, Wetland, and Riparian Habitat

A gradation in vegetation cover is apparent from large tracts of meadow, intensive agriculture and old fields at the north end of the study boundary and cultural woodlands, deciduous and mixed forest closer to the lake (Figure 4-7).

Few areas in this coastal reach were accessible for in-depth study. However, similar to 6- Refinery Coastal Reach, natural or naturalized habitats in the middle of the coastal reach likely support migratory birds and hunting by birds of prey and urban mammals.Through aerial photo interpretation, these habitats consist of deciduous woodlands, cultural woodlands, and cultural meadows.

East-west terrestrial linkages in 7 - Clearview Coastal Reach appear unobstructed (Figure 3-44), providing wildlife access to Joshua's Creek valley to the west and free access along the beach or tableland to 6 - Refinery Coastal Reach to the east. North-south access between the shoreline and northern limit of this coastal reach is considered open due to relatively unobstructed Clearview Creek stream corridor and adjacent natural, semi-natural and agricultural areas. However, the bluff and concrete channel at the mouth of Clearview Creek may prove challenging for some species.

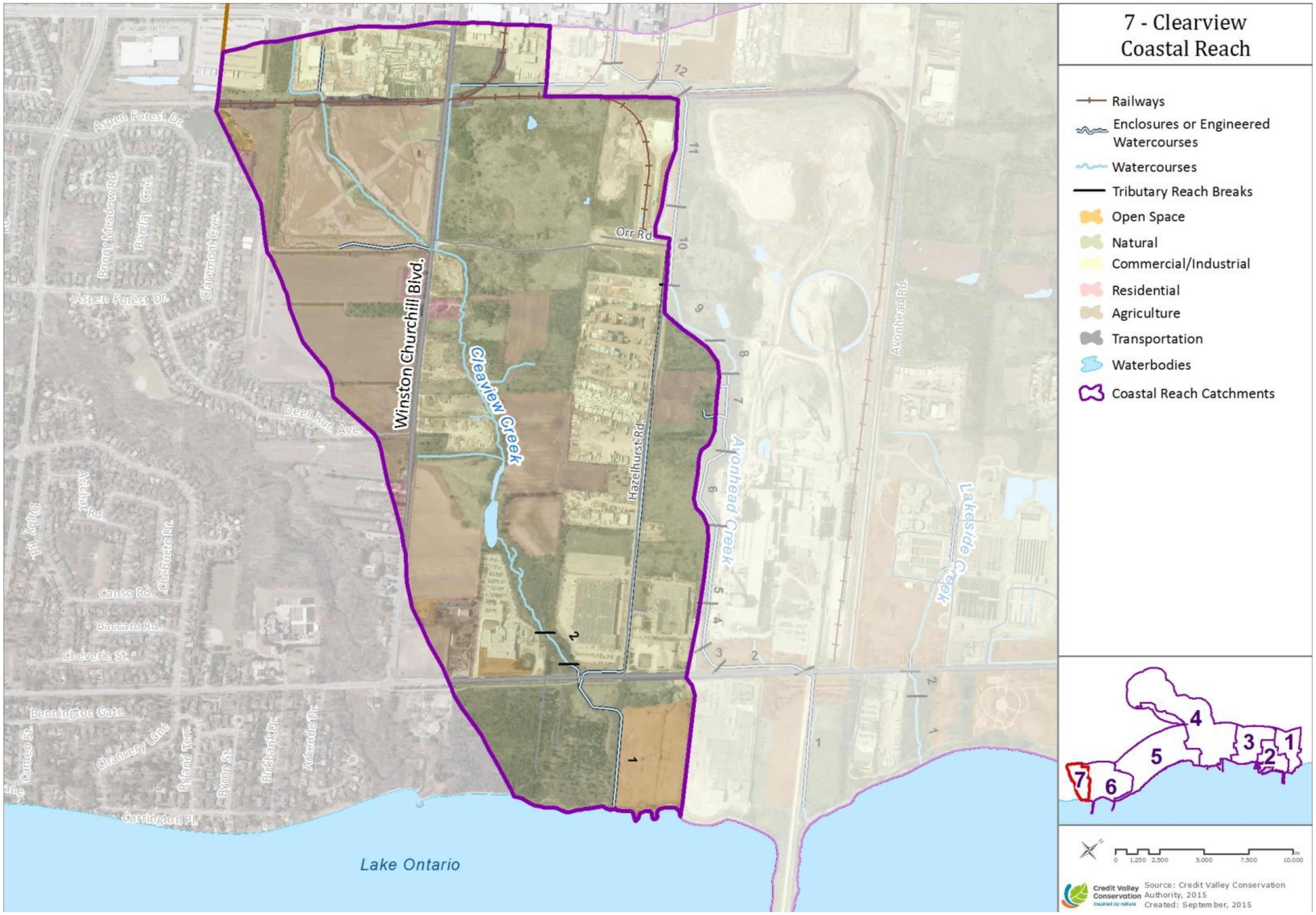


Figure 4-7: 7 - Clearview Creek Coastal Reach: Land Use

Future land use will likely result in a loss of natural cover as these areas develop in accordance with the City of Mississauga Official Plan, which calls for increased industrial land use in this coastal reach (City of Mississauga 2017).

The habitat types along the lake in this coastal reach are dominated by woodlands. Coyote and White-tailed Deer are also commonly observed in these woodlands, suggesting that sufficient habitat is present in the area for these species to complete at least part of their life cycles.

Limited public access to the beach at Harding Estates currently makes this area a refuge for wildlife including migrating birds and waterfowl. CVC staff made visual observations of bank swallows feeding over the lake and of several nests in the bluff in this reach in 2011 and 2012, one of only two known colonies of Bank Swallows found along the shoreline. The occurrence of Bank Swallows is consistent with the persistence of bluff habitat west of Clearview Creek. As aerial insectivores, and given the dominance of chironomids (non-biting midges or lake flies) at the benthic macroinvertebrate sampling station in 6 - Refinery Coastal Reach, it is probable that this makes up a significant portion of the bank swallows' diet.

Birds of prey, including a nesting Cooper's Hawk (*Acipiter cooperii*) and Great Horned Owl (*Bubo virginianus),* have been observed in the mixed forest and complex of cultural woodlands, cultural savannahs and plantations at Harding Estates. These habitat types are typical of Cooper's Hawk and Great Horned Owl, which hunt for medium-sized birds and rodents along forest edges, clearings and riparian zones.

Clearview Creek

The flows in Clearview Creek have been increased by diversions from Avonhead Creek (6 - Refinery Coastal Reach) and changes in drainage area at different flow events (stormflows vs. baseflows). The 2-25 year event flows for Clearview Creek remain a data gap. Clearview Creek is contained in a concrete-lined channel (Tributary Reach 1) south of Lakeshore Road and in an armour stone-lined channel immediately north of Lakeshore Road (Tributary Reach 2 south end), resulting in downcutting, as opposed to widening, as a dominant process. Unless abated, downcutting identified in Clearview Creek is anticipated to lead to the stream being disconnected from its floodplain. Access to the floodplain is a key function of streams to reduce bed and bank erosion.

Baseflows in Clearview Creek are relatively low, suggesting very few inputs from groundwater. This is further supported by the instream temperature ranges. Average baseflow measurements, however, are not considered to limit fish movement within the stream.

Water quality sampling revealed concentrations of both Total Phosphorous (0.105 mg/L) and *E.Coli* (163.6 cfu/100 mL) higher than the PWQO (0.03 mg/L and 100 cfu/100mL, respectively). Further investigation is needed to determine the sources contributing to these higher concentrations.

Despite the hydrologic changes in Clearview Creek, instream habitat is considered 'fair' from a geomorphic perspective. However, Tributary Reach 1 was not included, as it is conveyed through a trapezoidal concrete channel. In the other stream reaches, the classification of 'fair' under RSAT implies that riffles and runs dominate, that there is point bar formation, and little/no cover-structure. The sinuosity of the stream is evident in aerial photographs, particularly in open field areas. There is evidence of sediment sorting (through erosion, deposition and riffle formation) and the source of coarse organic material from adjacent woody and herbaceous vegetation in Clearview Creek.

The concrete channel in Tributary Reach 1 contributes to the mouth being perched at the lake, which is impassable to all fish. A head cut and steep gradient upstream of the concrete channel in Tributary Reach 2 pose additional obstacles for fish movement in this stream. Overall, habitat in this stream has been affected by erosion protection efforts and vegetation removal typical in urban environments. However, pool and riffle formations are present as well as diverse substrates suitable for refuge, cover and spawning.

Fish abundance and species diversity is low with only resident Creek Chub and Fathead Minnow found, where there should be upwards of four species based on the size of the drainage area (Table 3-23). The reoccurrence of fish species recorded in Clearview Creek over many years implies that some refuge habitat areas exist. Spawning substrate requirements of Creek Chub and Fathead Minnow – gravel and the underside of rocks, respectively – suggest that the substrates in Clearview Creek are sorted, varied and consistent with the geomorphic assessment noting the presence of bedrock, cobble and gravel in riffles and silt in the pools. Creek Chub and Fathead Minnow are omnivorous, with insects being an important food source for larger Creek Chub. Fathead Minnow are likely to depend more on vegetation found along the length of much of this stream.

Lake Ontario
Clearview Creek discharges into the lake at the western limits of CVC's jurisdictional boundary. Although it contains one of the only remaining natural bluffs in the study area, the majority of this coastal reach is engineered when including treatment of the pier associated with CRH Canada. The bluff makes up about 5% of the shoreline within the reach. Protection from the prevailing current from the east is provided by a pier at the east end of 7 - Clearview Coastal Reach. Along with other structures along the shoreline, this pier interrupts coastal processes, including erosion, deposition and littoral transport. The CRH Canada pier may also disrupt movement of fish between 6 - Refinery Coastal Reach and this reach. Shallower nearshore waters act as a refuge for smaller fish. Piers extending into deeper waters force smaller fish into areas more likely inhabited by larger predatory fish.

The nearshore coastal habitat is dominated by bedrock with a shallow cover of sand, gravel and cobble. With the exception of the material eroded from the bluff at Harding Estates, sources of new material to contribute to aquatic habitat structures and niches are extremely limited. Exposure to wind, waves and currents reduces the suitability of this habitat for spawning and rearing fish species. The lack of cover (e.g. large boulders, woody material) leaves aquatic species vulnerable to predators and sudden changes in waves and water temperatures. All fish species found in this coastal reach are transient. Biomass (by year) has dropped sharply at open coast sites in 7 - Clearview Coastal Reach over 4 years of sampling from 4266 g in 2009 to 569 g in 2011. No sampling was conducted between 2012 and 2014, and no open coast benthic macroinvertebrate sampling has been conducted in this coastal reach.

Summary
7 - Clearview Coastal Reach has the highest percent of natural cover of all coastal reaches in the study area, primarily due to high coverage of cultural communities on industrial lands. The open landscape provides connections in all directions for terrestrial wildlife. The highest quality terrestrial habitat is located at the mouth of Clearview Creek on the Harding Estate property. Clearview Creek is contained in a concrete channel at the mouth preventing

access by fish from the lake. Despite this lack of access, a small fish community persists upstream.

The following opportunities should be explored in greater detail for 7 – Clearview Coastal Reach through the Implementation report:

Opportunities: 7-Clearview Coastal Reach	Notes
Improve Habitat Quality	
• Terrestrial habitat quality improvements, particularly to support migratory species, including invasive species management and wetland creation.	
• Coastal and riverine riparian habitat enhancements for aquatic and terrestrial species.	
• Enhancement of nearshore fish habitat diversity.	
• Investigate opportunities to implement soft approaches (e.g. vegetation, bioengineering) to erosion protection in Clearview Creek to improve riparian habitat for terrestrial and aquatic species.	
Manage Existing Habitats	
• Maintain bluff habitat at mouth of Clearview Creek for use by Bank Swallows.	
• Maintain east-west terrestrial linkage between 7 – Clearview Coastal Reach and Joshua's Creek valley to the west and 6 – Refinery Coastal Reach to the east.	
• Maintain north-south terrestrial linkage from Lake Ontario to the rail track and beyond.	
• Maintain woodland cover in Clearview Creek watershed.	
• Investigate opportunities to maintain wildlife sanctuary areas (i.e., no or limited access by people) along the shoreline at Harding Estates to maintain refuge for migratory species.	
Connect Habitats	
• Improve fish passage from Lake Ontario into Clearview Creek.	
• Improve fish passage in Clearview Creek upstream of Lakeshore Road.	
• Establish terrestrial linkage within Clearview Creek corridor.	

• Undertake feasibility study regarding improvements for facilitating movement of fish along and substrates to and from adjacent coastal reaches.	
Manage Stormwater quality and quantity	
• Continue to monitor shoreline erosion at Harding Estates at established shoreline monitoring station.	
• Monitor, repair and replace priority shoreline erosion protection structures at Harding Estates.	
• Implement stormwater management methods to reduce total phosphorous and *E. coli* in Clearview Creek.	
Outreach, education, communications	
• Efforts should focus on healthy stream shorelines, water quality best management practices, stormwater control including Low Impact Development, and support for migratory birds, bats, and butterflies.	

5 CONCLUSIONS AND RECOMMENDATIONS

The Characterization phase of the LOISS has summarized Background Review information and findings from studies to fulfill the data gaps identified in the Background Review. The majority of the data gaps identified in the Background Review phase have either been initiated or completed (Appendix A).

Generally, the environment within the LOISS study area can be described as disturbed, reflecting common signs of influence by urban development in both terrestrial and aquatic ecosystems. The human effect on the environment has negatively affected both biotic and abiotic constituents in the study area. The extent of urban development limits the opportunities for restoration of these ecosystems. However, the potential to improve both the quality and quantity of habitat features and functions exists in both terrestrial and aquatic systems. Restoration of the study area will need to consider the complexities of interrelationships of the natural heritage features (e.g., streams) and their functions (e.g., conveyance of stormwater and fish habitat) to develop solutions that are sustainable in the face of both stressors from the surrounding land use and existing and new threats such as climate change and invasive species.

Overall, aquatic systems would benefit greatly from implementation of stormwater management techniques to better manage water quantity and quality. Water quantity targets should consider the environmental flow needs for stream form and function and ecological form and function as well as flooding and erosion protection. Water quality targets should consider both recreation and drinking water objectives to protect both recreational water users in tributaries, beaches, and the nearshore of Lake Ontario, and drinking water intakes located in the nearshore waters of Lake Ontario.

Connectivity and habitat quality are the main issues facing the terrestrial natural heritage system. This report identifies known areas where opportuntities to enhance connectivity between terrestrial features exist as well as known areas where invasive species threaten the integrity of key terrestrial features (e.g., Rattray Marsh and Credit River Marshes). Further opportunities to improve habitat quality, particularly stopover habitat for migratory birds have been identified. Opportunities to improve connectivity and enhance habitat quality may exist outside of the areas identified in this report and should be considered through land redevelopment.

Recommendations identified in this report are summarized in Table 5-1 (by technical discipline) and 5-2 (by coastal reach). Some recommendations are broad-scale in nature (e.g., increase the profile of CVC as partner and technical experts rather than only regulatory body) and can be applied throughout the LOISS study area. These broad-scale recommendations have not been included in the reach-by-reach summary for simplicity but are included on the recommendations listed by discipline. The findings presented in this report will be explored further in relation to the objectives for the next phase of the LOISS: Implementation.

