Credit Valley Conservation

LAKE ONTARIO INTEGRATED SHORELINE STRATEGY

BACKGROUND REVIEW AND DATA GAP ANALYSIS

Final Report

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Executive Summary

Introduction

Credit Valley Conservation initiated the Lake Ontario Integrated Shoreline Strategy (LOISS) in response to a need for an integrated systems approach to the management of the shoreline within its jurisdiction. The strategy is intended to facilitate the integration of the CVC initiative with other watershed planning processes currently underway or planned in the Credit River watershed. It is also intended to provide information to link inland and offshore ecosystems and to integrate local initiatives with those at the Lake Ontario and Great Lakes basin scale.

Since its foundation in 1954, Credit Valley Conservation Authority has acquired existing or potential high-quality natural areas within the Credit River watershed for conservation purposes. Occurring almost exclusively in the 1970s, the waterfront acquisition program was designed to implement the recommendations for the Mississauga section of the 1967 Metropolitan Toronto Waterfront Plan. The legacy of this acquisition program is that CVC remains the largest single landowner of Lake Ontario shoreline in the Credit River Watershed. CVC owns 8 distinct properties along the shoreline, amounting to a total of approximately 7.3 km, or 26% of the Lake Ontario shoreline. Currently, all CVC conservation land along the shoreline, with the exception of Rattray Marsh Conservation Area, is leased to the City of Mississauga for park, recreation, and conservation purposes.

The LOISS is multidisciplinary in nature and is being completed in three phases:

1. Background Review and Data Gap Analysis Report,
2. Shoreline Characterization and Impact Analysis, and
3. Shoreline Restoration Plan.

The report contained herein summarizes the first phase of the LOISS. This phase involved the collection and analysis of background information to determine historical and existing conditions within the Study Area. It also identified data gaps, prioritized these gaps, and developed approaches to addressing the gaps to adequately characterize the shoreline.

Objectives

The purpose of the LOISS is to provide guidance to local, regional, and provincial governments in planning future restoration initiatives, developments, and land use decisions, while at the same time meeting and improving the existing needs of the natural environment. To support the function of this significant bioregional corridor, the study will include a specific focus on opportunities for the protection and restoration of natural ecosystems along the shoreline inland to the first major barrier and into the lake in the nearshore environment. In addition, through a review of the City of Mississauga Waterfront Parks Strategy (MWPS), as approved in principle by the CVC Board of Directors, it was agreed that the LOISS would be undertaken to further inform the MWPS in its upcoming updates and future parkland redevelopment. CVC staff identified a number of needs related to environmental management and ecological restoration; the LOISS is being designed, in part, to help address these gaps.

CVC's Strategic Plan (2008 update) identifies "Great Lakes and Shoreline" as a #1 priority "*according to (its) importance, urgency and alignment with CVC's mandate*". Each of the identified priorities is to be addressed through relevant strategies, including the LOISS, with tactics identified in the 2006 Strategic Plan and the 2008 Update still applicable today and to the LOISS:

1. Groundwater
2. Water Management Implementation
3. Lake Ontario
4. Water Quality
5. Natural Heritage
6. Planning and Regulation
7. Monitoring
8. Greenland Securement
9. Land Management and Conservation Areas
10. CVC Human and Financial Resources
11. Energy, Conservation, Waste Reduction and Air Quality
12. Responding to Climate Change
13. Watershed Restoration
14. Education and Public Outreach
15. Building Community Partnerships
16. Watershed Sustainability

LOISS is also aimed at responding to broader lake-wide initiatives such as the *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario,* the *Great Lakes Water Quality Agreement*, *Great Lakes, Great Beaches Initiative, Lake Ontario Collaborative Study to Protect Lake Ontario Drinking Water, the Lake Ontario LaMP (Lakewide Management Plan)*, and the *North American Bird Conservation Initiative (NABCI – Bird Conservation Region 13).* The Biodiversity Conservation Strategy has specifically recognized the importance of the Credit River for migratory fish and as a key historic site for both Atlantic Salmon and Lake Sturgeon. One of the priority actions focuses on the need to improve the quality of nearshore and coastal wetlands, such as Rattray and the Port Credit marshes.

At a more local scale, there are opportunities to achieve some of the LOISS objectives through various site-specific redevelopment scenarios (e.g. MTO's *QEW Improvements*), as well as through broader planning initiatives such as the City of Mississauga's *Waterfront Parks Restoration Strategy*, the City's *Credit River Parks Strategy Update*, the City's *2009 Future Directions: Implementation Guide for Parks and Natural Areas*, and the City's *Visionary Concept for the Former Lakeview Power Generating Station ("Inspiration Lakeview").*

Committees

A Technical Steering Committee and an Advisory Committee either have been or are in the process of being established for the LOISS. The Technical Steering Committee is comprised of CVC, City of Mississauga, Region of Peel, Ministry of Natural Resources, Environment Canada, and consultant staff and participates in a "hands-on" manner by providing background information, providing input on study direction, reviewing findings, and participating in meetings. Both Fisheries and Oceans Canada and Ministry of the Environment are acting as observers on the TSC and are circulated on all key matters. The Advisory Committee will be made up of representatives from key agencies including those listed above as well as experts from other agencies and non-government agencies and other key stakeholders. This committee will provide "value-added" services by responding to findings at key points in the study.

Study Area

The Study Area for the LOISS encompasses shoreline and nearshore environments as well as inland areas immediately adjacent to the shoreline. The general boundaries of the Study Area extend from 6 km offshore in Lake Ontario to 2 km inland within the jurisdiction of Credit Valley Conservation and 5 km inland within the Credit River watershed. It is acknowledged that while some of the issues can be addressed from within the formal study boundaries, many will require working within the full extent of the watershed boundaries (e.g. water quality) and within the context of broader lakewide initiatives (e.g. coastal processes).

The following watercourses area included within the study:

1. Clearview Creek,
2. Avonhead Creek,
3. Sheridan Creek ,
4. Turtle Creek,
5. Birchwood Creek,
6. Moore Creek,
7. Lornewood Creek,
8. Tecumseh Creek (including Port Credit West subwatershed),
9. Credit River (including Port Credit East, Loyalist Creek, Wolfedale Creek, Mary Fix Creek, Kenollie Creek, Sawmill Creek, and Stavebank Creek),
10. Cumberland Creek,
11. Cooksville Creek (including Cawthra Creek subwatershed),
12. Serson Creek,
13. Applewood Creek, and
14. Lakeside Creek.