Table 5-1: Summary of recommendations by technical discipline identified in the characterization phase of LOISS

Action	Location	Priority (High, Medium Low)	Lead Agency
Hydrogeology			
Studies to be completed on a project-by-project basis			
Hydrology and Hydraulics			
Study of techniques to mitigate stormwater impacts	All tributaries except Lakeside Creek, Moore Creek and Cumberland Creek*	High	CVC
Feasibility studies to reduce or remove risk of flooding of structures	All tributaries except Lakeside Creek, Moore Creek and Cumberland Creek and shoreline – Priority to Cooksville, Turtle, Serson Creeks.	High	CVC and City of Mississauga
Assessment of capacity of structures associated with diversions to perform under climate change scenarios	Clearview Creek/Avonhead Creek Lornewood Creek Cooksville Creek Applewood Creek Serson Creek	High	CVC and City of Mississauga
Update floodplain mapping to include climate change	All tributaries	Medium	CVC and City of Mississauga
Development of flood forecasting model	All Tributaries	Medium	CVC (currently underway)
Removing tributaries from underground pipes	All tributaries, where feasible	Medium	CVC and City of Mississauga
Geomrophology			
Further studies to be completed on a project-by-project basis			
Coastal Processes			
Establish a formal annual shoreline erosion monitoring program at established stations	Harding Estates, Lakeside Park, Watersedge Park, Rattray Marsh Conservation Area, Jack Darling Park, Richards Memorial Park, Brueckner Rhododendron Gardens, JC Saddington Park, Tall Oaks	Medium	CVC

	Park, Hiawatha Park, The Adamson Estate, RK McMillan, Marie Curtis Park		
Create guidance document on best management practices for development adjacent to shorelines		Medium	CVC
Repair/maintenance of shoreline erosion protection structures and concurrent efforts to restore nearshore substrate	See Table 3-16	High	CVC/City of Mississauga
Water Quality			
Year-round temperature monitoring	Tributaries and Lake Ontario	Low	CVC/ECCC/MECP/RoP
Temperature and algae resurgence correlation study	Lake Ontario	Low	MECP/ECCC/RoP
Sediment source study	CVC watershed	Medium	ECCC
TP reduction opportunities assessment	CVC watershed	Medium	CVC/ECCC
Continuous NO_3-N monitoring	Serson Creek, Lornewood Creek	Low	CVC/ MECP
Salt application best management practices	CVC watershed	High	All Municipalities
Establish a real-time water quality station	Lake Ontario	Medium	CVC/Region of Peel
Investigate role of chloride-rich water in pollutant dynamics and Cladophora resurgance	Lake Ontario	Medium	MECP/Academia
Aquatic Natural Heritage			
Potential for fish barrier mitigation (concurrent with existing public works projects)	Clearview Creek, Avonhead Creek, Sheridan Creek, Birchwood Creek, Lornewood Creek, Cooksville Creek, Serson Creek	High	CVC
Investigate alternatives to control Common Carp in high quality wetlands	Rattray Marsh, Credit River Marshes	High	CVC/MNRF
Seasonal fish surveys	Lake Ontario and LOISS tributaries (except Lakeside Creek, Moore Creek, Cumberland Creek)	Medium	CVC/MNRF
Thermal studies in embayments	Lakefront Promenade Park, Port Credit Marinas	Low	CVC
Restoration to improve quality and	Lake Ontario nearshore, LOISS	Medium	CVC

quantity of aquatic habitat	tributaries. Credit River Marshes		
Terrestrial Natural Heritage			
Ecological Land Classification Mapping	Throughout LOISS study area	Low	CVC/City of Mississauga
Completion of wetland evaluations	Throughout LOISS study area	Medium	MNRF
Implementation and protection of natural heritage system	Throughout LOISS study area	High	City of Mississauga
Increase wetland cover to support migratory landbirds, shorebirds, and waterfowl	Throughout LOISS study area	Medium	CVC/City of Mississauga
Increase terrestrial habitat cover to support migratory landbirds, bats and butterflies	Throughout LOISS study area	Medium	CVC/City of Mississauga
Improve linkages between habitats (including between aquatic and terrestrial habitats) to support movement of urban wildlife and migratory landbirds	Throughout LOISS study area	Medium	CVC/City of Mississauga
Wildlife surveys	Credit River Marshes	Low	CVC
Butterfly and odonate surveys using standardized protocols to determine abundance	Throughout LOISS study area including identified new sites (Arsenal Lands, Port Credit Village Partners Lands)	Low	CVC
Landbird, waterfowl, and shorebird surveys using standardized protocols to determine abundance.	Throughout LOISS study area	Low	CVC
Migratory bird habitat quality improvements	Throughout LOISS study area	Medium	CVC/City of Mississauga
Assessment of identified Significant Wildlife Habitat	Throughout LOISS study area	High	CVC
Management Plans for natural areas	Throughout LOISS study area	Medium	CVC
Contine to implement CVC's and the City of Mississauga's Invasive Species Management strategies	Throughout LOISS study area	High	CVC/City of Mississauga
Outreach, Education and Communications			
Continue to advance recommendations from the Urban Recreational Fishing	Lakefront Promenade, mouth of Credit River, JC Saddington Park,	Medium	MNRF/CVC/City of Mississauga

Strategy (MNRF 2015) including promoting urban fishing opportunities	Jack Darling Park, Lakeside Park, JJ Plaus Park, Marina Park, Memorial Park, Brueckner Rhododendron Park, Richard's Memorial Park, RK McMillan Park, Watersedge Park, Tall Oaks Park.		
Continue to advance recommendations in the Great Lakes Nearshore Framework (Lakewide Management Annex Nearshore Framework Task Team 2016) including promoting concept of links between nearshore habitat health and human health, social learning and increased awareness	Throughout LOISS study area	Medium	CVC/City of Mississauga
Increase profile of CVC as partner and technical experts rather than only regulatory body	Throughout LOISS study area	High	CVC
Advance communications that respond to widespread stressors such as water quality impacts including use inappropriate disposal of pharmaceuticals and personal care products, use on non-native invasive species in landscaping, etc, and water quantity including Low Impact Development.	Throughout LOISS study area	High	CVC/City of Mississauga
Continue to advance the Frontliners program focused on peer-to-peer outreach	Throughout LOISS study area	Medium	CVC
Continue to foster relationships and to undertake targeted presentation to ratepayer groups, building on completed efforts	Throughout LOISS study area	Low	CVC
Focus restoration efforts through CYC st. on less-naturalized parks.	Throughout LOISS study area	Medium	CVC/City of Mississauga
Engaging community and corporate	Throughout LOISS study area	Medium	CVC/City of Mississauga

volunteers in restoration opportunities including tree, shrub and wildflower plantings and invasive species management on public lands.			
Provide educational opportunities including interpretive signage along Credit Valley Trail linked to Lake Ontario shoreline.	Credit River	Medium	CVC
Build upon Riverwood/CVC Native Plant Propagation program to increase supply of locally sourced native plant seeds and plants.	Throughout LOISS study area	Low	CVC/City of Mississauga
Partner with Great Canadian Shoreline Clean Up to engage community in the state of our shorelines and build support for shoreline projects.	Credit River and public spaces along Lake Ontario shoreline	Medium	CVC/City of Mississauga
Lake Ontario Learning Centre at Adamson - public engagement programs and events, including partnership with Blyth Academy and other community agencies	Adamson Estates	Low	CVC
School outreach education – regional targeted program focusing on specific school-based or residential intervention(s) e.g. butterfly or bird habitat	Throughout LOISS study area	Low	CVC
Teacher professional development – focused on key issues or interventions	Throughout LOISS study area	Low	CVC
Multicultural Outreach with local newcomer and social service agencies – offering experiential education services to residents in the region	Throughout LOISS study area	Medium	CVC

Table 5-2: Summary of recommendations by Coastal Reach identified in the characterization phase of LOISS

Opportunity	Notes	Responsible Agency	Timeframe for Initiation
1-Lakeview Coastal Reach			
Improve Habitat Quality			

Create higher quality nesting habitat for Bank Swallows currently using ash lagoons at G.E. Booth WWTF	Bank Swallow nesting habitat has been included in the design for Lakeview Waterfront Connection	CVC	5-10 years
Create higher quality foraging habitat for shorebirds currently using mud flats at G.E. Booth WWTF ash lagoons.	Muds flats may be available for use at Lakeview Waterfront Connection during some seasons depending on water levels in the marshes	CVC	1-10 years
Create higher quality foraging habitat for bats currently using G.W. Booth WWTF ash lagoons	Wetlands at Lakeview Waterfront Connection will provide a source of insects once established	CVC	1-10 years
Improve instream habitat in Serson and Applewood Creeks by increasing diversity of structures and bed form as appropriate.	Instream habitat diversity is included in the design for Serson Creek and Applewood Creek works associated with Lakeview Waterfront Connection	CVC/City of Mississauga	
Increased diversity and cover of riparian zone on Serson and Applewood Creeks. Softer, natural bank treatments should be implemented where feasible.	Diverse planted riparian zones are included in the design of the creeks works associated with Lakeview Waterfront Connection	CVC/City of Mississauga	
Create in-water fish habitat (e.g. substrate, structures, etc.) in the nearshore of 1 – Lakeview Coastal Reach where bedrock dominates.	Fish habitat features (e.g., cold water shoals, wetlands, cobble substrate, reefs, etc.) have been incorporated in the design of Lakeview Waterfront Connection	CVC	1 – 10 years
Increase cover of wetlands in the coastal reach	Three coastal wetlands are being created through Lakeview Waterfront Connection	CVC	1 – 10 years
Manage Existing Habitats			
Manage invasive species in deciduous and cultural		CVC/City of Mississauga	

woodlands and cultural meadows in the southern and eastern areas of the coastal reach.			
Manage invasive species on treed beach ridge on east side of Applewood Creek.		CVC/City of Mississauga	
Connect Habitats			
Maintain existing terrestrial connectivity between Serson Creek, G.E Booth woodland (LV2), Applewood Creek, and Marie Curtis Park.		CVC/City of Mississauga	Ongoing
Maintain connectivity between Lake Ontario and beach and forest at Marie Curtis Park.		CVC/City of Mississauga/TRCA	Ongoing
Improve wildlife connectivity along the shoreline between Lakefront Promenade Park and Marie Curtis Park and Lake Ontario	Wildlife connectivity will be improved through habitat creation associated with Lakeview Waterfront Connection	CVC/City of Mississauga	1 – 10 years
Improve cover and small stepping stone habitat to create terrestrial connectivity between Lakefront Promenade Park and Serson Creek.		CVC/City of Mississauga	1 – 10 years
Improve fish passage from the lake to the upper reaches of Serson Creek for spawning, feeding and rearing.	Access from the lake to Serson Creek will be improved through Lakeview Waterfront Connection and proposed changes to crossing at Lakeshore Road.	CVC/City of Mississauga	1 – 10 years
Undertake feasibility study regarding improvements to longshore movement of fish and substrates to and from adjacent coastal reaches		CVC/Academia	
Manage Stormwater quality and quantity			

Reduce flooding of structures in Serson Creek through improved flow conveyance and other methods (e.g. improve stormwater management, remove structures, etc.).		CVC/City of Mississauga/CN Rail	
Continue real-time stream flow monitoring on Serson Creek and Applewood Creek		CVC	Ongoing
Implement stormwater management quality controls on Serson and Applewood Creeks to reduce impacts of phosphorus, *E. coli* and nitrates in the nearshore of Lake Ontario.		City of Mississauga	5 – 10 years
Undertake a study to determine the extent and effect of flood spill from Etobicoke Creek to adjacent watersheds.	Currently under discussion between CVC, TRCA and City of Mississauga	CVC	1 – 5 years
Outreach, education, communications			
Efforts should focus on stormwater management for residential landowners including Low Impact Development for water quantity control and water quality improvements (particularly regarding Phosphorous, *E. coli*, and Nitrates.			

2-Lakefront Promenade Coastal Reach			
Improve Habitat Quality			
Improve terrestrial habitat quality (cover and food sources) by increasing diversity of native species in upland areas connecting Cooksville Creek and Lakefront Promenade.		CVC/City of Mississauga	
Increase cover of woodlands throughout this coastal reach.		CVC/City of Mississauga	
Create fish habitat (e.g., spawning, rearing, feeding, cover) along existing shoreline erosion structures. Incorporate fish habitat features in design for repair and replacement structures.		CVC/City of Mississauga	
Increase diversity of aquatic plants (i.e., emergent, floating, etc.) in thumb basin and other protected areas of Lakefront Promenade basin.		CVC/City of Mississauga	
Conduct a study to determine thermal refuge areas within the Lakefront Promenade basin to inform fish species targets.		CVC	
Increase diversity of open water habitats (e.g., cover, vegetation, shoals, etc.) for suitable target fish species (to be determined based on future study of thermal regime).		CVC	
Investigate habitat conditions beyond the Lakefront Promenade breakwater (e.g., substrate type, size and coverage, unique features, existing fish usage).		CVC	

Manage Existing Habitats			
Investigate potential to isolate areas of the basin from boat traffic to encourage aquatic plant growth and use by fish.		CVC/City of Mississauga	
Investigate potential to create isolated (i.e., no human presence) nesting, wading and feeding habitats for waterfowl, shorebirds and landbirds.		CVC/City of Mississauga	
Continue to support the City of Mississauga in implementation of the Canada Goose Manamgenet program, including habitat modification as a deterent.		CVC/City of Mississauga	Ongoing
Connect Habitats			
Maintain connection between Cooksville Creek and Lakefront Promenade Park		CVC/City of Mississauga	Ongoing
Improve terrestrial connection between Lakefront Promenade Park and 1-Lakeview Coastal Reach by increasing cover and creating stepping stone habitat.		CVC/City of Mississauga	
Maintain Cawthra Creek from Lakefront Promenade Marina through A.E. Crookes Park as stormwater management.		CVC/City of Mississauga	Ongoing
Maintain connection between existing naturalized beach at Lakefront Promenade Park and Lake Ontario		CVC/City of Mississauga	Ongoing
Manage Stormwater quality and quantity			
Investigate potential to implement stormwater quality control on private lands and on Cawthra Creek discharging		CVC/City of Mississauga	

through A. E. Crookes Park to Lakefront Promenade Marina.			
Repair and replacement of priority shoreline erosion structures at Lakefront Promenade Park (see Table 3-16).		CVC/City of Mississauga	
Outreach, education, communications			
Efforts should focus on impacts of feeding geese, recreational fish opportunities, interpretive signage at Lakefront Promenade Park, and support for migratory birds, bats, and butterflies.			
3-Mineola Coastal Reach			
Improve Habitat Quality			
Create habitat (e.g., foraging, spawning, rearing) for fish along hardened Lake Ontario shorelines (e.g., rip rap and concrete structures, steel sheet pile walls)		CVC/City of Mississauga	
Improve instream fish habitat (e.g., cover, woody material, diverse bed form, softer bank treatments, etc.) in Cooksville Creek using natural channel principles.		CVC/City of Mississauga	
Identify opportunities to create wetlands throughout this coastal reach		CVC/City of Mississauga	Ongoing
Identify opportunities to increase forest cover throughout this coastal reach (e.g. Cawthra Woods).		CVC/City of Mississauga	Ongoing

Investigate opportunities to enhance open coast habitat for coldwater fish species (e.g., enhance existing habitats at the mouth of Cooksville Creek and in front of St. Lawrence Park)		CVC	
Manage Existing Habitats			
Maintain existing beaches at mouth of Cooksville Creek, Tall Oaks Park and downdrift of St. Lawrence Park.		CVC/City of Mississauga	Ongoing
Maintain Cumberland Creek as stormwater management.		CVC/City of Mississauga	Ongoing
Study fish use of the nearshore at St. Lawrence Park to inform habitat enhancement and/or protection.		CVC/MNRF	
Continue to support the City of Mississauga in implementation of the Canada Goose Management program, including habitat modifications as a deterrent.		CVC/City of Mississauga	Ongoing
Continue monitoring hydrology at Cawthra Woods Provincially Significant Wetlands and identify enhancement opportunities		CVC	Ongoing
Connect Habitats			
Expand and improve the quality (e.g., increase native species, reduce hardened surfaces, etc.) of riparian areas of Cooksville Creek to improve connectivity from Lake Ontario to Cawthra Woods.		CVC/City of Mississauga	

Examine opportunities to create east-west linkages to connect Lakefront Promenade Park to the Credit River.		CVC/City of Mississauga	Ongoing
Mitigate fish barrier at CN tracks on Cooksville Creek to improve fish passage from Lake Ontario.		CVC/CN Rail	
Manage Stormwater quality and quantity			
Reduce flooded structures on Cooksville Creek by improving conveyance, removing structures from flood prone areas, and reconnecting Cooksville Creek to its floodplain and other methods.		CVC/City of Mississauga	
Continue real-time flow monitoring on Cooksville Creek		CVC	Ongoing
Conduct geomorphic study of Cooksville Creek to provide recommendations to improve channel function.		CVC/City of Mississauga	
Create stormwater management and creek restoration master plan to address current and future stormwater quantity and erosion impacts to Cooksville Creek.		CVC/City of Mississauga	
Implement stormwater management to reduce impacts of phosphorus, and *E. coli* on Cooksville Creek.		CVC/City of Mississauga	
Monitor, repair and replace priority erosion structure at mouth of Cooksville Creek and RK McMillan headland (Table 3-16).		CVC/City of Mississauga	
Outreach, education, communications			

Efforts should focus on supporting migratory birds, bats, and butterflies, water quality controls including Low Impact Development in residential areas draining to Cooksville Creek			
4-Port Credit Coastal Reach			
Improve Habitat Quality			
Conduct seasonal fish studies to inform management and restoration of Credit River estuary and embayments		CVC/MNRF	
Conduct wildlife studies at Credit River Marshes to enhance understanding of habitat functions and usages.		CVC/MNRF	
Implement terrestrial habitat quality improvements, particularly to support migratory species, including wetland enhancement (Credit River Marshes) and potential wetland creation.		CVC/City of Mississauga	
Enhance habitat for migratory species at JC Saddington Park		CVC/City of Mississauga	
Increase diversity of habitats (e.g., cover, vegetation, shoals, etc.) for suitable target fish species (to be determined based on future study of thermal regime) in the Credit River estuary, embayments and open coast.		CVC	
Relocate and improve quality of common tern nesting habitat at Credit Harbour Marina.		City of Mississauga/Canadian Wildlife Services	

Investigate feasibility to create shoals off Credit River mouth to enhance existing and historic Lake Trout/Whitefish habitat.		MNRF	
Investigate suitability to restore Walleye and Lake Sturgeon habitat at Credit River mouth.		CVC	
Create habitat at mouth of Credit River to support Burbot and Cisco.		CVC	
Create fish habitat (e.g., spawning, rearing, feeding, cover) along existing shoreline erosion structures. Incorporate fish habitat features in design for repair and replacement structures.		CVC/City of Mississauga	
Pursue recommendations from the Credit River Estuary: Species at Risk Research Project (CVC 2014)		CVC/City of Mississauga/MNRF	
Manage Existing Habitats			
Manage Yellow Floating Heart in Credit River Marshes and other invasive species.	CVC initiated discussions with MNRF in 2015. MNRF is not taking action at this time.	CVC/MNRF	1 – 5 years
Protect and enhance important and uncommon habitats (e.g., Stavebank Oak Forest and Tallgrass Prairie, Huron Park Oak Savannah).		CVC/City of Mississauga	Ongoing
Continue to support the City of Mississauga in implementation of the Canada Goose Management program including habitat modification as a deterrent.		CVC/City of Mississauga	Ongoing

Develop stewardship plan for Credit River Marshes Centre of Biodiversity	Expand on findings of CVC's Credit River Estuary report (2014)	CVC/City of Mississauga	
Connect Habitats			
Examine opportunities to create terrestrial east-west linkages to connect Lakefront Promenade Park to the Credit River		CVC/City of Mississauga	
Expand and improve the quality (e.g., increase native species, reduce hardened surfaces, etc.) of riparian areas of Credit River to improve wildlife connectivity from Lake Ontario to Credit River Marshes and riverine riparian habitat improvements.		City of Mississauga	
Manage Stormwater quality and quantity			
Install a realtime water quality station in Lake Ontario.		CVC/Region of Peel	
Conduct year round water temperature monitoring on Credit River and Lake Ontario.		CVC/Region of Peel	
Conduct temperature and algae resurgence correlation study on Lake Ontario		CVC/Region of Peel	
Conduct watershed wide sediment and total phosphorus source study and identify opportunities for reduction.	Hot spot Implementation Tool Model under development by CVC. Models priority areas for non-point sources of phosphorus	CVC	Ongoing
Monitor, repair and replace priority erosion structure on Lake Ontario at JC Saddington Park, Port Credit Village Partners Lands, and Credit River Harbour Marina		CVC/City of Mississauga/Partners	
Continue real-time stream flow		CVC	Ongoing

and water quality monitoring on the Credit River			
Outreach, education, communications			
Efforts should focus on invasive species, healthy stream shorelines, recreational fishing opportunities, water quality best management practices (particularly concerning chloride and phosphorous), support for migratory birds, bats, butterflies, and interpretive signage (e.g., Credit Valley Trail)			
5-Lorne Park/Meadowwood Coastal Reach			
Improve Habitat Quality			
Terrestrial habitat quality improvements in Jack Darling Park, Richard's Memorial Park. Bruekner Rhododendron Garden Park, Meadowwood Park and Ben Machree Park, particularly to support migratory species, including wetland enhancement and potential creation.		CVC/City of Mississauga	
Improve in-water habitat diversity in tributary reach 1 and upstream of Kos Blvd. on Birchwood Creek using natural channel design principles.		CVC/City of Mississauga	
Create riverine wetlands associated with Lornewood and Tecumseh Creeks to replicate historic wetland features and provide habitat for migratory species, fish and amphibians.		CVC/City of Mississauga	
Improve nearshore aquatic habitat and riparian habitat		CVC	

diversity.			
Manage Existing Habitats			
Manage terrestrial invasive species throughout natural areas and increase native plants for higher quality food sources for wildlife in this coastal reach.		CVC/City of Mississauga	
Continue to manage for Emerald Ash Borer at Rattray Marsh and associated restoration of impacted habitats.	Emerald Ash Borer tree removal at Rattray Marsh initiated in 2015	CVC	Ongoing
Continue to support City of Mississauga in implementation of Canada Goose Management program including habitat modification as a deterrent.		CVC/City of Mississauga	Ongoing
Continue to manage common carp in Rattray Marsh to protect aquatic vegetation and water quality. Open discussions regarding long-term management options with appropriate agencies	Carp exclusion fencing installed in 2015	CVC/MNRF	Ongoing
Continue to monitor sediment Rattray Marsh sediment accumulation, invasive species (*Phragmites*), and vegetation re-establishment	Sediment accumulation monitoring initiated in 2015	CVC	Ongoing
Investigate need to stock warmwater fish in Turtle Creek upstream of Lakeshore Road to establish diverse resident warmwater fish community.		CVC/MNRF	
Pursue detailed inventories of Turtle Creek Marsh and Fudgers Marsh and Lornewood Creek marsh. Develop management		CVC/MNRF	

plans for long-term sustainability of these habitats.			
Protect and enhance bluff habitats at Lorne Park Estates and Petro-Canada lands.		CVC/City of Mississauga/Private Landowners	
Regularly remove collection of debris on trash grates on Lornewood Creek and Birchwood Creeks to ensure fish passage is maintained.		City of Mississauga	Ongoing
Protect dynamically stable beaches at Petro-Canada, Richard's Memorial Park, Jack Darling Park, Rattray Marsh and Lorne Park Estates.		CVC/City of Mississauga	Ongoing
Update Rattrray Marsh Master Plan including developing Rattray Marsh – Turtle Creek Centre of Biodiversity Management Plan		CVC	
Connect Habitats			
Enhancement of east-west terrestrial habitat linkages to connect this coastal reach to JC Saddington Park and the Credit River to the east and Lakeside Park and Harding Estates to the west.		CVC/City of Mississauga	
Improve fish passage from Lake Ontario to the headwaters of Sheridan Creek, Birchwood Creek and Lornewood Creek.		CVC/City of Mississauga	
Reconnect downcutting streams to their floodplains to relieve flooding, improve water quality and channel morphology, and enhance aquatic habitat.		CVC/City of Mississauga	
Manage Stormwater quality and quantity			

Identify sources of NO_3-N and *E.coli*, particularly in Lornewood Creek and Richard's Memorial Park beach.		CVC/MECP/City of Mississauga/Region of Peel.	
Explore opportunities to implement green infrastructure to mitigate stormwater quality and quantity, particularly in the headwaters.		CVC/City of Mississauga	1 – 5 years
Implement stormwater quality methods to improve water quality, particularly total phosphorus and *E.coli* in Sheridan Creek, Turtle Creek, and Lornewood Creek. Continuous monitoring for nitrate-nitrogen and E. coli in Lornewood Creek and Richard's Memorial Park is recommended.		CVC/City of Mississauga	
Reduce flooding of structures in Turtle Creek.		City of Mississauga	
Protect Infrastructure and development from erosion in Moore Creek downstream of Lakeshore Road.		CVC/City of Mississauga	1 – 5 years
Conduct study to ensure conveyance infrastructure downstream of stream diversions and piped section of creek (e.g., Turtle Creek, Birchwood Creek, Lornewood Creek, Tecumseh Creek) are appropriate for climate change scenarios.		CVC/City of Mississauga	
Continue shoreline erosion monitoring at Rattray Marsh, Jack Darling Park, Richard's Memorial Park, and Brueckner		CVC	Ongoing

Rhododendron Gardens.			
Monitor, repair and replace priority shoreline erosion protection structures at Turtle Creek, RK McMillan Park, Rattray Marsh and Ben Machree Park (Table 3-16)		CVC/City of Mississauga	
Continue real-time flow monitoring on Turtle Creek and Sheridan Creek		CVC	Ongoing
Outreach, education, communications			
Efforts should focus on stormwater management controls including Low Impact Development (particularly concering the Turtle Creek watershed), invasive species (particularly adjacent to natural areas), septic system care and best management practices, healthy stream shorelines, impacts of feeding geese, and interpretive signage at Rattray Marsh			
6-Refinery Coastal Reach			
Improve Habitat Quality			
Rehabilitate bluff habitat on eastern side of Lakeside Park and Petro-Canada lands for use by bank swallows.		CVC/Private Landowners	
Investigate opportunities to increase wetland cover in 6 – Refinery Coastal Reach.		CVC/City of Mississauga	
Investigate opportunities to improve north-south terrestrial connectivity to connect the Lake Ontario shoreline to the rail line		CVC/City of Mississauga	

and beyond.			
Increase habitat diversity and improve habitat quality for migratory landbirds, particularly at Lakeside Park and the cultural woodland central of the Avonhead Creek watershed.		CVC/City of Mississauga	
Undertake feasibility study regarding improvements to longshore movement of fish and substrates to and from adjacent coastal reaches		CVC/Academia	
Improve diversity of aquatic habitat in Lake Ontario nearshore between the piers in 6- Refinery Coastal Reach.		CVC/City of Mississauga	
Manage Existing Habitats			
Maintain open field foraging habitat for aerial insectivores and birds of prey.		CVC/City of Mississauga	
Manage invasive species, particularly along the shoreline at Lakeside Park and cultural woodlands central to the Avonhead Creek watershed.		City of Mississauga	
Maintain large woodlands central to Lakeside and Avonhead Creek watershed.		CVC/City of Mississauga	
Continue to support City of Mississauga in implementation of Canada Goose Management program including habitat modification as a deterrent.		CVC/City of Mississauga	Ongoing
Connect Habitats			
Remove Avonhead Creek from pipe from Lake Ontario to Lakeshore Road to improve	Feasibility Study completed in 2016	CVC/Private landowner	

channel morphology and fish passage into Avonhead Creek watershed.			
Investigate opportunities to improve fish passage in Avonhead Creek upstream of Lakeshore Road.		CVC/Private landowner	
Improve fish passage at the waterfront trail on Lakeside Creek.		CVC/City of Mississauga	
Manage Stormwater quality and quantity			
Monitoring and potential repair and replacement of priority shoreline erosion protection structure at Lakeside Park.		City of Mississauga	
Continue to monitor erosion on the shoreline at Lakeside Park		CVC	Ongoing
Initiate study to determine if diversion structures on Avonhead Creek are suitable under climate change scenario.		CVC/City of Mississauga	
Investigate feasibility for stormwater management in Avonhead Creek to control flows diverted to Clearview Creek.		CVC/City of Mississauga	
Outreach, education, communications			
Efforts should focus on supporting migratory birds and impacts of feeding geese			
7-Clearview Coastal Reach			
Improve Habitat Quality			
Terrestrial habitat quality improvements, particularly to support migratory species, including invasive species management and wetland creation.		CVC/City of Mississauga	

Coastal and riverine riparian habitat enhancements for aquatic and terrestrial species.		CVC/City of Mississauga	
Enhancement of nearshore fish habitat diversity.		CVC	
Investigate opportunities to implement soft approaches to erosion protect in Clearview Creek to improve riparian habitat for terrestrial and aquatic species.		CVC/City of Mississauga	
Manage Existing Habitats			
Maintain bluff habitat at mouth of Clearview Creek for use by Bank Swallows.		CVC/City of Mississauga	Ongoing
Maintain east-west terrestrial linkage between 7 – Clearview Coastal Reach and Joshua's Creek valley to the west and 6 – Refinery Coastal Reach to the east.		CVC/City of Mississauga	Ongoing
Maintain north-south terrestrial linkage from Lake Ontario to the rail track and beyond.		CVC/City of Mississauga	Ongoing
Maintain woodland cover in Clearview Creek watershed.		CVC/City of Mississauga	Ongoing
Investigate opportunities to maintain wildlife sanctuary areas (i.e., no or limited access by people) along the shoreline at Harding Estates to maintain refuge for migratory species.		City of Mississauga	
Connect Habitats			
Improve fish passage from Lake Ontario into Clearview Creek.		CVC/City of Mississauga	
Improve fish passage in Clearview Creek upstream of		CVC/City of Mississauga	

Lakeshore Road			
Establish terrestrial linkage within Clearview Creek corridor		CVC/City of Mississauga/Private Landowners	
Undertake feasibility study regarding improvements to longshore movement of fish and substrates to and from adjacent coastal reaches		CVC/Academia	
Manage Stormwater quality and quantity			
Continue to monitor shoreline erosion at Harding Estates at established shoreline monitoring station		CVC/City of Mississauga	Ongoing
Monitor, repair and replace priority shoreline erosion protection structures at Harding Estates.		City of Mississauga	
Implement stormwater management methods to reduce total phosphorous and *E. coli* in Clearview Creek.		City of Mississauga	
Outreach, education, communications			
Efforts should focus on healthy stream shorelines, water quality best management practices, stormwater control including Low Impact Development, and support for migratory birds, bats, and butterflies.			