Public land accounts for approximately 43% of the Lake Ontario shoreline in the CVC watershed. This means that between Conservation Authority (CVC), Municipal (City of Mississauga and Peel Region), Provincial (MNR, MOE) and Federal (DFO) lands, approximately 12.2 km of the total 28.5 km of the Lake Ontario shoreline in the CVC watershed is publically owned.

The majority of the shoreline within the LOISS Study Area has been altered with either formal or informal shoreline protection structures. Figure 3.12 illustrates the shoreline treatments within the Study Area. The expected life-span of a shoreline protection structure is dependent upon a number of conditions including materials, construction, controlling substrate, and maintenance. As yet, no formal assessment has been made of the current condition the shoreline structures.

CVC Lake Ontario Integrated Shoreline Study
Shoreline Characterization

Legend

Shoreline Characterization

- Armour Stone
- Boulder and Broken Rock
- Breakwall
- Broken Brick or Concrete
- Cobble
- Eroded Bluff
- Natural
- Retaining Wall (Concrete, Sheet Pile)
- Sand (Public Beach, Private Beach, Natural)

Study Disciplines

As the study is being completed in an integrated manner, information has been contributed to the report from various disciplines. These disciplines are as follows:

- Hydrology and Hydraulics,
- Fluvial Geomorphology,
- Coastal Processes,
- Water Quality,
- Terrestrial Natural Heritage,
- Hydrogeology,
- Aquatic Natural Heritage,
- Stewardship, Education, and Communications
- Ecological Goods and Services, and
- Conservation Lands.

As part of the Shoreline Characterization and Impact Analysis phase, a report related to relevant legislation and policies (Shoreline Policy Framework) is being developed.

Within each discipline, background information was compiled from existing reports and data sources. In some cases (e.g. fluvial geomorphology, aquatic natural heritage), field assessments were completed to better evaluate conditions within the Study Area. Once background information was assembled, a technical assessment was completed within each discipline. Conclusions were drawn from the assessment and data gaps were identified. Key findings and data gaps from each discipline are presented in the report. Summaries of these findings are presented below.

<u>Hydrology and Hydraulics</u>

Hydrologic and hydraulic models and floodline mapping have been developed for all watersheds within the LOISS Study Area with the exception of Cumberland and Moore Creeks. Precipitation data are available within the Study Area but flow gauging stations are limited.

Data pertaining to return period flows, overtopping of structures, and flooding of buildings are incomplete or missing in four of the Study Area watersheds (i.e., Sheridan, Avonhead, Moore, and Cumberland Creeks). Additionally, information on Cumberland and Moore Creeks is very limited as no studies are currently available on these watersheds.

<u>Fluvial Geomorphology</u>

Assessments of the watercourses within the Study Area showed that most were “moderately stable” and in “fair” condition. Aggradational and widening processes dominated in the downstream-most reaches of the watercourses (Figure i). An interaction between the beach form and the creek mouths was found to be present in all watercourses except those that are conveyed via storm sewer to Lake Ontario, more specifically Birchwood, Lornewood, Cumberland, and Cawthra Creeks. The watercourses most sensitive to backwater effects from the lake were

Applewood, Lakeside, and Turtle Creeks. The primary source of sediment to the lake within the Study Area was found to be the Credit River which supplies more than 174,000 tonnes of sediment annually.

One limitation to the data available within the Fluvial Geomorphology portion of the LOISS was that sediment data were available only for the Credit River. Thus, further studies may be warranted to collect sediment data on the larger tributaries such as Sheridan and Cooksville Creeks. Also arising from the results of the Fluvial Geomorphology component of the study is the possibility to investigate daylighting of reach 1 of Cumberland Creek and reach 2 of Birchwood Creek. As well, the naturalization of reach 1 of Clearview Creek, which is currently contained within a concrete-lined channel, should also be investigated in association with the City of Mississauga who have already developed a concept for this work.

Figure i: Aggradational conditions are present in Reach 1 of Applewood Creek.

<u>Coastal Processes</u>

Within the LOISS Study Area, the majority of the shoreline is protected and the majority of the lakebed is bedrock. The latter is largely a result of historic stonehooking, prevalent from the Credit River to Burlington Bay from the 1830s until just after World War I when concrete became more readily available. In fact, Port Credit was centre of the stonehooking industry with various stonehooking vessels being built there. This activity resulted in largescale removal of shale and stone from the nearshore zone of the LOISS area, the effects of which persist to this day.

As a result, littoral sediment transport rates are low but may be significant in terms of effects on aquatic habitat diversity and quality. However, there are still some natural beach habitats (Figure ii). Wind generated waves and water levels are the factors that have the greatest effect on the coastal processes within the Study Area. Sufficient wind and water level data exist to allow for long-term simulations of nearshore wave and sediment transport conditions if desired.

The most significant data gap within the Coastal Processes portion of the report is the lack of shoreline recession rate data; new monitoring stations should be established at selected locations on publically owned shoreline within the Study Area. An additional data gap is the extent and condition of existing shoreline protection structures. Within public lands, these structures should be inventoried and assessed. Additional gaps in shoreline modeling within the Study Area may be addressed depending on requirements from other disciplines such as Water Quality.

Figure ii: Both natural beach habitats and hardened shoreline treatments are present along the Lake Ontario shoreline.

<u>Water Quality</u>

As the largest watercourse within the LOISS Study Area, the Credit River (Figure iii) 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. Contribution of ammonia, however, is not dominated by the Credit River; rather, urbanized watersheds contribute 90% of the ammonia while the Credit River contributes less than 1% of the total ammonia entering the Lake from within the Study Area (Region of Peel, 2009).

While sufficient data exist relating to concentrations of water quality parameters from storm sewer outfalls and within watercourses, water quality data along the waterfront is limited. As noted in the Fluvial Geomorphology section, sediment loading data are unavailable for all watercourses except the Credit River. Additionally, an assessment should be completed as to how flows, sediment, and pollutants move along the waterfront. The relative importance of loadings from watercourses within the Study Area versus in-lake loads from adjacent municipalities should be determined.

Figure iii: The Credit River at Lake Ontario (circa 1990)

Hydrogeology

Groundwater flow systems are largely controlled by topographic relief and the permeability of the subsurface geologic materials. Groundwater discharge to streams helps to maintain flow even during prolonged dry periods, and thereby contribute to aquatic habitat. As groundwater is generally of better quality than surface runoff, and is also a more consistent temperature, groundwater also adds to the overall quality of stream flow.

The primary ground water function within the Study Area appears to be support of surface water features and aquatic habitat, and contributions to stream baseflow in particular, through groundwater discharge. Baseflow measurements suggest that groundwater discharge supports baseflow in streams across the Study Area. Additional baseflow measurements should be collected to confirm the groundwater contributions to baseflow and to improve our understanding of where the discharge occurs within the Study Area.

Terrestrial Natural Heritage

Terrestrial Natural heritage refers to the terrestrial and wetland ecosystems, plant and wildlife species, populations and communities, habitats and sustaining environments that are found within the Lake Ontario Integrated Shoreline Strategy area. Each neighbourhood in the Study Area has a unique character influenced by the age of the development, the method of construction, and the subsequent landscaping of the open space. These factors all affect the resulting vegetation and the habitat utilization by wildlife (Figure iv).

While many surveys and studies have been conducted along isolated sections of the LOISS Study Area, a detailed natural heritage assessment of the features and functions it represents has not been previously undertaken.

Several data gaps exist within the Terrestrial Natural Heritage portion of the LOISS. Mapping of shoreline and nearshore vegetation should be completed as should evaluation of terrestrial and wetland communities. Surveys of turtle and amphibian populations should be conducted while staging and stopover areas for migratory birds, bats, butterflies, and odonates should be identified. Monitoring of invasive species should be undertaken and restoration opportunities identified. The City of Mississauga is in the process of undertaking a shoreline and natural heritage assessment of the three waterfront parks: JC Saddington, Marina and Port Credit, Memorial Park West. The study is scheduled for completion in 2011.

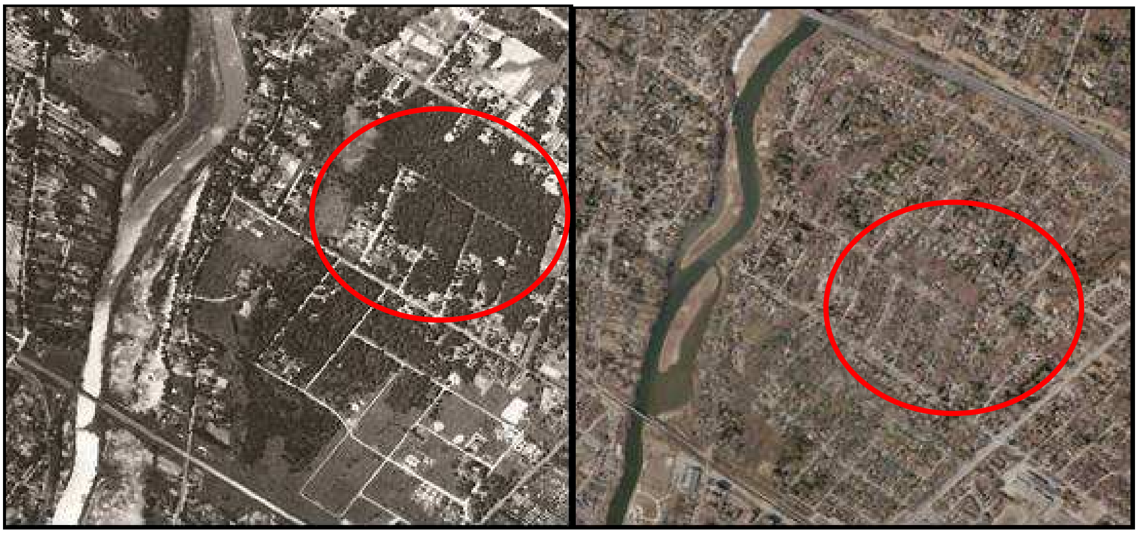

Figure iv: Encroachment and building within natural areas was a common practice that has had lasting effects on native biodiversity throughout the Study Area.

Aquatic Natural Heritage

Fish survey data are available for a number of the watercourses and along the shoreline within the Study Area. Urbanization, channelization, bank hardening, and conveyance of watercourses within stormsewers have limited fish movement through the watercourses and degraded habitat. Additional data, albeit limited, are available related to aquatic invertebrates and filamentous green algae.

Data gaps within the Aquatic Natural Heritage portion of the study include seasonal fish use, detailed substrate assessments, nearshore water temperatures, and formal surveys of aquatic vegetation. Data are also lacking for some tributaries regarding fish species and population, and for benthic invertebrates including freshwater mussels in certain tributaries as well as the nearshore.

Stewardship, Education and Communications

Few local initiatives are currently underway that are specific to the Lake Ontario shoreline. However, many existing programs could be adapted to develop programs more specific to the lakeshore.

To enable the development of appropriate programs, there is a need to develop a comprehensive Communications Strategy for LOISS. To further inform the Communications Strategy, there is a need to gain an understanding of the current shoreline uses, and how and by whom the shoreline is being used. As well, the interests of environmental non-government organizations, community groups, and stakeholders must be catalogued and an inventory should be completed of shoreline-specific programs and resources developed by other agencies within the Great Lakes Basin.

Ecological Goods and Services

Economic valuation of the lakeshore is based on how people use the shoreline and nearshore environment. The value transfer method of placing a monetary value on ecosystem services or environmental damages involves the smallest investment in time and resources. However, there is insufficient information from previous studies to use this technique to assess the full range of ecosystem benefits relevant to the Study Area. This method can serve as the first step in providing preliminary estimates of the total value of environmental benefits that the shorelines provides. However, a more complex approach will be required to produce economic value estimates that would assist in making future trade-off decisions with respect to the shoreline management and restoration.

To complete the economic valuation of the lakeshore, data gaps pertaining to this portion of the study will need to be filled. Existing environmental issues along the shoreline and nearshore environment will need to be detailed as will impacts from potential future land, shoreline, and nearshore uses. Additionally, characterization of existing shoreline resources will need to be completed.

Integrated Assessment of Interactions of Disciplines

The previous sections provided an overview with respect to the objectives of the study, key findings within each discipline and identification of data gaps.

This study is somewhat unique for CVC in that the disciplines were considered from a watercourse as well as lake perspective. Furthermore, discussions were held with external agencies as conditions outside of CVC's jurisdiction can and do impact the health of the resources along the waterfront. For this reason an initial assessment was undertaken in order to:

- Qualitatively assess which disciplines have an influence on the condition of other disciplines;
- Assess whether the influence is the same or different for the streams under consideration as compared to the lake system;
- Qualitatively assess the influence of each of the disciplines as compared to major controlling factors including land use, climate and basin wide influences.

The accompanying figure illustrates the different scales that could be considered (Figure v). The Study Area is the smallest of the three scales as it is generally limited to a distance of 2 to 5 km from the edge of the lake. The subwatershed scale would include all of the Credit River and associated tributaries (an area of approximately 100 times the size of the Study Area). Lastly the basin wide scale includes not only Lake Ontario but also inputs to the lake (a total area that is significantly larger than the Credit River subwatershed).