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7 GLOSSARY

Annual Maximum Ice Concentration: The greatest percentage of ice coverage achieved within a given winter.

Aggradation: The deposition of material by a river, stream or current.

Baseflow: The portion of stream flow that results from seepage of water from the ground (not runoff), typically measured in drought conditions.

Catch per unit effort: An indirect measure of the abundance of a target species determined by the number of target species caught during a specific amount of time. Changes in the catch per unit effort are inferred to signify to that target species' true abundance.

Centre for Biodiversity: Landscapes with a concentration of natural heritage features representative of physiographic regions in the watershed, which collectively represent important ecological features and functions capable of supporting native biodiversity over the long term.

Coriolis Force: The deflection of objects relative to a rotating reference frame. In the northern hemisphere, wind currents rotate in a clockwise direction due to the rotation of the earth.

Credit Valley watershed: The area that drains its rain or snow melt (runoff) into the Credit River

Degree days: The average number of temperature degrees above a minimum threshold over a 24-hour period.

Deposition: The accumulation of stream material.

Downwelling: The downward movement of water as a result of winds and/or currents.

Dynamic Beach: Areas of inherently unstable accumulation of shoreline sediment following natural processes of erosion and accumulation of beach materials. The dynamic beach hazard limit includes the flooding hazard limit plus a dynamic beach allowance.

Epilimnion: The upper layer of water in a stratified lake.

Erosion Hazard Limits: The extent to which erosion is predicted to occur within a specified timeframe or under a specific circumstance.

Gyre: The natural clockwise direction of lake currents in the northern hemisphere.

Hydrograph: A graph showing the rate of flow (discharge) versus time.

Isotherm: A line that connects points of equal temperature.

Littoral drift: the transportation of sediment along the coast

Lake Iroquois: Glacial Lake Iroquois was a prehistoric pro-glacial lake that existed at the end of the last ice age approximately 13,000 years ago. Lake Iroquois was in the general area of the current Lake Ontario.

Metalimnion: A thermal transition zone under the epilimnion where temperature changes more rapidly with depth than it does in the layers above or below.

Nearshore: the open waters of the lake from the 20 m depth contour to the mean highwater mark along the coast.

Overtopped: All structures located within the flood zone of a watercourse that are inundated with flood waters during storm events (including culverts, bridges and buildings).

Rapid Geomorphic Assessment (RGA): A method to determine and document the current and historic adjustment processes in a stream segment based on characteristics of sediment movement including deposition and erosion.

River Continuum Concept: A framework integrating a series of physical gradients and associated biotic adjustments as the river flows from headwater to mouth.

Sewershed: A sewer network encompassing the natural drainage area of a stream.

Stonehooking: A method of gathering stone slabs from the shallow lake shore to be used primarily for building construction. It flourished as an industry from the mid-nineteenth century to the early twentieth century.

Thermal bars: The vertical transition area between stratified waters and isothermal waters.

Thermocline: A steep horizontal temperature gradient in a body of water, between thermally well mixed waters above and isothermal waters below.

Top predator: A predator residing at the top of the food chain on which no other creature predates.

Upwelling: The process by which warm, less dense surface water is drawn away from along a shore by offshore currents and replaced by cold, denser water brought up from the subsurface.

Urban Stream Syndrome: The consistently observed ecological degradation of tributaries draining urban land.

8 APPENDICES

APPENDIX A – DATA GAPS FROM BACKGROUND REVIEW

Table A1: Data Gaps Identified in the LOISS Background Review

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
Current legal opinion on lakebed ownership and riparian rights	CVC		Initiated
Policy review of applicable legislation to identify barriers/needs of Authority for carrying out works (shoreline/lakebed)	CVC		Initiated
Review CVC conservation land agreements with Mississauga – recommendations for integrating LOISS priorities into new lease agreements	CVC	Mississauga DFO MECP	Initiated
Communications Strategy: Planning and Implementation	CVC	Mississauga Region of Peel	Completed
Workshops: Ratepayer Reps and Corporate	CVC	Mississauga Region of Peel	Completed
Living by the Lake : Factsheet	CVC		Completed
LOISS webpage: CVC website	CVC		Completed
Historic Shoreline Mapping	CVC	University of Toronto at Mississauga	Completed
Video – Robert Bateman Public Service Announcement	CVC		Completed
Determine current land use in LOISS study area (Natural Heritage Strategy Landscape Scale Analysis)	CVC		Completed
NHS LSA to identify potential core areas and supporting areas/corridors.	CVC	Mississauga	Completed
Field truthing/prioritization of restoration opportunities	CVC		Ongoing
Integrate LSA into Greenlands Securement Strategy to guide priority acquisitions in LOISS	CVC	Mississauga	Ongoing
Spring surveys: stopover landbird	CVC	Canada Wildlife Service	Completed
Spring surveys: staging/stopover areas, shorebird/waterfowl	CVC	Canada Wildlife Service MNRF	Completed
Fall surveys: stopover landbird	CVC		Completed
Fall surveys: staging/stopover areas - waterfowl	CVC		Completed
Radar Interpretation	CVC		Not pursued
Surveys: butterfly/odonate surveys	CVC		Completed
Bat acoustic surveys	CVC		Completed

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
Amphibian surveys: Breeding	CVC		Completed
Turtle Surveys : Presence/Absence	CVC	MNRF	Completed
Georeference Species of Conservation Concern	CVC	Mississauga	Planning Initiated through Mississauga Natural Areas Survey
Invasive species surveys	CVC		Planning Initiated
Shoreline Treatment – NRSI 2009 and Shoreplan	CVC		Completed
Broadscale surveys of nearshore vegetation (NRSI 2009)	CVC		Completed
Detailed Nearshore Vegetation Surveys	CVC		Completed
Habitat: video (JC Saddington)	CVC	Trent University (C. Chu) Great Lakes Information Network	Completed
Tributaries water temperatures (temp loggers)	CVC	Region of Peel Environment Canada and Climate Change	Completed
Summer fish use (complete) and access into tributaries (2009–2011) Sampling in tributaries where data lacking	CVC	MNRF	Completed
Nearshore fish sampling	CVC	MNRF	Completed
Sample Round Goby/abundance	CVC	MECP	Completed
Beach/offshore spawning and locations. Identify rearing/nursery habitats spawning areas for some species (e.g. bass, lake trout, forage species) not identified	CVC	MNRF	Planning Initiated
Pike survey	CVC		Completed
Airlift Sampling: MECP Divers	CVC	MECP	Completed (2011)
Invertebrate Surveys: benthic insects, dreissenid mussel	CVC	MECP Environment Canada and Climate Change/ Canada Wildlife Survey	Completed (2011)

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
Gill Netting	CVC		Completed at Lakeview site in fall 2015 and spring 2016
MNRF recreational fishing: conduct seasonal user surveys at various access points in the study area.	MNR	CVC	Not CVC Priority Workshop with Angling Community (Completed 2015
Atlantic salmon research: conduct creel surveys of boat anglers; check stomach contents of retained fish; track angling information (e.g. location, depth, date) from capture	MNR	CVC	Not CVC Priority
Pacific salmonid competition: scale and effects of competition with Pacific salmonids with native species not known	MNR	CVC	Not CVC Priority
Coaster brook trout: historic reports and one recent capture Continue monitoring of Streetsville fishway in fall. Genetic analysis of any future brook trout from lower river	MNR	CVC	Not CVC Priority
Map Ice Cover using existing data from NOAA	CVC		Initiated using CVC ice monitoring protocol
Precipitation data collection and maintenance of stations Replacement of Station 1 gauge with heated gauge	City of Mississauga	CVC	Ongoing
Sediment loading to Lake Ontario from Cooksville Creek (suspended? bedload?)	CVC	Mississauga	Identified for future study
Sediment loading to Lake Ontario for Serson, Applewood, Lornewood, and Birchwood Creeks	CVC	Mississauga	Completed for Serson, Applewood, Moore, and Avonhead Creeks
Sediment loading to Lake Ontario from Sheridan Creek (suspended? bedload?) Geomorphic Solutions (2007) Sedimentological Study of Rattray Marsh	CVC	Mississauga	Identified for future study
Real-time flood forecast and climate vulnerability	CVC	Mississauga	Ongoing
Real-time rainfall and	CVC	Mississauga	Ongoing

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
streamflow data			
Imperviousness	CVC	Mississauga	Not pursued
Drainage Area	CVC	Mississauga	Completed
Hydrological and hydraulic modeling of Cumberland Creek including floodplain mapping[1]	CVC	Mississauga	Identified for future study
Hydrological and hydraulic modeling of Moore Creek including floodplain mapping[1]	CVC	Mississauga	Identified for future study
Hydrological and hydraulic modeling of Cooksville including floodplain mapping	Mississauga	Mississauga	Study completed by City
Hydrological and hydraulic modeling of Credit River including floodplain mapping (Regional): u/s of Hwy 5; u/s QEW; CNR	CVC	Mississauga	Identified for future study
Hydrological and hydraulic modeling (2 to 25 yr) Avonhead Creek including floodplain mapping: north of Lakeshore; western portion of watershed (post development)	CVC	Mississauga	Identified for future study
List of overtopped structures and flooded buildings - Avonhead; Cumberland; Moore Creeks	CVC	Mississauga	Identified for future study
Geological Cross-Sections	CVC		Completed
Quantification of groundwater contributions in baseflows to tributaries of L. Ontario, and other groundwater-surface water interactions	CVC	MECP	Not CVC Priority
Integrate baseflow measurements with Aquatic Natural Heritage and Water Quality	CVC		Planning Initiated
Orientation, size, and infill material for the buried bedrock valley	CVC	MECP	
Groundwater Quality: local scale impacts?	CVC	MECP	
Groundwater Discharge: Scope	CVC	MECP	Not pursued
Centralized database of water quality data: agreement to	MOE	CVC	Not CVC Priority

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
share data			
Upgrade existing MIKE3 model to define how pollutants move along waterfront. 270 m grids (basin); 90 m grids (local)	CVC Ray Dewey Ram Yerubandi Gary Bowen	Environment Canada and Climate Change Region of Peel MECP Mississauga	Completed
Phosphorus EMC values	CVC	Region of Peel	Completed
HSP-F model for remaining tributaries	CVC	Environment Canada and Climate Change and/or MECP, Mississauga	Completed
Integrate WQ data City of Mississauga Goose Mgmt Program	City	CVC	Planning Initiated
Water quality sampling at key locations of key parameters	CVC	Environment Canada and Climate Change and MECP	Completed
Sampling Credit River at Mississagua Golf Course · Event Sampling (6-8 samples over season) · Winter Sampling · Install Stream Gauge (ice - bridge)	CVC	MECP	Ongoing
Key pollution sources and impact on environmental quality/health		Environment Canada and Climate Change MECP Mississauga	Planning Initiated
Thermal Monitoring: Nearshore and Offshore transects	Environment Canada	CVC	Completed
Document detailed historic shoreline events, changes since 1988	CVC		Completed.
Inventory and assess public protection structures Effects of Piers	CVC	Mississauga	Completed
Inventory and assess private protection structures Effects of Piers	CVC	Mississauga	Completed (PetroCan Lubricants)
Assess effect of waves on nearshore currents	CVC	Mississauga	Site-specific
1-D littoral sediment transport analysis	CVC	Mississauga	Site-specific
2-D littoral or sub-littoral sediment transport analysis	CVC	Mississauga	Site-specific

Action	Lead Agency/ Organization	Partner Agency/ Organization*	Status
Collection of baseline cross shore bathymetric data, sediment composition and underwater video	CVC		Completed
Bathymetry (JC Saddington)	City of Mississauga	CVC	Completed
Establish erosion monitoring stations and initial surveys Aerial photos: 35 year review	CVC	Mississauga	Completed
Aerial photos: Annual	CVC		Planning Initiated
LiDAR Survey: water penetrating	CVC	Conservation Halton TRCA	Cancelled – not practical. May be pursued as a pilot in or after 2016.
Seasonal fluctuations as station surveys spring/summer/storm events	CVC		2013
Public perception survey (and literature review)	CVC		Completed
Cost - Benefit Analysis of Restoration Options	CVC	Mississauga Region of Peel	Cancelled
Cross-section/ longitudinal/planform data collected but not analysed	CVC		Planning Initiated
Seasonal backwater impact on biological elements (suspended sediment data collection - coastal process integration - FG detailed substrate analysis)	CVC	CVC	Completed
Assessment to determine feasibility of replacement of concrete channel with naturalized channel for Reach 1 of Clearview Creek (455 m)	Mississauga	CVC	Waterfront Parks Management Strategy
Assessment to determine feasibility of restoration of Serson Creek	Mississauga: Inspiration Lakeview	CVC	Completed. Implementation through Lakeview Waterfront Connection
Assessment to determine feasibility of daylighting of Lornewood Creek Reach 1 (340 m)	CVC	Mississauga	Initiated

* MNRF – Ministry of Natural Resources
MECP – Ministry of the Environment, Conservation and Parks
DFO – Fisheries and Oceans Canada
CVC – Credit Valley Conservation
TRCA – Toronto and Region Conservation Authority

APPENDIX B – AQUATIC NATURAL HERITAGE

Table B1: Fish Abundance by species for all CVC records (2008-2014) in Lake Ontario and LOISS Tributaries (Source: CVC)