For the purpose of this assessment, the Study Area and subwatershed were grouped together and compared to the basin-wide influences.

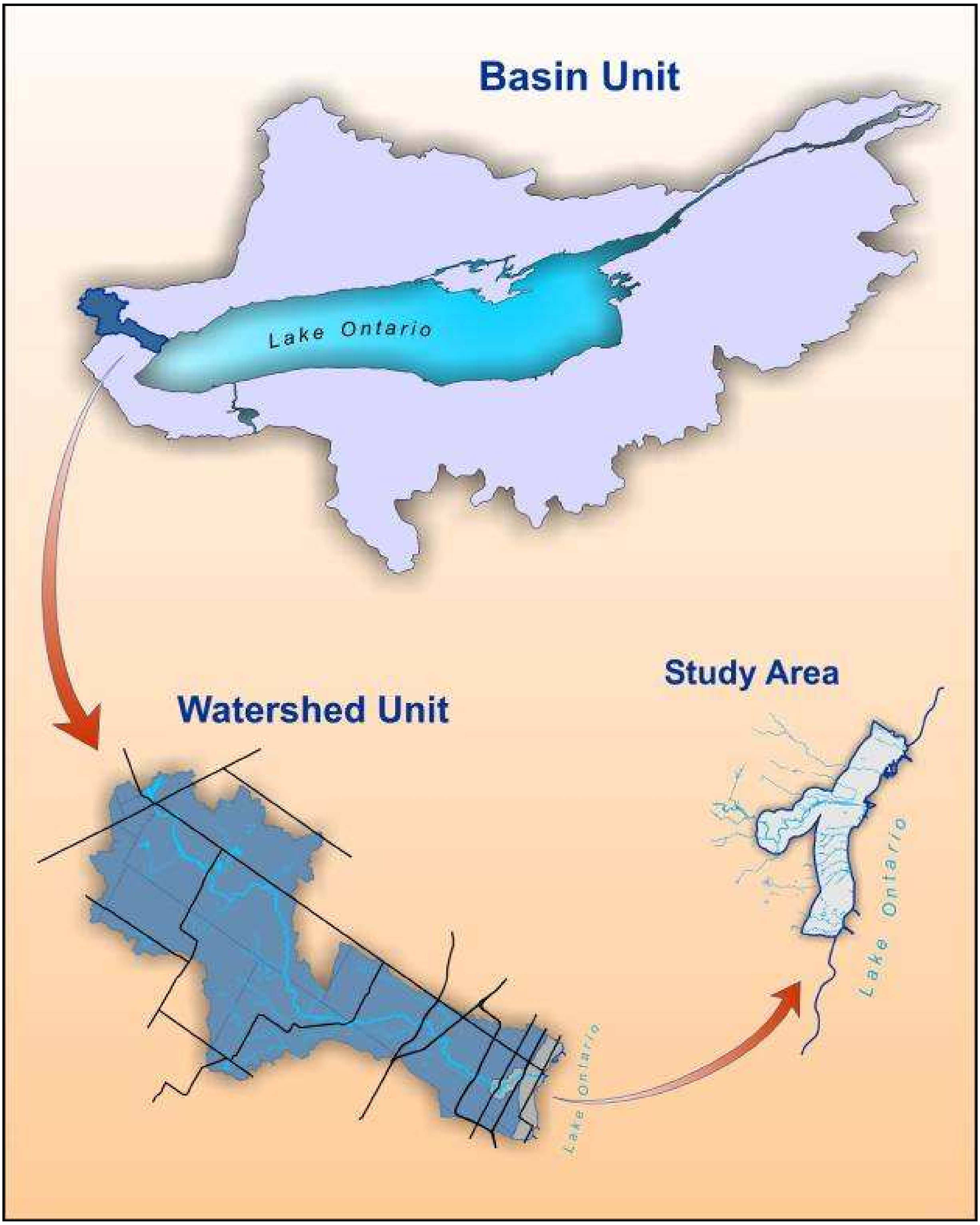

Figure v: Relative Scales of Study Unit

Tables i and ii were prepared in order that a comparison of the relative influences of the disciplines on each other to other factors including land use, climate and basin-wide influences could be undertaken. The first table summarizes the relative influences as they relate to the streams within the Study Area and the adjacent shorelines. The second table summarizes the relative influences as they relate to the resources within the lake.

The objective of this assessment is to provide a **qualitative assessment** to:

- define which disciplines influence the others ;
- determine the degree of influence changes based on whether the assessment considers the stream system or lake; and
- compare the influences of each discipline to other factors including land use, climate and basin wide influences (basin wide influences were only included when considering influences on the lake).

The intent is to bring this information forward and develop the initial findings in a more integrated manner during the Characterization and Impact Analysis and Restoration components of the project.

Table i: Disciplinary, Basin-Wide and Climatic Impacts on Lake Resources

	Study Area/ Subwatershed Scale									
Influenced by \ Influenced on	Hydrology and Hydraulics	Fluvial Geomorphology	Coastal Process	Water Quality	Terrestrial Natural Heritage	Hydrogeology	Aquatic Natural Heritage	Land Use	Basin Wide Influences	Climatic Influences
Hydrology and Hydraulics										High Influence
Fluvial Geomorphology			Low Influence							
Coastal Process	Low Influence	Low Influence						Moderate Influence	High Influence	High Influence
Water Quality						Low Influence	Low Influence	Moderate Influence	High Influence	Moderate Influence
Terrestrial Natural Heritage	Moderate Influence	Low Influence				Low Influence		High Influence	Low Influence	High Influence
Hydrogeology								Low Influence		Moderate Influence
Aquatic Natural Heritage	High Influence	Low Influence	Low Influence	High Influence	Low Influence	Low Influence		Moderate Influence	Moderate Influence	High Influence

Legend:

(red)	High Influence
(yellow)	Moderate Influence
(green)	Low Influence
(white)	No Influence

Table ii: Disciplinary, Basin-Wide and Climatic Impacts on Stream / Nearshore Resources

Study Area / Subwatershed Scale									
Influenced on / Influenced by	Hydrology and Hydraulics	Fluvial Geomorphology	Coastal Process	Water Quality	Terrestrial Natural Heritage	Hydrogeology	Aquatic Natural Heritage	Land Use	Climatic Influences
Hydrology and Hydraulics					Moderate Influence	Low Influence		High Influence	High Influence
Fluvial Geomorphology	High Influence		Low Influence	Moderate Influence	Moderate Influence			High Influence	Moderate Influence
Coastal Process		Low Influence		Low Influence	Low Influence				Low Influence
Water Quality					Moderate Influence	Low Influence		High Influence	Moderate Influence
Terrestrial Natural Heritage	Low Influence	Low Influence		Low Influence		Moderate Influence		High Influence	High Influence
Hydrogeology					Low Influence			High Influence	Moderate Influence
Aquatic Natural Heritage	High Influence	High Influence	Low Influence	High Influence	Moderate Influence	Moderate Influence		High Influence	High Influence

Legend:
- High Influence (red)
- Moderate Influence (yellow)
- Low Influence (green)
- No Influence (white)

Provided below is a summary of the key findings of Background Review and Data Gap Analysis:

Impacts on Streams/Nearshore Resources

- Hydrology and hydraulics and water quality impact several of the disciplines including fluvial geomorphic processes as well as the terrestrial and aquatic natural heritage systems.
- The existing terrestrial natural heritage system is also important as the system moderates the hydrologic regime, assists in filtering storm water runoff (water quality) and provides several benefits (e.g. shading, filtering runoff, and providing a food source) for aquatic natural heritage features and functions.
- The hydrogeologic conditions within both the Study Area and the Credit River watershed as a whole are unique and also influence various other disciplines. On a watershed basis the headwaters of the Credit River provide a significant contribution to baseflow through groundwater recharge. As a result, almost one third of the flows that discharge from the Credit River to Lake Ontario are relatively clean and originate as groundwater from the headwater areas. Within the Study Area a majority of the lands are considered as moderate to high recharge areas. This, in turn, results in moderating the hydrologic regime, providing baseflow for aquatics, moderating water quality during dry weather conditions and influencing the type and health of the terrestrial heritage system along the stream corridors.
- Aquatic natural heritage features and functions (which are generally considered to be a good indicator of overall environmental health of a watershed) are impacted by all of the other disciplines.
- Development within both the Study Area (virtually all of available lands have been developed) and within the Credit River watershed as a whole has a significant impact on all of the disciplines (except coastal processes). This is typical of urbanized areas due the significant influence on hydrologic, fluvial geomorphic, and water quality disciplines.
- The local climate also significantly influences each discipline as a result of local temperate conditions as well as the characteristics of rain and snow fall patterns.

Impacts on Lake Resources

- Intuitively the influences of a given discipline on lake resources (as compared to the streams and nearshore) would diminish as there are significant external influences from the basin that also come into play. This finding is generally reflected in the accompanying tables. However, there are still influences that are exerted on the lake system. For example, hydrologic conditions will impact coastal processes on a local basis and will, together with water quality, influence the health of the aquatic system within the lake. Preliminary findings suggest that there may (as a result of a high water table in the Study Area) be areas of upwelling in the lake. This, in turn, would influence the aquatic habitat and associated biota. Other influences are also shown on the table.

- The land uses within the Study Area and the Credit River watershed as a whole will also influence the lake resources. However, as noted above, the influences are muted due to outside impacts associated within the basin.
- Climatic influences are still considerable for similar reasons as noted above.

Basin wide influences are high with respect to water quality and coastal processes (for example a majority of the sands and gravels are transported from outside of the CVC waterfront) and low to moderate from a terrestrial and aquatic perspective.

Data Gap Analysis

Having identified all data gaps within each discipline, these data gaps were compiled and prioritized. Required studies were identified to address the various data gaps and a timeline was developed for the studies. A summary of the work plan is presented below by discipline. The work plan is periodically updated based on new information and identification of data gaps.

Action	Lead Agency/ Organization	Partner Agency/ Organization	Location	Study	Status
Conservation Lands/Stewardship, Education, and Communication/Planning					
Current legal opinion on lakebed ownership and riparian rights	CVC		All	Conservation Lands Shoreline Policy	Initiated
Policy review of applicable legislation to identify barriers/needs of Authority for carrying out works (shoreline/lakebed)	CVC		All	Conservation Lands Shoreline Policy	Initiated
Review CVC conservation land agreements with Mississauga – recommendations for integrating LOISS priorities into new lease agreements	CVC	Mississauga DFO MOE	8 CVC-owned properties	All	Initiated
Communications Strategy: Planning and Implementation	CVC	Mississauga Region of Peel	All	Stewardship, Educ and Comm	Ongoing
Workshops: Ratepayer Reps and Corporate	CVC	Mississauga Region of Peel	All	Stewardship, Educ and Comm	Completed
Living by the Lake : Factsheet	CVC		All	Stewardship, Educ and Comm	Completed
LOISS webpage: CVC website	CVC		All	Stewardship, Educ and Comm	Completed
Historic Shoreline Mapping	CVC	University of Toronto at Mississauga	Shoreline	Stewardship, Educ and Comm Coastal Processes	Ongoing

Video	CVC		All	Stewardship, Educ and Comm	Completed (Draft)
Terrestrial Natural Heritage					
Determine current land use in LOISS study area (TEEM LSA)	CVC		All	Terrestrial Natural Heritage	Completed (Draft)
TEEM Landscape scale analysis to identify potential core areas and supporting areas/corridors.	CVC	Mississauga	All	Terrestrial Natural Heritage Conservation Lands	Completed (Draft)
Field truthing/prioritization of restoration opportunities	CVC		All	Terrestrial Natural Heritage Planning	2013++
Integrate TEEM into Greenlands Securement Strategy to guide priority acquisitions in LOISS	CVC	Mississauga	All	Terrestrial Natural Heritage Aquatic Natural Heritage Conservation Lands	2013++
Spring surveys: stopover landbird	CVC	CWS	All Point Count/area searches	Terrestrial Natural Heritage	Ongoing
Spring surveys: staging/stopover areas; shorebird / waterfowl	CVC	CWS MNR	Rattray Port Credit marshes	Terrestrial Natural Heritage	Ongoing
Fall surveys: stopover landbird	CVC		All	Terrestrial Natural Heritage	Ongoing
Fall surveys: staging/stopover areas - waterfowl	CVC		Rattray Port Credit Marshes	Terrestrial Natural Heritage	Ongoing
Radar Interpretation	CVC		All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Surveys: butterfly / odonate monitoring	CVC		All	Terrestrial Natural Heritage	Ongoing
Bat acoustic surveys	CVC		All	Terrestrial Natural Heritage	Ongoing
Amphibian surveys: Breeding	CVC		Rattray Port Credit marshes Turtle Creek	Terrestrial Natural Heritage	Ongoing
Turtle Surveys : Presence/Absence Credit	CVC	MNR	Rattray Port Credit marshes	Terrestrial Natural Heritage	Ongoing
Georeference Species of Conservation Concern	CVC	Mississauga	All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated Miss NAS by North-South but need more detail