Station Number	American Brook Lamprey	Sea Lamprey	Longnose Gar	Bowfin	American Eel	Alewife	Gizzard Shad	Blacknose Dace	Bluntnose Minnow	Common Carp	Common Shiner	Creek Chub	Emerald Shiner	Fathead Minnow	Golden Shiner	Goldfish	Hornyhead Chub	Lake Chub	Longnose Dace	River Chub	Rosyface Shiner	Spotfin Shiner	Spottail Shiner	Greater Redhorse	Longnose Sucker	Northern Hog Sucker	Shorthead Redhorse	White Sucker	Brown Bullhead	Stonecat	Northern Pike	Rainbow Smelt	Atlantic Salmon	Brown Trout	Chinook Salmon	Coho Salmon	Rainbow Trout	Trout-perch	Brook Stickleback	Threespine Stickleback	White Bass	White Perch	Black Crappie	Largemouth Bass	Pumpkinseed	Rock Bass	Smallmouth Bass	Fantail Darter	Johnny Darter	Logperch	Rainbow Darter	Walleye	Yellow Perch	Freshwater Drum	Round Goby	Bluegill	Burbot	Central Stoneroller	Iowa Darter	Mottled Sculpin	No Catch	Northern Redbelly Dace
LAKE ONTARIO																																																														
1 - Lakeview Coastal Reach																																																														
24241001											2		3	2					7				3																																3							
24241002										1			2						14									6																			1								27							
24241003										2			17																																									3	3							
24241004						23				1	18		38					1	2																																											
24241005										1			1														1																												1							
24241006																																																					1									
24241007																																																							2							
24241008						99				4	1		29			1												7						1	2																											
24241009																																																														
24243301						15				1								1																										1																		
24244001																		2	1																																											
24244002																		1										2																											3							
24244003																																																														
24244004																		1																																					12					1		
24244005						67				6			22					2										4																		1																
24244006						1				3																		4																											1							
24245501						1							317						1				2																											1								1				
24245502													12						5				5																					1											9							
2 - Lakefront Promenade Coastal Reach																																																														
24240708					1					1	4																1	6	3		3													3	6	2	2								4							
24240901						18				1			33															15			1														3	3							12		12							
24240902						34							12														1	9	1		1			4											5	5	4						4		54							
24240903						5							5															21	1		2														1	6	4						3			1						
24240904													7															5	3		1														1	3							6		15							
24240905						20																						3																		4	1						3									
24240906						5			1	6	1		25										1					36	6		1			1										15	15	2	3						16		1							
24240907					1																							1			2													1									2		7							
24240908						9				3			5															17			1														1	4	2						1									
24241101									1																			1																																		
24241102						20				1	1		5														1	14	2								1							1	2	16	8								4							
24241103						2			1	2			11															1																	3	7	13						7		1							
24241104										3			19															11																	1	4	1															
24241105						8				3			28										3					9			1												1	1	3	6	7						2		2							

24241106								1																			3	1		1													1			4						4		5							
24241107					3	11			4			28														2	14							1											1	7							1								
24241108						1			3																	1	11																			4															
24241202												5																																										74							
24241503												6															7	1																	10	1						1		9							
24243201					8	1			4			1														2	1																									1		11							
24243202				1					3																		4							2											3	2						6		91							
24243203									5																																													1							
24243204												6																1																										13							
24243205																																																													
24244101				1					3	4								1									17																2	4	1							1		2							
24244102									4																			2						1																											
24245301																																											1	2	1							1		274							
24245302																																												4										342							
24245401					1							257										2																					1											40							
3 - Mineola Coastal Reach																																																													
24243101					3												4					3					5	1								1										3								7							
24243102					4				2			24										2					4	1																	2	1						5		30							
24243103					2				5			89										1				1	12	1																	1	4								7							
24243104					178	1			2			18										1					1						1										1	2										2							
24245101												26					2																																												
24245102																																																								1					
4 - Port Credit Coastal Reach																																																													
501090004								20		25		15	1	1					2		1	1					5	7		9													2	80	14	2						7		8							
501090009		3			1		22	1	128	1	515	4	21	1			1		220	47	114	29	21	2	1	3	94	271		82			1		3		1				5			1	24	79	39	137	14	63	149		1		880				1			
230911101																																																				1										
230911801																						22						4		1													3	41										42							
23095310					200																																																								
5 - Lorne Park/Meadowwood Coastal Reach																																																													
24240301												2										1					3																											4							
24240302					106	1			4			2														1	2	1																																	
24240303					60				1			234					1					1					16	3																								3		13							
24240304												76						3									1							1																			1	1							
24240401												14					2																																												
24240402					44				3			16															1																																		
24240403					4							94					5										6	2			1		1	2												1						1		1							
24240404												13						5				8																															1								
24240405																																																													
24240406					44																						5							4																											
24241601												10										1					1																											1							
24242801					438				3			11															1																																		
24242901					150				2			25										3				1	5																			2							1								
24243001					56				1			8															2									1													1					2							

24243602													16															2			
24243702													34	2				1	1												
24243703							5		3		17		1	105				1										24			
24243704																															
24244501						4							26										17								
24244601													24																		
24244602						1000				4																					
24244701													10						1												
24244702													20										7								
24244703																															
24244801						7							13					2													
24244802													3						6												
24244901													56																		
24245001													160																		
24245002													7															3			
6 - Refinery Coastal Reach																															
24240201									3				7					34	1									8			
24240202						411				1																		13			
24240203													159					246	1									47			
24240204						4							7					33	1									39			
24240205						3																						6			
24240206						13																						1			
24244201													28					1	1				3								
24244301						1							2										3								
24244302																		10	20												
7 - Clearview Coastal Reach																															
24240101																												4			
24240102						21	1						1															15			
24240103						42				1																		35			
24240104						1	1																				2	2			
24240105																												1			

24243602																							6								
24243702																															
24243703											11		1	3									57								
24243704																															
24244501																															
24244601																															
24244602																															
24244701																															
24244702																			1				1								
24244703																							3								
24244801																															
24244802																							29								
24244901																															
24245001																															
24245002																							5								
6 - Refinery Coastal Reach																															
24240201																							2								
24240202																							2								
24240203																					3		38								
24240204																							14								
24240205																					2		6								
24240206																															
24244201																							3								
24244301																															
24244302																							7								
7 - Clearview Coastal Reach																															
24240101																					1		16								
24240102				3		1									1	2					2		8								
24240103																1						1	8								
24240104	2																						8								
24240105																5							7								

Station Number	Alewife	American Eel	Atlantic Salmon	Black Crappie	Blacknose Dace	Bluegill	Bluntnose Minnow	Bowfin	Brook Stickleback	Brown Bullhead	Brown Trout	Carp and Minnow Family	Central Mudminnow	Central Stoneroller	Chinook Salmon	Coho Salmon	Common Carp	Common Shiner	Creek Chub	Emerald Shiner	Fantail Darter	Fathead Minnow	Freshwater Drum	Gizzard Shad	Golden Shiner	Goldfish	Greater Redhorse	Hornyhead Chub	Iowa Darter	Johnny Darter	Lake Chub	Largemouth Bass	Logperch	Longnose Dace	Longnose Gar	Longnose Sucker	Mottled Sculpin	Northern Hog Sucker	Northern Pike	Northern Redbelly Dace	Pumpkinseed	Rainbow Darter	Rainbow Smelt	Rainbow Trout	River Chub	Rock Bass	Rosyface Shiner	Round Goby	Sea Lamprey	Shorthead Redhorse	Smallmouth Bass	Spotfin Shiner	Spottail Shiner	Stonecat	Threespine Stickleback	Walleye	White Bass	White Perch	White Sucker	Yellow Perch
LOISS Tributaries																																																												
Applewood Creek																																																												
22221501																																																												
22222701					46														2												16			55																										
22223001																																																												
22220202	No Catch																																																											
22220201	No catch																																																											
Serson Creek																																																												
22222901	No Catch																																																											
22220201	No Catch																																																											
Cawthra Creek																																																												
22221601																																																												
Cooksville Creek																																																												
22220604																				5														2																			1							
22221302																																		17																										
22221801																																																												
22222001	No Catch																																																											
Credit River																																																												
501090003		1			7		103					124					201		23		137	9						32		23		2	7	982				37			58	507		5	148	3	1		26		17			162					79	1
501090009		1	1		1		128					37			3		1	449	4	21	137	1		22			2	1	1	14		1	61	220		1		3			24	149		1	47	79	114	859	3	95	39	29	21	82			5		271	1
23090218					1		8											35	1		4											1	2	131				4			2	48			74		1				2			19					4	
23090640															20																													1																
23090641											1				14	12																												12																
23090642											1				11																																													
23090643			1												25																													2																
23090644															10																																													
23090646			3								6				2	2																												11																
23090647																1																																												
23090648			1																																									13																
23090649															2	1																												2																
23090650															1	6																												11																
23090651											2				1	6																												29																
23090652											2					2																												45																
2309102134							2											12										2														3																		
2309102135							4											84																								1																		

2309102136																		20																								1							2											
2309102137							1											21																								2												1						
2309102138							1								1			7																								1																		
2309102139					1		3											10																1											1				1											
2309102140							1											10																								1							2					1						
2309102141							1											1																															1											
2309102142							1											17					2						5						1						1	9							1										1	
2309102143			1															18					3																		1	7			2				5					1					1	
2309102144							2								1			7					6						3						1						1	6		10					3											
2309102145															3			3					17						2												2	12		8					2											
2309102146			3		1													2					1																		1			5					2										1	
2309102147			3												1			5											2													1		28															1	
2309102148			1												2			5					3			2																6		19					2											
2309102149			3							1					3			1											5													9		7					1					1						
2309102150			3				2				1				2			2					2						3						1							3		7															1	
2309102151			4								1				7			3																							1	3		5										1						
2309102152			3						1		3				13			17																	1									3					2					1					1	
2309102153															5			13					3												2							4		1					1											
2309102154			3		2										1			13					5			1			7						1						1	1		3					2										1	
2309102155					1										11			4											1													1							1											
2309102156			6												7			4					2						4												1	1																	2	
2309102157			8		1		1								1			9					12						10												3	1							1										2	
2309102158			33		3		1				2				617			23					10						7						1						6	1		2															2	
2309102159			16		4		3			1	2				421			18	1				6						5												5			7																
2309102160			24		1						2				131 2			12	2				4						2						2						1			2															1	
2309102161			14								6				10			5					1						1						2									5																
2309102162			21				4				7				453			13					2						1						2									3															1	
2309102163			5								2				275			5											1						3									7															2	
2309102164			11								3				311			7					2						2						3									5															1	
2309102165			5		1										122			5					1						1						3									2																
2309102166			4								2				63			5											1						10									6															3	
2309102167			6							1	10				298	2		3											1						1						2			30																
2309102168			13												11			8					1												4						1			7															2	
2309102169			18								1				70	1		1															1					1			2			3					1											
2309102170			5												93			1																								1																		
2309102171			5												105																													3																
2309102172			2								1				3			7	1				1												5						1													1						
2309102173			7												5	1		8					1						4						8						1			1																
2309102174											1				10			7																	2						1																			
2309102175			23				1				6				771			20					1												3				1		5	1		9					1											
2309102176			4								1				175			28					1										1		2						28			1															1	

2309102177			9								1				338			35				7			2								1		4								9			1											1						
2309102178			6												63			12	1			1						1				2		2								5			4																	1	
2309102179			9		1										62			7	1					1												5								1																				
2309102180			5				1								20			7															1		13								2			1																	1	
2309102181			5		2		1								10			16					1						1							27												1															1	
2309102182			1												1																																																	
2309102183			24				1			1	1				1591	1		4																														2	1		2										1				4	
2309102184			13												650	2		1				2						1																		1		3																		1	
2309102185			15												175	1								1																												2																					1	
2309102186															9														1																						1																							
2309102187			2												10	170		3				2						1						1									1				1			1												1	
2309102188			5												1	127		3				2																															7																			
2309102189			5								1					8		11				4																															10					1											
2309102190			1								1				1	1		1																																					1																			
2309102191			2				1								5			1											1																									1																			
2309102192			5		1										2			3																													2			1																			
2309102193			7		2		1				1				1			18				1						1						1								1								1											
2309102194			21												1	1		9				1																													1			1																			
2309102195			13								1				2			4																															1								1											
2309102196			40		1								5				1	5		12				1																	2										1		6					1											
2309102197													1		1		8			1				2						1								1																															
2309102198			14								3				5	1		5				1			1																							1			2													1						
2309102199			8												1			2				5						1								1								1			2					1											
2309102200			3												1	1		1				1																	1																													
2309102201			2								1				2								1																	2														1																			
2309102202			4												2			3																									4																															
2309102203			8												1								1																	1				1									2																			
2309102204			8															8				2																	6														2					1											
2309102205			17													2		19				1																	8								1			1													1						
2309102206			5												2			8				1																	5														5					2												1	
2309102207			1		1										5			6				3			1												3																					1											
2309102208			12		1										12			23				1			1												3														5					1											
2309102209			15												5			16											1								11														4					6											
2309102210			16												23			17											1								5														3					2											
2309102211			10												18			11											1								3														1					1											
2309102212			6												32			15		1		2																1											1		1					2											
2309102213			6												83			11	1							2			1								7														1					1											
2309102214			9												82			13																									8														2					3											
2309102215			9												52			7											1								3																					1											
2309102216			9												128			11																									2											1		2					2											
2309102217			10		1										127			9				3			1												3								1			10					3											

2309102218			8												29			10							3			2						1										26					1					1						
2309102219			1												20			4	1															3							1			7					3										1	
2309102220			2		1		1								13			15										2																2					3											
2309102221			3		1										44			8										1						3							1			1					2											
2309102222			7		1										66			6																2							3			3					2											
2309102223			2		2		2								55			7							2									3							1			2					1											
2309102224			3				1								108			9				1						1						5							3			1					1					1						
2309102225			6							1	1				555			6										4						3							3			1					4											
2309102226			4												68			2																1										1																
2309102227			2												29			6				1			1									1																										
2309102228			1												10			3										1						1																										
2309102229			1																									1																																
2309102230			4		1		1								72			4																1										3																
2309102231			8												137			8																3							2			5																
2309102232			7												10			4				4			2			1						1										2					1											
230910901					5		7											46	1		1									3				27				1				2		2	3														1	
230911101																																																							1				
230911601		1																																																										
23094401									1																																																			
23095310	200																																																											
23095701	33																2	13		56			3				3												4							1				9	9		6							1
23095702	6									1							5	9		16				1															1		2					3					30		4					1	1	
23095703										1										2																										1				2	6						1		2	2
23095704	24						3			26										69																												3		3	3		7						6	
23095801																		2		6		1			23		1														2					1		2		1	6	1	7							2
23095804	1						4											12		10																			1		1					4		1			8							1		2
23098202										56								3		18			1	5								1									10					4	1	1		1	5									
23098203										4														4	2														1		4																			1
23098305	200																																																											
23099101			4		1						1							6										1						1							1													1						
23099102					2													4				1																																					1	
23099103																		8										1														1												1						
23099104			6															7																															1					12						
23099105					1													1																										9										2						
Tecumseh Creek																																																												
21213401					1																										1			2																										
21213501																																																												
Lornewood Creek																																																												
21213801					15														5			3												2																										

Birchwood Creek																																																												
21210801																																																												
21213201					11				1									1	5	5		4									9			28																					7				6	
21213202					31				12	6							7	1	42			43									5			57							6														3				6	
21214101																			40																																									
21214201																			200																																									
23210307																																																												
23210308																																																												
23210401																	5					60																									2													
Turtle Creek																																																												
21211802									313										9			16									3			2																										
21213701																																																												
23212302									53													3																																						
23212303									3										1			1																																						
Sheridan Creek																																																												
Shoreline of Lake Ontario located at the outflow of Rattray Marsh	44														4																																												5	
21212901																						17									14																		4											
23211201												31						1																																										
Rattray Marsh	78			5		18	35			3365		90			3		419	20		1335		835		16	13	10					258	2		5					20		1198		1			4			98	1	1				2	121				
Lakeside Creek																																																												
21213301	No Catch																																																											
Avonhead Creek																																																												
21213001																																																												
21213101																	1					1									18			21						1	4														1				10	
Clearview Creek																																																												
21210703																						16																																						
21213601																						2																																						