Invasive species surveys	CVC		All: shoreline	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Aquatic Natural Heritage					
Shoreline Treatment – NRSI 2009 and Shoreplan	CVC		Aquatic Natural Heritage	Aquatic Natural Heritage	Completed
Broadscale surveys of nearshore vegetation (NRSI 2009)	CVC		Shoreline	Aquatic Natural Heritage	Completed
Detailed Nearshore Vegetation Surveys	CVC		All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Habitat: video (JC Saddington)	CVC	C. Chu – Trent U GLIN		Aquatic Natural Heritage Coastal Processes	Completed
Tributaries water temperatures (temp loggers)	CVC	Region of Peel Env Canada	Clearview Avonhead Tecumseh Turtle Applewood	Aquatic Natural Heritage Water Quality	Ongoing
Seasonal fish use (complete) and access into tributaries (2009-2011) Sampling in tributaries where data lacking	CVC	MNR	Shoreline 3 IWMP (Sheridan, Cooksville, Port Credit)	Aquatic Natural Heritage	Completed
Nearshore fish sampling Species at Risk status (e.g. Lake Sturgeon; American Eel) Sample gobies/abundance	CVC	MNR DFO	Shoreline (18-19 stns) 1 IWMP Finalize hoop netting IBI analysis Electrofishing Seining	Aquatic Natural Heritage	Ongoing
Beach/offshore spawning and locations. Identify rearing/nursery habitatsSpawning areas for some species (e.g. bass; lake trout; forage species) not identified	CVC	MNR	Shoreline	Aquatic Natural HeritageMNR Lake Unit	Planning Initiated
Pike survey	CVC		Rattray Marsh	Aquatic Natural Heritage	Planning Initiated
Airlift Sampling: MOE Divers	CVC	MOE	Transects mouth of tributaries (2m-10m) Shoreline	Aquatic Natural Heritage Water Quality	Planning Initiated

			(control)		
Invertebrate Surveys: benthic insects; dreissenid mussel	CVC	MOE Env Can / CWS	Shoreline (6 stns) (1) Kick and Sweep (nearshore) (2) Ponar (offshore)	Terrestrial Natural Heritage Aquatic Natural Heritage Water Quality	Completed (2011)
Gill Netting	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	Planning Initiated
MNR recreational fishing: conduct seasonal user surveys at various access points in the study area.	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority
Atlantic salmon research: conduct creel surveys of boat anglers; check stomach contents of retained fish; track angling information (e.g. location, depth, date, etc) from capture	MNR	CVC	Shoreline/Offshore	MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority
Pacific salmonid competition: scale and effects of competition with Pacific salmonids with native species not known	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	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		MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority
Hydrology and Hydraulics					
Map Ice Cover using existing data from NOAA	CVC		Shoreline	Hydrology and Hydraulics Coastal Processes	2013++
Precipitation data collection and maintenance of stations Replacement of	City of Mississauga	CVC		Hydrology and Hydraulics	Ongoing

Station 1 gauge with heated gauge					
Sediment loading to Lake Ontario from Cooksville Creek (suspended? bedload?)	CVC	Mississauga	Cooksville	Hydrology and Hydraulics Fluvial Geomorphology Aquatic Natural Heritage	2013++
Sediment loading to Lake Ontario for Serson, Applewood, Lornewood, and Birchwood Creeks	CVC	Mississauga	All	Hydrology and Hydraulics Fluvial Geomorphology	Planning Initiated Lakeview Waterfront Connection Inspiration Lakeview
Sediment loading to Lake Ontario from Sheridan Creek (suspended? bedload?) Geomorphic Solutions (2007) Sedimentological Study of Rattray Marsh	CVC	Mississauga	Sheridan	Fluvial Geomorphology Aquatic Natural Heritage	2013++
Real-time flood forecast and climate vulnerability	CVC	Mississauga		Hydrology and Hydraulics	2013++
Real-time rainfall and streamflow data	CVC	Mississauga		Hydrology and Hydraulics	2013++
Imperviousness	CVC	Mississauga	Clearview Creek Credit River Cumberland Creek Moore Creek Sheridan Creek	Hydrology and Hydraulics Aquatic Natural Heritage	2013++
Drainage Area	CVC	Mississauga	Cumberland Creek Moore Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Cumberland Creek including floodplain mapping[1]	CVC	Mississauga	Cumberland Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Moore Creek including floodplain mapping[1]	CVC	Mississauga	Moore Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Cooksville including floodplain mapping	Mississauga	City	Cooksville Creek	Hydrology and Hydraulics	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	Credit River	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling (2 to 25 yr) Avonhead Creek including floodplain mapping: n of Lakeshore; western portion of watershed (post dev)	CVC	Mississauga	Avonhead Creek	Hydrology and Hydraulics	2013++
List of overtopped structures and flooded buildings - Avonhead; Cumberland; Moore Creeks	CVC	Mississauga	Avonhead Creek Cumberland Creek Moore Creek	Hydrology and Hydraulics	2013++
Hydrogeology					
Geological Cross-Sections	CVC			Hydrogeology	Completed
Quantification of groundwater contributions in baseflows to tributaries of L. Ontario, and other groundwater-surface water interactions	CVC	MOE	28 stations (2 per tributary) Public access	Hydrogeology	Ongoing GW or lake upwellings? Piezometers? Temp probes?
Integrate baseflow measurements with Aquatic Natural Heritage and Water Quality	CVC			Hydrogeology ANH Water Quality	Planning Initiated
Orientation, size, and infill material for the buried bedrock valley	CVC	MOE	All	Hydrogeology	2013++
Groundwater Quality: local scale impacts?	CVC	MOE	All	Hydrogeology Water quality	2013++
Groundwater Discharge: Scope	CVC	MOE	All	Hydrogeology Terrestrial Natural Heritage Aquatic Natural Heritage	2013++
Water Quality					
Centralized database of water quality data: agreement to share data	MOE	CVC	All	Water Quality	Not CVC Priority

Upgrade existing MIKE3 model to define how pollutants move along waterfront. 270 m grids (basin); 90 m grids (local) Flow Monitors?? (MOE - In-Kind)	CVC Ray Dewey Ram Yerubandi Gary Bowen	Environment Canada Region of Peel MOE Mississauga	Shoreline and Tributaries	Water Quality Coastal Processes	Completed (Draft)
Phosphorus EMC values	CVC	Region	All	Water Quality	Completed
HSP-F model for remaining tributaries	CVC	Environment Canada and/or MOE, Mississauga	Shoreline and Tributaries	Water Quality Ecological Goods and Services	Planning Initiated
Integrate WQ data City of Mississauga Goose Mgmt Program	City	CVC	Shoreline and Tributaries	Water Quality Terrestrial Natural heritage	Planning Initiated
Water quality sampling at key locations of key parameters	CVC	EC and MOE	4 stations @ mouths Cooksville Sheridan Clearview Serson	Water Quality Fluvial Geomorphology Aquatic Natural Heriage	Ongoing
Sampling Credit River at Mississaugua Golf Course · Event Sampling (6-8 samples over season) · Winter Sampling · Install Stream Gauge (ice - bridge)	CVC	MOE	Credit River	Water Quality	Ongoing
Divers Algae, phosphorus / nitrates transects	CVC	MOE	2 stations	Water Quality Aquatic Natural Heritage	Planning Initiated
Key pollution sources and impact on environmental quality/health		Environment Canada MOE Mississauga	Shoreline and Tributaries	Water Quality Ecological Goods and Services	Planning Initiated
Thermal Monitoring: Nearshore and Offshore transects	Environment Canada	CVC	4 stations @ mouths CooksvilleSheridan ClearviewSerson	Water QualityFluvial GeomorphologyAquatic Natural Heritage	Ongoing (monitor installed)2011-2013
Coastal Processes					
Develop Coastal Shoreline Monitoring Protocol: IWMP	CVC	Region of Peel MOE Env Can TRCA	Shoreline	All	Planning Initiated
Document detailed historic shoreline events, changes since	CVC		All	All	Completed.

1988					
Inventory and assess public protection structures Effects of Piers	CVC	Mississauga	Shoreline	Coastal Processes	Planning Initiated
Inventory and assess private protection structures Effects of Piers	CVC	Mississauga	Shoreline	Coastal Processes	2013++
Assess effect of waves on nearshore currents	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific
1-D littoral sediment transport analysis	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific
2-D littoral or sub-littoral sediment transport analysis	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific
Collection of baseline cross shore bathymetric data, sediment composition and underwater video	CVC		All	All	Completed
Bathymetry (JC Saddington)	City of Mississauga	CVC	Shoreline	Coastal Processes Aquatic Natural Heritage	Completed
Establish erosion monitoring stations and initial surveys Aerial photos: 35 year review	CVC	Mississauga	Shoreline	Coastal Processes	Ongoing
Aerial photos: Annual	CVC		Shoreline	Coastal Processes Aquatic Natural Heritage	Planning Initiated
LiDAR Survey: water penetrating	CVC	Cons Halton TRCA	Shoreline	Coastal Processes Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Seasonal fluctuations as station surveys spring/summer/storm events	CVC		Shoreline	Coastal Processes Aquatic Natural Heritage	2013
Resuspension of sediments	CVC	MOE	Nearshore	Coastal Processes Water Quality	Planning initiated
Ecological Goods and Services					
Public perception survey (and literature review)	CVC		All	Ecological Goods and Services Conservation Lands Stewardship, Education and Communications	Completed
Cost - Benefit Analysis of Restoration Options	CVC	Mississauga Region of	All	Economics	Planning Initiated

		Peel			
Fluvial Geomorphology					
Cross-section/ longitudinal/planform data collected but not analysed	CVC		All	Fluvial Geomorphology	Planning Initiated
Seasonal backwater impact on biological elements (suspended sediment data collection - coastal process inetegration - FG detailed substrate analysis)	CVC	CVC	Applewood Lakeside Turtle	Fluvial Geomorpholoy Aquatic Natural Heritage Terrestrial Natural Heritage	2012 -
Assessment to determine feasibility of replacement of concrete channel with naturalized channel for Reach 1 of Clearview Creek (455 m)	Mississauga	CVC	Clearview	Fluvial Geomorphology Aquatic Natural Heritage Terrestrial Natural Heritage	Waterfront Parks Management Strategy
Assessment to determine feasibility of restoration of Serson Creek	Mississauga: Inspiration Lakeview	CVC	Serson	Fluvial Geomorphology Aquatic Natural Heritage Terrestrial Natural Heritage	Planning Initiated Lakeview Waterfront Connection Inspiration Lakeview
Assessment to determine feasibility of daylighting of Lornewood Creek Reach 1 (340 m)	CVC	Mississauga	Lornewood	Fluvial Geomorphology	2013++
Assessment to determine feasibility of daylighting of Birchwood Creek Reach 2 (450 m)	CVC	Mississauga	Birchwood	Fluvial Geomorphology	2013++

Recommendations

Numerous studies have been identified to address the data gaps identified in Phase 1 of the LOISS. Of these studies, the majority will be undertaken by CVC as part of their mandate. Those studies to be emphasized are the ones which involve CVC as well as partner organizations such as the City of Mississauga, The Region of Peel, and the provincial and federal governments. These key studies are as follows:

- Communications strategy,
- Water quality modeling program for phosphorus and other parameters of interest,
- Centralized database for water quality,

- Water quality loadings from tributaries,
- Sediment program examining loads and transport,
- Inventory of public shoreline treatments, and
- Establishment of shoreline erosion monitoring stations.

The proposed timeline provides a prioritization of the studies and surveys designed to address the data gaps. Adherence to the schedule will ensure that the required data are collected and that initiatives and planning associated with the LOISS Study Area are carried out in a timely manner. The summary of background information and the timeline to address knowledge gaps will form the basis for the next two phases of the LOISS, the Shoreline Characterization and Impact Analysis and the Shoreline Restoration Plan.

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1 INTRODUCTION

CVC initiated the Lake Ontario Integrated Shoreline Strategy (LOISS) in recognition of the need for an integrated systems approach to the management of the shoreline: integration of information from multiple disciplines of study; integration with other watershed planning processes underway and planned in the Credit River watershed; integration of information linking inland and offshore ecosystems; integration of this shoreline with adjacent shoreline jurisdictions; and integration of local initiatives with those at the Lake Ontario wide and Great Lakes basin scale.

In 1990, CVC completed the Phases I and II Credit River Watershed Management Studies. The objective of these studies was to protect environmental resources as land use changes occurred. In 1988, CVC completed a draft Lake Ontario Shoreline Management Plan. This plan was completed largely in response to concerns over flooding and erosion along the shoreline and corresponded to efforts at provincial, federal and international levels.