Table B2 – Fish species by thermal guild

Thermal	Trophy	Scientific Name	Common Name	Species ID
Coldwater	Non-piscivore	*Petromyzon marinus*	Sea lamprey	S014
		Acipenser fulvescens	Lake sturgeon	S031
		Coregonus clupeaformis	Lake whitefish	S091
		Coregonus artedii	Cisco(lake herring)	S093
		Prosopium cylindraceum	Round whitefish	S102
		Catastomus catastomus	Longnose sucker	S162
		Margariscus margarita	Pearl dace	S214
		Percopsis omiscomaycus	Trout-perch	S291
		Cottus bairdii	Mottled sculpin	S381
		Cottus cognatus	Slimy sculpin	S382
		Myoxocephalus thompsonii	Deepwater sculpin	S384
	piscivore	*Oncorhynchus gorbuscha*	Pink salmon	S071
		Oncorhynchus kisutch	Coho salmon	S073
		Oncorhynchus tshawytscha	Chinook salmon	S075
		Oncorhynchus mykiss	Rainbow trout	S076
		Salmo trutta	Brown trout	S078
		Salvelinus namaycush	Lake trout	S081
		Lota lota	Burbot	S271
Coolwater	Non-piscivore	*Lethenteron appendix*	American brook lamprey	S011
		Ichthyomyzon unicuspis	Silver lamprey	S013
		Alosa pseudoharengus	Alewife	S061
		Osmerus mordax	Rainbow smelt	S121
		Hiodon tergisus	Mooneye	S152
		Catastomus commersoni	White sucker	S163
Coolwater	Non-piscivore	*Moxostoma anisurum*	Silver redhorse	S168
		Moxostoma erythrurum	Golden redhorse	S170
		Moxostoma macrolepidotum	Shorthead redhorse	S171
		Moxostoma valenciennesi	Greater redhorse	S172
		Chrosomus eos	Northern redbelly dace	S182
		Chrosomus neogaeus	Finescale dace	S183
		Couesius plumbeus	Lake chub	S185
		Hybognathus hakinsoni	Brassy minnow	S189
		Macrhybopsis storeriana	Silver chub	S191
		Nocomis micropogon	River chub	S193
		Notemigonus crysoleucas	Golden shiner	S194
		Notropis anogenus	Pugnose shiner	S195
		Notropis atherinoides	Emerald shiner	S196
		Notropis bifrenatus	Bridle shiner	S197
		Luxilus cornutus	Common shiner	S198
		Notropis heterodon	Blackchin shiner	S199
		Notropis heterolepis	Blacknose shiner	S200
		Notropis hudsonius	Spottail shiner	S201
		Rhinichthys atratulus	Blacknose dace	S210
		Rhinichthys cataractae	Longnose dace	S211
		Semotilus atromaculatus	Creek chub	S212
		Semotilus corporalis	Fallfish	S213

Thermal	Trophy	Scientific Name	Common Name	Species ID
		Luxilus chrysocephalus	Striped shiner	S217
		Fundulus diaphanus	Banded killifish	S261
		Culaea inconstans	Brook stickleback	S281
		Gasterosteus aculeatus	Threespine stickleback	S282
		Pungitius pungitius	Ninespine stickleback	S283
Coolwater	Non-piscivore	*Perca flavescens*	Yellow perch	S331
		Etheostoma caeruleum	Rainbow darter	S337
		Etheostoma exile	Iowa darter	S338
		Etheostoma flabellare	Fantail darter	S339
		Etheostoma microperca	Least darter	S340
		Etheostoma nigrum	Johnny darter	S341
		Percina caprodes	Logperch	S342
		Percina copelandi	Channel darter	S343
		Percina maculata	Blackside darter	S344
		Etheostoma olmstedi	Tessellated darter	S346
		Labidesthes sicculus	Brook silverside	S361
Coolwater	Piscivore	*Lepisosteus osseus*	Longnose gar	S041
		Lepisosteus oculatus	Spotted gar	S042
		Esox lucius	Northern pike	S131
		Esox masquinongy	Muskellunge	S132
		Esox americanus	Grass pickerel	S133
		Anguilla rostrata	American eel	S251
		Sander vitreus	Walleye	S334
Warmwater	Non-piscivore	*Dorosoma cepedianum*	Gizzard shad	S063
		Umbra limi	Central mudminnow	S141
		Carpiodes cyprinus	Quillback	S161
		Erimyzon sucetta	Lake chubsucker	S164
		Hypentelium nigricans	Northern hog sucker	S165
		Carassius auratus	Goldfish	S181
		Cyprinus carpio	Common Carp	S186
		Nocomis biguttatus	Hornyhead chub	S192
Warmwater	Non-piscivore	*Notropis rubellus*	Rosyface shiner	S202
		Cyprinella spiloptera	Spotfin shiner	S203
		Notropis stramineus	Sand shiner	S204
		Notropis volucellus	Mimic shiner	S206
		Pimephales notatus	Bluntnose minnow	S208
		Pimephales promelas	Fathead minnow	S209
		Campostoma anomalum	Stoneroller	S216
		Scardinius erythrophthalmus	Rudd	S220
		Ameiurus natalis	Yellow bullhead	S232
		Ameiurus nebulosus	Brown bullhead	S233
		Ictalurus punctatus	Channel catfish	S234
		Noturus flavus	Stonecat	S235
		Noturus gyrinus	Tadpole madtom	S236
		Morone americana	White perch	S301
		Ambloplites rupestris	Rock bass	S311

Thermal	Trophy	Scientific Name	Common Name	Species ID
		Lepomis cyanellus	Green sunfish	S312
		Lepomis gibbosus	Pumpkinseed	S313
		Lepomis macrochirus	Bluegill	S314
		Lepomis megalotis	Longear sunfish	S315
		Pomoxis annularis	White crappie	S318
		Pomoxis nigromaculatus	Black crappie	S319
		Aplodinotus grunniens	Freshwater drum	S371
Warmwater	Piscivore	*Amia calva*	Bowfin	S051
		Morone chrysops	White bass	S302
		Micropterus dolomieu	Smallmouth bass	S316
		Micropterus salmoides	Largemouth bass	S317

APPENDIX C – TERRESTRIAL NATURAL HERITAGE

Table C1: Summary of bird surveys in the LOISS study area (2012, 2013)

Species Name		Location												
		1 - Lakeview Coastal Reach			2 - Lakefront Promenade Coastal Reach	4 - Port Credit Coastal Reach		5 - Lorne Park/Meadowwood Coastal Reach					6 - Refinery Coastal Reach	7 - Clearview Coastal Reach
Common Name	**Scientific Name**	Marie Curtis Park	GE Booth	Ontario Power Generation	Lakefront Promenade Park	J J Plaus-JC Saddington Parks	Credit River Marshes	Breuckner Rhododendron Park	Lorne Park Estates	Jack Darling Park	Rattray Marsh	Watersedge Park	Lakeside Park	Harding Estates
Shorebirds														
Baird's Sandpiper	*Calidris bairdii*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	3	N/A	N/A	N/A
Black-bellied Plover	*Pluvialis squatarola*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	9	N/A	N/A	N/A
Dunlin	*Calidris pusilla*	N/A	2	N/A	-	N/A	N/A	-	N/A	-	6	N/A	N/A	N/A
Greater Yellowlegs	*Tringa melanoleuca*	N/A	3	N/A	2	N/A	N/A	-	N/A	-	-	N/A	N/A	N/A
Killdeer	*Charadrius vociferus*	N/A	107	N/A	6	N/A	N/A	-	N/A	-	120	N/A	N/A	N/A
Least Sandpiper	*Calidris minutilla*	N/A	81	N/A	7	N/A	N/A	-	N/A	-	54	N/A	N/A	N/A
Lesser Yellowlegs	*Tringa flavipes*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	29	N/A	N/A	N/A
Pector Sandpiper	*Calidris melanotos*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	4	N/A	N/A	N/A
Sanderling	*Calidris alba*	N/A	7	N/A	-	N/A	N/A	-	N/A	1	1	N/A	N/A	N/A
Short-billed Dowitcher	*Limnodromus griseus*	N/A	1	N/A	-	N/A	N/A	-	N/A	-	-	N/A	N/A	N/A
Semipalmated Plover	*Charadrius semipalmatus*	N/A	2	N/A	1	N/A	N/A	-	N/A	-	28	N/A	N/A	N/A
Semipalmated Sandpiper	*Calidris pusilla*	N/A	56	N/A	3	N/A	N/A	-	N/A	-	24	N/A	N/A	N/A
Solitary Sandpiper	*Tringa solitaria*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	16	N/A	N/A	N/A
Spotted Sandpiper	*Actitis macularius*	N/A	12	N/A	1	N/A	N/A	1	N/A	2	13	N/A	N/A	N/A
Stilt Sandpiper	*Calidris himantopus*	N/A	-	N/A	-	N/A	N/A	-	N/A	-	1	N/A	N/A	N/A
White-rumped Sandpiper	*Calidris fuscicollis*	N/A	13	N/A	-	N/A	N/A	-	N/A	-	-	N/A	N/A	N/A
Waterfowl														
American Black Duck	*Anas rubripes*	-	47	N/A	3	22	-	28	N/A	-	21	N/A	1	126
American Wigeon	*Anas americana*	1	1	N/A	-	-	-	-	N/A	-	-	N/A	53	102
Bufflehead	*Bucephala albeola*	13	287	N/A	32	58	-	23	N/A	22	16	N/A	144	385
Blue-winged Teal	*Anas discors*	-	8	N/A			1	-	N/A	-	10	N/A	-	-
Canada Goose	*Branta canadensis*	392	133	N/A	1471	1109		200	N/A	515	154	N/A	1192	498
Canvasback	*Aythya valisineria*	-	20	N/A	-	-	-	-	N/A	-	1	N/A	-	-
Common Goldeneye	*Bucephala clangula*	10	41	N/A	-	1	-	-	N/A	7	1	N/A	60	366
Common Loon	*Gavia immer*	1	-	N/A	-	-	-	1	N/A	-	2	N/A		
Common Merganser	*Mergus merganser*	200	20	N/A	19	78	-	-	N/A	5	9	N/A	73	259
Gadwall	*Anas strepera*	9	29	N/A	54	15	-	163	N/A	18	17	N/A	15	586
Greater Scaup	*Aythya marila*	-	4	N/A	-	-	-	-	N/A	-	-	N/A	-	-
Green-winged Teal	*Anas carolinensis*	-	6	N/A	-	-	-	1	N/A	-	227	N/A	-	-

Species Name		Location												
		1 - Lakeview Coastal Reach			2 - Lakefront Promenade Coastal Reach	4 - Port Credit Coastal Reach		5 - Lorne Park/Meadowwood Coastal Reach					6 - Refinery Coastal Reach	7 - Clearview Coastal Reach
Common Name	**Scientific Name**	Marie Curtis Park	GE Booth	Ontario Power Generation	Lakefront Promenade Park	J J Plaus-JC Saddington Parks	Credit River Marshes	Brueckner Rhododendron Park	Lorne Park Estates	Jack Darling Park	Rattray Marsh	Watersedge Park	Lakeside Park	Harding Estates
Harlequin Duck	*Histrionicus histrionicus*	-	-	N/A	-	-	-	1	N/A	-	-	N/A	-	-
Horned Grebe	*Podiceps auritus*	22	2	N/A	-	14	-	1	N/A	-	3	N/A	-	6
Hooded Merganser	*Lophodytes cucullatus*	-	5	N/A	-	1	-	-	N/A	-	15	N/A	-	-
Lesser Scaup	*Aythya affinis*	-	14	N/A	26	-	-	-	N/A	-	-	N/A	-	-
Mallard	*Anas platyrhynchos*	111	1234	N/A	425	618	-	1167	N/A	107	593	N/A	150	756
Mute Swan	*Cygnus olor*	32	17	N/A	52	108	3	131	N/A	36	52	N/A	17	51
Northern Pintail	*Anas acuta*	-	1	N/A	1	-	-	-	N/A	-	-	N/A	-	-
Northern Shoveler	*Anas clypeata*	-	11	N/A	-	-	-	-	N/A	-	2	N/A	-	-
Long-tailed Duck	*Clangula hyemalis*	7	62	N/A	70	262	-	-	N/A	1	-	N/A	51	7
Red-breasted Merganser	*Mergus serrator*	39	120	N/A	14	9	-	13	N/A	15	52	N/A	133	348
Ring-necked Duck	*Aythya collaris*		1	N/A	2	-	-	-	N/A	-	-	N/A	-	-
Red-necked Grebe	*Podiceps grisegena*	77	199	N/A	3	1	-	17	N/A	8	439	N/A	2	4
Ruddy Duck	*Oxyura jamaicensis*	2	-	N/A	-	-	-	-	N/A	-	-	N/A	-	-
Trumpeter Swan	*Cygnus buccinator*	-	-	N/A	1	4	-	9	N/A	4	-	N/A	-	1
Wood Duck	*Aix sponsa*	-	3	N/A	-	-	2	-	N/A	-	23	N/A	-	-
White-winged Scoter	*Melanitta deglandi*	1	6	N/A	-	1	-	-	N/A	-	-	N/A	-	4
Landbirds														
Acadian Flycatcher	*Empidonax virescens*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
American Crow	*Corvus brachyrhynchos*	10	6	-	2	8	N/A	N/A	2	-	24	20	1	16
American Goldfinch	*Spinus tristis*	22	51	12	21	34	N/A	N/A	4	22	68	49	43	43
American Kestrel	*Falco sparverius*	2	3	25	-	-	N/A	N/A	-	-	-	-	-	-
American Redstart	*Setophaga ruticilla*	6	4	-	-	-	N/A	N/A	1	-	9	4	3	1
American Robin	*Turdus migratorius*	47	8	5	62	59	N/A	N/A	2	13	103	46	69	67
American Tree Sparrow	*Spizella arborea*	6	-	-	-	-	N/A	N/A	-	-	-	-	4	-
Bald Eagle	*Haliaeetus leucocephalus*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Bank Swallow	*Riparia riparia*	1	73	66	-	-	N/A	N/A	-	-	-	1	11	2
Baltimore Oriole	*Icterus galbula*	4	9	3	6	2	N/A	N/A	3	1	16	7	14	2
Barn Swallow	*Hirundo rustica*	10	27	7	95	48	N/A	N/A		1	7	3	17	34
Black and White Warbler	*Mniotilta varia*	3	8	-	-	-	N/A	N/A	1	-	6	4	4	-
Black-billed Cuckoo	*Coccyzus erythropthalmus*	1	1	-	-	-	N/A	N/A	-	-	-	-	-	-

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Bay-breasted Warbler	*Setophaga castanea*	-	-	-	-	-	N/A	N/A	-	-	-	-	1	-
Black-capped Chickadee	*Poecile atricapillus*	31	9	1	16	18	N/A	N/A	3	23	143	44	21	49
Belted Kingfisher	*Megaceryle alcyon*	6	1	8	1	3	N/A	N/A	2	-	28	2	2	22
Blue-gray Gnatcatcher	*Polioptila caerulea*	10	7	-	1	3	N/A	N/A	1	-	18	3	3	-
Brown-headed Cowbird	*Molothrus ater*	15	9	1	5	5	N/A	N/A	2	-	14	19	24	10
Blue-headed Vireo	*Vireo solitarius*	-	1	-	-	-	N/A	N/A	-	-	1	5	-	-
Blackburnian Warbler	*Setophaga fusca*	3	4	-	1		N/A	N/A	1	-	7	7	3	-
Blue Jay	*Cyanocitta cristata*	20	9	6	1	8	N/A	N/A	1	12	58	17	6	18
Black Tern	*Chlidonias niger*		-	-	-	-	N/A	N/A	-	-	-	-	-	1
Blackpoll Warbler	*Setophaga striata*	2	-	1	-	1	N/A	N/A	-	-	4	4	2	-
Bobolink	*Dolichonyx oryzivorus*	1	1	5	-	-	N/A	N/A	-	-	-	1	1	-
Boreal Chickadee	*Poecile hudsonicus*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Brown Creeper	*Certhia americana*	-	-	-	-	-	N/A	N/A	-	1	10	1	1	1
Brown Thrasher	*Toxostoma rufum*	2	1	1	-	-	N/A	N/A	-	-	-	1	1	-
Black-throated Blue Warbler	*Setophaga caerulescens*	4	1	-	-	-	N/A	N/A	1	-	6	5	5	1
Black-throated Green Warbler	*Setophaga virens*	2	4	-	-	-	N/A	N/A	2	-	14	13	4	-
Blue-winged Warbler	*Vermivora cyanoptera*	-	-	-	-	-	N/A	N/A	-	-	2	1	2	-
Carolina Wren	*Thryothorus ludovicianus*	-	1	-	-	-	N/A	N/A	1	-	5	8	-	-
Canada Warbler	*Cardellina canadensis*	-	-	-	-	-	N/A	N/A	-	-	-	4	1	-
Cedar Waxwing	*Bombycilla cedrorum*	10	4	2	2	9	N/A	N/A	1	-	50	16	19	14
Chipping Sparrow	*Spizella passerina*	-	1	-	3	-	N/A	N/A	-	-	2	7	2	-
Chimney Swift	*Chaetura pelagica*	-	-	-	-	-	N/A	N/A	1	-	17	2	-	-
Cliff Swallow	*Petrochelidon pyrrhonota*	-	12	17	7	-	N/A	N/A	-	-	-	-	-	-
Cape May Warbler	*Setophaga tigrina*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Cooper's Hawk	*Accipiter cooperii*	1	-	-	-	-	N/A	N/A	-	-	8	3	-	5
Common Nighthawk	*Chordeiles minor*	-	-	-	-	-	N/A	N/A	-	-	16	-	-	-
Connecticut Warbler	*Oporornis agilis*	-	-	-	-	-	N/A	N/A	-	-	2	-	-	-
Common Yellowthroat	*Geothlypis trichas*	3	2	-	-	-	N/A	N/A	-	-	5	2	4	-
Chestnut-sided Warbler	*Setophaga pensylvanica*	5	10	-	1	-	N/A	N/A	-	-	3	3	6	-
Dark-eyed Junco	*Junco hyemalis*	5	-	8	10	2	N/A	N/A	-	16	6	9	6	21

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Downey Woodpecker	*Picoides pubescens*	14	4	-	2	3	N/A	N/A	2	5	38	9	4	7
Eastern Bluebird	*Sialia sialis*	1	-	-	-		N/A	N/A	-	-	-	-	-	1
Eastern Kingbird	*Tyrannus tyrannus*	6	4	5	-	1	N/A	N/A	2	-	2	2	6	2
Eastern Meadowlark	*Sturnella magna*	2	-	-	-		N/A	N/A	-	-	-	-	-	-
Eastern Phoebe	*Sayornis phoebe*	4	-	-	-	1	N/A	N/A	-	-	5	2	6	3
Eastern Screech-Owl	*Megascops asio*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Eastern Towhee	*Pipilo erythrophthalmus*	-	1	1	-	-	N/A	N/A	-	-	4	-	1	2
Eastern Wood-pewee	*Contopus virens*	3	1	-	-	-	N/A	N/A	3	-	1	2	3	1
Field Sparrow	*Spizella pusilla*	1	-	-	-	2	N/A	N/A	-	-	-	2	2	1
Fox Sparrow	*Passerella iliaca*	-	-	-	-	-	N/A	N/A	-	-	3	-	-	-
Great Crested Flycatcher	*Myiarchus crinitus*	6	1	-	-	-	N/A	N/A	2	-	13	7	-	-
Golden-crowned Kinglet	*Regulus satrapa*	-	3	3	2	-	N/A	N/A	-	2	17	3	15	12
Gray Catbird	*Dumetella carolinensis*	17	10	1	2	6	N/A	N/A	1	-	20	5	12	7
Hairy Woodpecker	*Leuconotopicus villosus*	9	1	-	-	-	N/A	N/A	2	3	19	6	-	5
Hermit Thrush	*Catharus guttatus*	-	2	-	-	-	N/A	N/A	-	2	6	4	11	-
House Finch	*Haemorhous mexicanus*	-	-	-	-	1	N/A	N/A	-	1	-	1	1	10
Horned Lark	*Eremophila alpestris*	-	1	-	-	-	N/A	N/A	-	-	-	-	-	-
House Sparrow	*Passer domesticus*	-	17	2	7	59	N/A	N/A	1	12	9	3	-	1
Hooded Warbler	*Setophaga citrina*	-	-	-	-	-	N/A	N/A	-	-	-	1	-	-
House Wren	*Troglodytes aedon*	3	1	-	1	-	N/A	N/A	1	-	10	10	1	2
Indigo Bunting	*Passerina cyanea*	-	1	-	-	-	N/A	N/A	-	-	1	1	1	-
Least Flycatcher	*Empidonax minimus*	4	4	-	-	1	N/A	N/A	1	-	5	6	3	-
Lincoln's Sparrow	*Melospiza lincolnii*	-	-	-	-	-	N/A	N/A	-	-	-	-	1	-
Magnolia Warbler	*Setophaga magnolia*	1	2	-	-	-	N/A	N/A	1	-	4	4	1	-
Merlin	*Falco columbarius*	1	1	1	-	-	N/A	N/A	-	-	1	-	-	-
Mourning Dove	*Zenaida macroura*	1	79	24	3	9	N/A	N/A	1	3	6	2	1	1
Mourning Warbler	*Geothlypis philadelphia*	-	-	-	-	-	N/A	N/A	-	-	-	1	1	-
Nashville Warbler	*Leiothlypis ruficapilla*	4	10	-	-	-	N/A	N/A	1	-	8	5	10	1
Northern Cardinal	*Cardinalis cardinalis*	22	11	3	16	11	N/A	N/A	3	11	88	33	11	37
Northern Flicker	*Colaptes auratus*	10	4	7	1		N/A	N/A	1	4	14	8	10	7

Species Name		Location												
		1 - Lakeview Coastal Reach			2 - Lakefront Promenade Coastal Reach	4 - Port Credit Coastal Reach		5 - Lorne Park/Meadowwood Coastal Reach					6 - Refinery Coastal Reach	7 - Clearview Coastal Reach
Common Name	**Scientific Name**	Marie Curtis Park	GE Booth	Ontario Power Generation	Lakefront Promenade Park	J J Plaus-JC Saddington Parks	Credit River Marshes	Brueckner Rhododendron Park	Lorne Park Estates	Jack Darling Park	Rattray Marsh	Watersedge Park	Lakeside Park	Harding Estates
Northern Harrier	*Circus cyaneus*	-	-	1	-	-	N/A	N/A	-	-	-	-	-	-
Northern Mockingbird	*Mimus polyglottos*	5	4	21	-	6	N/A	N/A	-	-	2	-	-	-
Northern Parula	*Setophaga americana*	1	1	-	-	1	N/A	N/A	-	-	5	2	-	-
Northern Pintail	*Anas acuta*	-	-	-	-	-	N/A	N/A	-	-	-	-	-	2
Northern Waterthrush	*Parkesia noveboracensis*	1	-	-	-	-	N/A	N/A	-	-	-	-	-	-
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	5	15	7	2	4	N/A	N/A	-	-	18	2	6	44
Northern Saw-whet Owl	*Aegolius acadicus*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Osprey	*Pandion haliaetus*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Ovenbird	*Seiurus aurocapillus*	2	1	-	-	-	N/A	N/A	1	-	1	3	1	-
Parasitic Jaeger	*Stercorarius parasiticus*	-	-	-	-	-	N/A	N/A	-	-	-	-	-	1
Palm Warbler	*Setophaga palmarum*	-	-	5	-	-	N/A	N/A	-	-	-	-	-	-
Peregrine Falcon	*Falco peregrinus*	-	1	1	-	-	N/A	N/A	-	-	-	-	-	-
Philadephia Vireo	*Vireo philadelphicus*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Pine Siskin	*Spinus pinus*	-	-	16	-	-	N/A	N/A	-	-	3	2	-	20
Pine Warbler	*Setophaga pinus*	2	2	-	-	2	N/A	N/A	4	-	15	2	2	2
Pileated Woodpecker	*Hylatomus pileatus*	-	1	-	-	-	N/A	N/A	-	-	5	3	-	-
Purple Finch	*Haemorhous purpureus*	-	-	-	-	-	N/A	N/A	-	-	2	-	-	-
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	3	-	-	1	1	N/A	N/A	-	-	4	1	-	-
Red-breasted Nuthatch	*Sitta canadensis*	-	1	-	-	-	N/A	N/A	1	-	3	4	1	2
Red-bellied Woodpecker	*Melanerpes carolinus*	1	1	-	-	-	N/A	N/A	2	-	12	6	1	-
Ruby-crowned Kinglet	*Regulus calendula*	5	1	-	-	6	N/A	N/A	-	6	37	11	15	5
Red-eyed Vireo	*Vireo olivaceus*	8	4	-	-	-	N/A	N/A	3	-	14	4	2	-
Red-tailed Hawk	*Buteo jamaicensis*	10	7	9	-	1	N/A	N/A	1	-	1	5	6	2
Ruby-throated Hummingbird	*Archilochus colubris*	4	-	-	-	1	N/A	N/A	-	-	3	1	3	-
Rusty Blackbird	*Euphagus carolinus*	-	1	-	-	-	N/A	N/A	-	1	3	-	1	-
Red-winged Blackbird	*Agelaius phoeniceus*	65	47	28	177	77	N/A	N/A	-	1	231	46	51	65
Savannah Sparrow	*Passerculus sandwichensis*	4	21	23	-	-	N/A	N/A	-	-	-	-	5	3
Scarlet Tanager	*Piranga olivacea*	1	-	-	-	-	N/A	N/A	-	-	2	1	1	-
Snow Bunting	*Plectrophenax nivalis*	-	-	1	-	-	N/A	N/A	-	-	-	-	-	-
Song Sparrow	*Melospiza melodia*	37	20	12	24	45	N/A	N/A	1	6	58	10	34	23

Species Name		Location												
		1 - Lakeview Coastal Reach			2 - Lakefront Promenade Coastal Reach	4 - Port Credit Coastal Reach		5 - Lorne Park/Meadowwood Coastal Reach					6 - Refinery Coastal Reach	7 - Clearview Coastal Reach
Common Name	**Scientific Name**	Marie Curtis Park	GE Booth	Ontario Power Generation	Lakefront Promenade Park	J J Plaus-JC Saddington Parks	Credit River Marshes	Breuckner Rhododendron Park	Lorne Park Estates	Jack Darling Park	Rattray Marsh	Watersedge Park	Lakeside Park	Harding Estates
Sharp-shinned Hawk	*Accipiter striatus*	1	-	-	-	-	N/A	N/A	-	1	-	-	-	-
Swamp Sparrow	*Melospiza georgiana*	-	-	-	-	-	N/A	N/A	-	-	3	-	-	-
Swainson's Thrush	*Catharus ustulatus*	1	-	-	-	-	N/A	N/A	-	-	2	-	2	-
Tennessee Warbler	*Leiothlypis peregrina*	-	-	-	-	-	N/A	N/A	-	-	-	2	1	-
Tree Swallow	*Tachycineta bicolor*	24	10	-	19	58	N/A	N/A	-	-	84	109	9	101
Turkey Vulture	*Cathartes aura*	5	3	1	-	-	N/A	N/A	-	-	6	5	7	5
Veery	*Catharus fuscescens*	-	1	-	-	-	N/A	N/A	-	-	1	1	-	-
Vesper Sparrow	*Pooecetes gramineus*	-	1	-	-	-	N/A	N/A	-	-	-	-	-	-
Warbling Vireo	*Vireo gilvus*	7	8	1	7	7	N/A	N/A	1	1	20	7	20	1
White-breasted Nuthatch	*Sitta carolinensis*	7	2	1	1	-	N/A	N/A	2	3	21	9	1	3
White-crowned Sparrow	*Zonotrichia leucophrys*	7	4	-	1	7	N/A	N/A	-	-	3	2	20	3
Willow Flycatcher	*Empidonax traillii*	3	4	5	-	-	N/A	N/A	-	-	-	-	2	-
Wilson's Warbler	*Cardellina pusilla*	-	1	-	-	-	N/A	N/A	-	-	1	1	4	-
Winter Wren	*Troglodytes hiemalis*	1	1	-	-	-	N/A	N/A	3	-	6	2	1	-
Wood Thrush	*Hylocichla mustelina*	-	1	-	-	-	N/A	N/A	2	-	1	-	-	-
White-throated Sparrow	*Zonotrichia albicollis*	5	4	20	1	6	N/A	N/A	1	6	37	6	83	13
Yellow-bellied Flycatcher	*Empidonax flaviventris*	-	1	-	-	-	N/A	N/A	-	-	-	1	-	-
Yellow-bellied Sapsucker	*Sphyrapicus varius*	-	-	-	-	-	N/A	N/A	-	-	4	-	-	1
Yellow Palm Warbler	*Setophaga palmarum*	1	8	-	-	2	N/A	N/A	-	1	3	-	2	-
Yellow-rumped Warbler	*Setophaga coronata*	9	127	10	2	14	N/A	N/A	-	1	9	15	20	15
Yellow-throated Warbler	*Setophaga dominica*	-	-	-	-	-	N/A	N/A	-	-	1	-	-	-
Yellow Warbler	*Setophaga petechia*	11	49	7	7	10	N/A	N/A	1	-	28	7	27	10

Table C2: Fall Butterflies and Migratory Dragonfllies in Mississauga, Ontario 2009/2010 (source: McIlveen 2009, 2010)

Species		Location																
		1 - Lakeview	2- Lakefront Promenade			3 - Mineola					4 – Port Credit	5 – Lorne Park/ Meadowwood					6 - Refinery	7 - Clearview
Common Name	Scientific Name	Marie Curtis Park	Lakefront Promenade	Kennedy Headland	RK McMillan Park	Cawthra Woods	Mouth of Cooksville Creek	Adamson Estate	Hiawatha Park	Tall Oaks Park	JC Saddington Park	Rhododendron Park	Richards Memorial Park	Jack Darling Park	Rattray Marsh	Watersedge Park	Lakeside Park	Harding Estates
Butterflies																		
Monarch	*Danaus plexippus*	96/119	NA*/32	NA/13	3/61	7/26	NA/9	NA/13	NA/7	NA/21	7/93	NA/31	NA/8	2/8	0/9	NA/1	54/23	4/NA
Cabbage White	*Pieris rapae rapae*	25/47	NA/5	NA/19	44/64	31/3	NA/20	NA/10	NA/10	NA/14	66/92	NA/19	NA/2	24/11	10/42	NA/3	51/65	9/NA
Clouded Sulfur	*Colias philodice philodice*	13/12	NA/3	NA/3	2/11	21/0	NA/0	NA/0	NA/1	NA/4	4/34	NA/5	NA/3	8/6	3/0	NA/2	14/10	3/NA
American Lady	*Vanessa virginiensis*	0/0	NA/0	NA/0	0/1	0/1	NA/0	NA/0	NA/0	NA/0	0/1	NA/0	NA/0	0/0	0/0	NA/0	0/0	1/NA
Common Ringlet	*Coenonympha tullia*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/0	9/0	0/NA
Dun	*Euphyes vestris*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/0	1/0	0/NA
Eastern Comma	*Polygonia comma*	0/0	NA/0	NA/0	0/0	0/1	NA/0	NA/1	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/1	NA/0	0/0	1/NA
Eastern Tailed Blue	*Everes comyntas comyntas*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/1	NA/0	0/2	NA/1	NA/0	0/0	0/0	NA/0	0/0	0/NA
Giant Swallowtail	*Papilio cresphontes*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/1	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/1	0/0	0/NA
Least Skipper	*Ancyloxypha numitor*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	1/0	NA/0	0/0	0/NA
Mourning Cloak	*Nymphalis antiopa antiopa*	0/1	NA/0	NA/0	1/0	0/0	NA/0	NA/0	NA/0	NA/0	4/1	NA/0	NA/0	0/0	0/0	NA/0	2/0	0/NA
Northern Crescent	*Phyciodes cocyta*	0/0	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/0	0/0	1/NA
Orange Sulphur	*Colias eurytheme*	0/1	NA/1	NA/1	0/1	0/0	NA/0	NA/0	NA/0	NA/0	1/0	NA/1	NA/0	0/0	0/0	NA/0	1/0	0/NA
Peck's Skipper	*Polites peckius*	0/0	NA/0	NA/0	0/0	1/0	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/0	0/0	0/NA
Red Admiral	*Vanessa atalanta*	1/1	NA/0	NA/0	0/0	0/0	NA/0	NA/0	NA/0	NA/0	0/1	NA/1	NA/0	0/0	0/1	NA/0	0/1	0/NA
Summer Azure	*Celastrina neglecta*	1/1	NA/0	NA/0	0/0	0/1	NA/0	NA/0	NA/0	NA/0	0/1	NA/0	NA/0	0/0	0/0	NA/0	5/0	2/NA
Viceroy	*Limenitis archippus*	0/1	NA/0	NA/0	0/0	0/1	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	0/0	0/0	NA/0	0/0	0/NA
Wild Indigo Duskywing	*Erynnis baptisiae*	0/1	NA/0	NA/0	0/0	0/1	NA/0	NA/0	NA/0	NA/0	0/0	NA/0	NA/0	2/0	0/2	NA/0	1/0	0/NA
Migratory Dragonflies																		
Black Saddlebags	*Tramea lacerata*	NA/2	NA/0	NA/0	NA/4	NA/0	NA/NA	NA/0	NA/0	NA/4	NA/3	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/NA
Common Green Darner	*Anax junius*	NA/64	NA/11	NA/4	NA/33	NA/118	NA/NA	NA/1	NA/2	NA/0	NA/25	NA/15	NA/4	NA/7	NA/4	NA/2	NA/11	NA/NA
Twelve-spotted Skimmer	*Libellula pulchella*	NA/0	NA/0	NA/0	NA/0	NA/0	NA/NA	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/0	NA/NA

*** NA = this location was not surveyed**

Table C3a – Amphibian Species in the LOISS Study Area (Pre-2009) (Green Frog, Northern Leopard Frog, American Toad, Spring Peeper, Western Chorus Frog and Wood Frog) (Source: ABL 2011)

Location	Green Frog *Rana clamitans*		Northern Leopard Frog *Lithobates pipiens*		American Toad *Anaxyrus americanus*		Spring Peeper *Pseudacris crucifer*		Western Chorus Frog *Pseudacris triseriata*		Wood Frog *Lithobates sylvaticus*	
	Year Observed	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**
Credit River Marshes (NAS site CRR9)	2001, 1989, 1927	1, 4	?	4	1989, 1987	1, 4	-	-	-	-	-	-
					2004	7						
					2005	7						
					2007	7						
Turtle Creek (NAS site CL8)	2007	7										
	2006	7										
	2008	7										
Marie Curtis Park (NAS site LV1)	-	-	-	-	-	-	-	-	-	-	-	-
Meadowwood Park (Potentially)	-	-	-	-	2008	1	-	-	-	-	-	-
					1990	3	-	-	-	-	-	-
Rattray Marsh (NAS site CL9)	1995, 2003, 2004, 2005, 2007	2	1975, 1986, 1987, 1989, 1994, 1995, 2007	2	1995, 2007	2	1995, 2007	2	1995	2	1975, 1995, 2007(?)	2
	2007	2, 7	2008	7	2004, 2005, 2006	7,2						
	2008	7			2008	7						
Joshua Creek area (unknown location)	1996	6	-	-	1996	6	-	-	1996	6	1996	6
Lakeside Park	2008	8	-	-	-	-	-	-	-	-	-	-
NAS site CRR7	1990	3	-	-	-	-	-	-	-	-	-	-
	1998, 2001	1	1990, 1987	1	1988, 1998, 1999	1	-	-	1943	1	-	-
NAS Site CRR6	1990	3	-	-	1990	3	-	-	-	-	-	-
	1998, 2001, 2002, 2006	1	2001	1	1999, 1990, 1987, 1985, 1981, 1973	1	2001, 1973	1	1985, 1973, 1972	1	-	-
Cawthra Woods (NAS Site LV7)	-	-	-	-	1989, 1991	1	-	-	-	-	-	-
Fudger's Marsh (NAS CL21)	-	-	-	-	1995	1	-	-	-	-	-	-
Orr Road Woodlands (NAS CL1/SD5)	-	-	-	-	2007, 2008	9	-	-			-	-
NAS Cl39	-	-	-	-	-	-	-	-	-	-	-	-
Lorne Park Estates (NAS site CL17)	-	-	-	-	-	-	-	-	-	-	-	-
NAS Site CRR8	-	-	-	-	-	-	-	-	-	-	-	-
NAS Site EM4	-	-	-	-	-	-	-	-	-	-	-	-
NAS Site SD1	-	-	-	-	-	-	-	-	-	-	-	-

Sources:
1 CVC Survey, 2009 (unpublished)
2 Mississauga NAS, 2008
3 McIlveen, March 2008
4 Hamilton Herp Atlas, 1990
5 Guindon & Varga 2008
6 Dougan & Associates 2008
7 McIlwrick, 1996
8 CVC Terrestrial Monitoring Program
9 CVC incidental observation

Table C3b – Amphibian Species in the LOISS Study Area (Pre-2009) (Bull Frog, Gray Treefrog, Jefferson Salamander Complex, Spotted Salamander, Eastern Newt and Eastern Red-backed Salamander) (Source: ABL 2011)

Location	**Bull Frog** *Lithobates catesbeianus*		**Gray Treefrog** *Hyla versicolor*		**Jefferson's Salamander Complex** *Ambystoma jeffersonianum*		**Spotted Salamander** *Ambystoma maculatum*		**Eastern Newt** *Notophthalmus viridescens*		**Eastern Red-backed Salamander** *Plethodon cinereus*	
	Year Observed	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**	**Year Observed**	**Source**
Credit River Marshes (NAS site CRR9)	-	-	1939	1							1943	1
	2001, 1927	1, 4	-	-	-	-	-	-	-	-	-	-
Turtle Creek (NAS site CL8)	1993	1, 4	-	-	-	-	-	-	-	-	-	-
Marie Curtis Park (NAS site LV1)	-	-	-	-	-	-	-	-	-	-	-	-
Meadowwood Park (Potentially)	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Rattray Marsh (NAS site CL9)	1993(?), 1995, 2007(?)	2	1976	1			1976	1	1976	1	1990	1
Joshua Creek area (unknown location)	-	-	-	-	-	-	-	-	-	-	-	-
Lakeside Park	-	-	-	-	-	-	-	-	-	-	-	-
NAS site CRR7	-	-	-	-	-	-	-	-	-	-	2001	1
NAS Site CRR6	1990	3	1985	1	2006	1	2006	1	1990	1	2006	1
	1973	1	-	-	-	-	-	-	-	-	-	-
Cawthra Woods (NAS Site LV7)	-	-	-	-	Not recorded	1	-	-	-	-	1988	1
Fudger's Marsh (NAS CL21)	-	-	-	-	-	-	-	-	-	-	-	-
Orr Road Woodlands (NAS CL1/SD5)	-	-	-	-	-	-	-	-	-	-	-	-
NAS Cl39	-	-	-	-	-	-	1990	1			1990	1
Lorne Park Estates (NAS site CL17)	-	-	-	-	-	-	-	-	-	-	1990	1
NAS Site CRR8	-	-	-	-	-	-	-	-	-	-	2001	1
NAS Site EM4	-	-	-	-	-	-	-	-	-	-	2001	1
NAS Site SD1	-	-	-	-	-	-	-	-	-	-	1990	1

Sources:
1 Mississauga NAS, 2008
2 McIlveen, March 2008
3 Hamilton Herp Atlas, 1990
4 Guindon & Varga 2008
5 Dougan & Associates 2008
6 McIlwrick, 1996
7 CVC Terrestrial Monitoring Program
8 CVC incidental observation

Table C3: Amphibians and Reptiles in the LOISS Study Area (2009-2012) (Source: CVC unpublished data)

Location/Survey date	**American Toad** Anaxyrus americanus	**Gray Treefrog** *Hyla versicolor*	**Green Frog** *Rana clamitans*	**Northern Leopard Frog** *Lithobates pipiens*	**Eastern Gartersnake** Thamnophis sirtali	**Eastern Milksnake** Lampropeltis triangulum	**Eastern Snapping Turtle** Chelydra serpentina	**Midland Painted Turtle** Chrysemys picta	**Northern Map Turtle** Graptemys geographica	**Grand Total**
Credit River Marshes										
2009-06-25			3							3
2011-06-21									1	1
2011-06-23							1			1
CRH										
2011-11-09		1								1
Jack Darling Park										
2009-06-10			1							1
Lakeside Park										
2012-04-12				1						1
2012-05-09	1		1	1						3
2012-05-22	1									1
Marie Curtis Park										
2009-04-16				1						1
2009-06-05			2							2
2012-05-03								1		1

Location/Survey date	**American Toad** Anaxyrus americanus	**Gray Treefrog** *Hyla versicolor*	**Green Frog** *Rana clamitans*	**Northern Leopard Frog** *Lithobates pipiens*	**Eastern Gartersnake** Thamnophis sirtali	**Eastern Milksnake** Lampropeltis triangulum	**Eastern Snapping Turtle** Chelydra serpentina	**Midland Painted Turtle** Chrysemys picta	**Northern Map Turtle** Graptemys geographica	**Grand Total**
2012-05-18								1		1
2012-06-06			1					1		2
Rattray Marsh										
2009-07-09	1			1						2
2010-06-20			1							1
2011-05-11					1					1
2011-05-19						1				1
2011-06-16							1			1
2011-06-24							2			2
2011-06-27	1		2							3
2011-06-28							10			10
2011-06-29							9			9
2011-06-30							6			6
2011-07-07			2							2
2011-08-30	1									1
2011-09-19							1			1
2011-09-20							1			1
2011-09-21							1			1

Location/Survey date	**American Toad** Anaxyrus americanus	**Gray Treefrog** *Hyla versicolor*	**Green Frog** *Rana clamitans*	**Northern Leopard Frog** *Lithobates pipiens*	**Eastern Gartersnake** Thamnophis sirtali	**Eastern Milksnake** Lampropeltis triangulum	**Eastern Snapping Turtle** Chelydra serpentina	**Midland Painted Turtle** Chrysemys picta	**Northern Map Turtle** Graptemys geographica	**Grand Total**
2012-05-09					1					1
2012-05-24	1									1
Watersedge Park										
2012-05-22	1									1
Grand Total	**7**	**1**	**13**	**4**	**2**	**1**	**32**	**3**	**1**	**64**

APPENDIX D – OUTREACH AND COMMUNICATIONS

List of outreach and communications activities undertaken for the Lake Ontario Integrated Shoreline Strategy through the Characterization Phase (2011-2015)

2011 LOISS Outreach and Communications Activities

- Stakeholder research – Engage key opinion leaders and tailor communications activities accordingly
- LOISS display panels – Create standing display for use at community sessions and events
- LOISS fact sheet – One page print material for use at community events
- News releases – Increase awareness on resident issues such as lake algae and pool draining best practices
- Port Credit BIA breakfast – LOISS info shared by local councillor
- Pre-meeting with Lorne Park Estates Association – important first step to build relationship with key waterfront landowners
- Ratepayers stakeholder session – workshop to develop project awareness amongst key resident leaders and gather feedback
- Corporate stakeholder session – workshop to develop project awareness amongst key corporate landowners and gather feedback
- Presentations
  - Lions Club meeting
  - CO/CA Watershed Stewardship/Forestry/Restoration Meeting
  - Great Lakes Conference
  - AD Latornell Conference: presentation

2012 LOISS Outreach and Communications Activities

- Community sessions – Community meeting for Lorne Park Estates Association homeowners
- Stakeholder outreach – CVC representatives present at the AGMs of key ratepayer/stakeholder groups
- Mississauga Waterfront Festival – CVC/LOISS booth at large waterfront event, includes display panel on before/after shoreline restoration, kids' activities, LOISS information card
- News release – low-impact development practices and how to implement at home
- LOISS e-newsletter – regular updates, profiles of shoreline activities for both resident and business audiences.
- Presentations
  - Port Credit Clarkson Hall
  - Ratepayers Groups
  - Cranberry Cove AGM
  - Park Royal AGM
  - Meadowood AGM
  - AD Latornell Conference: presentation

2013 LOISS Outreach and Communications Activities

- Web site 'virtual tour' – map, photos and description of demonstration projects to illustrate what shoreline restoration can look like
- Angler outreach – Presentation at angling association AGMs to develop awareness of LOISS and build relationships
- VIP Boat Tours – Minister of Finance, business leaders, resident leaders on guided boat tour to view the shoreline from the water
- Mississauga Waterfront Festival – restoration display panel, kids' activities
- LOISS e-newsletter

- Conservation Youth Corps – begin to engage youth and increase awareness of shoreline environmental issues
- Presentations
  - Clarkson Mothers Group
  - Forest Avenue School Parents Council
  - Conservation Ontario: Communication and Outreach BCPV
  - Lorne Park Estates Association AGM

2014 LOISS Outreach and Communications Activities

- Angler workshop held to seek input on LOISS and to gauge level of interest in participating in implementation of priority recommendations - http://www.creditvalleyca.ca/watershed-science/living-by-the-lake/angler-engagement/
- LOISS e-calendar developed - http://www.creditvalleyca.ca/watershed-science/living-by-the-lake/living-by-the-lake-ecalendar/
- Proactive news release distributed in May regarding migratory birds to broaden awareness of the local shoreline's role in transcontinental migration and provide tips for providing supportive habitats.
- Mississauga Waterfront Festival – attended by CVC staff
- Presentation to various ratepayers groups including White Oaks Lorne Park
- LOISS e-newsletter – 3 newsletters issued (March, June, September)
- Presence at Port Credit Salmon and Trout Association Salmon Derby in June
- Presentations:
  - White Oaks Ratepayers AGM

2015 LOISS Outreach and Communications Activities

- Presentations
  - Angler Workshop