Since the early 1990s, CVC has been conducting integrated multi-disciplinary studies of the 20 subwatersheds that make up the Credit River watershed.

Within the CVC jurisdiction, other than the Credit River, there are 13 watercourses that drain directly to Lake Ontario. In 2005, CVC began working on watershed studies for the 2 largest watersheds, Sheridan Creek and Cooksville Creek. Draft Background and Phase I: Characterization reports for these watersheds were completed in February 2009 and are currently being finalized. The watershed studies for the remaining eleven watercourses are planned for 2013, and data gathered as part of the LOISS will feed into these initiatives. The LOISS will include some impact assessment of climate change and intensified use of the shoreline. A final restoration plan and management guidelines relative to the watersheds and the shoreline will then be integrated into the LOISS initiative.

Since its foundation in 1954, Credit Valley Conservation Authority has acquired high-quality or potential natural areas within the Credit River watershed for conservation purposes. To fulfill the objectives of CVC and its purposes set out in the Conservation Authorities Act, the Authority acquired, and even created, land along the Lake Ontario Shoreline within its jurisdiction. Occurring almost exclusively in the 1970s, the waterfront acquisition program was designed to implement the recommendations for the Mississauga section of the 1967 Metropolitan Toronto Waterfront Plan. CVC was appointed as the agency which could best manage the implementation of the project and who could channel and combine multiple funding sources; funding for the waterfront project came primarily from the Province of Ontario and the City of Mississauga.

The legacy of this acquisition program is that CVC remains the largest single landowner of Lake Ontario shoreline in the Credit River Watershed. CVC owns 8 distinct properties along to shoreline, amounting to a total of approximately 7.3 km, or 26% of the Lake Ontario shoreline. Currently, all CVC conservation land along the shoreline, with the exception of Rattray Marsh Conservation Area, is leased to the City of Mississauga for park, recreation, and conservation purposes.

Public land accounts for approximately 43% of the Lake Ontario shoreline in the CVC watershed. This means that between Conservation Authority (CVC), Municipal (City of Mississauga and Peel Region), Provincial (MNR) and Federal (TransCanada) lands, approximately 12.2 km of the total 28.5 km of the Lake Ontario shoreline in the CVC watershed is publically owned.

Study Purpose

The purpose of Lake Ontario Integrated Shoreline Strategy (LOISS) is to provide guidance to local, regional, and provincial governments in planning future restoration initiatives, developments, and land use decisions, while at the same time meeting the needs of and enhancing the existing natural environment. To support the function of this significant bioregional corridor, the study will include a specific focus on opportunities for the protection and restoration of natural ecosystems along the shoreline inland to the first major barrier and into the lake in the nearshore environment. In addition, through a review of the City of Mississauga Waterfront Parks Strategy, CVC staff identified a number of needs related to environmental management and ecological restoration; the Lake Ontario Integrated Shoreline Strategy is being designed, in part, to help address these gaps.

The overall Lake Ontario Integrated Shoreline Strategy intends to proceed with the following stages:

1. Background Review and Data Gap Analysis Report
2. Shoreline Characterization and Impact Analysis Report
3. Shoreline Restoration Plan.

Background Review and Data Analysis (2009-2011) - the collection and analysis of background information to determine historical and existing conditions within the Study Area. Where data gaps are identified, methods for addressing additional data needs will be identified. The background review and data gap analysis will consider the planned initiation of watershed studies for the remaining 11 Lake Ontario tributaries in 2013.

Shoreline Characterization and Impact Analysis (2011-2012) - The Background Review and Data Gap Analysis results will direct additional data collection and analysis. The Shoreline Characterization and Impact Analysis Report will complete a description of historical and existing functions and linkages between shoreline resources. This phase of the Study will also include a significant effort to engage stakeholders along the shoreline through an effective public participation process. In addition to assessing existing environmental conditions, future land use changes and shoreline developments, the characterization will also report predicted future shoreline conditions in the context of climate change. Reporting key recommendations for restoration opportunities and ecological management of waterfront public properties (parks and conservation areas) will form key outcomes within this report.

Shoreline Restoration Plan (2012 ++) - the development of the Shoreline Restoration Plan will continue the process for public engagement and involvement established in the previous phase. This will involve communication of Background Review and Shoreline Characterization and

Impact Analysis results to stakeholders and discussion and input related to recommended actions.

1.1 Study Approach

Studies of this nature need to be undertaken in an integrated manner. For example, urbanization of lands typically increases the rate and volume of stormwater runoff which in turn, may result in increased erosion and flooding downstream in the watershed. The erosion, in turn, may adversely impact resident fisheries within the stream. In an analogous manner, increased use of fertilizers in each of the 14 watersheds within this Study Area (as well as the upstream lands) may adversely impact Lake Ontario, resulting ultimately in algae blooms.

In order to develop an integrated approach, a number of individual disciplines must be considered. For the purpose of this study the following disciplines have been considered:

- The **hydrology and hydraulic** component characterized meteorological and stream flow conditions in terms of floodplain and peak flows.

- The **fluvial geomorphological** and **coastal processes** components evaluated the physical processes of the shoreline and tributaries to determine sensitivity to changes in water levels or sediment regimes.

- The **water quality** component assessed the existing water quality conditions of Lake Ontario: offshore, nearshore, and the contributions from the watercourses within the CVC jurisdiction.

- The **terrestrial** component characterized and evaluates the sensitivity of the terrestrial system.

- The **hydrogeology** component evaluated the groundwater resources and characterizes interactions with surface water.

- The **aquatic** component characterized the fish community. The characterization of the benthic invertebrate community was identified as a knowledge gap.

- A background review of **Stewardship, Education** and **Communications** Campaigns, Shoreline **Ecological Goods and Services**, CVC Shoreline **Conservation Lands** was also completed**.** A review of the **Shoreline Policy Framework** will be developed as part of the Shoreline Characterization and Impact Analysis.

The technical components for the study are being cooperatively undertaken by CVC and Aquafor Beech Limited.

1.2 Study Organization

Completion of this study will be of benefit to the City of Mississauga, Region of Peel, Ministry of Natural Resources, Ministry of the Environment, and CVC in various areas. As noted above, the technical components will be undertaken jointly by CVC and Aquafor Beech Limited.

The Lake Ontario Integrated Shoreline Strategy also includes a Technical Committee and an Advisory Committee.

The Technical Committee is comprised of CVC, City of Mississauga, Region of Peel, and consultant staff and participates in a "hands-on" manner by providing background information, providing input on study direction, reviewing findings, and participating in meetings.

The Advisory Committee will be made up of representatives from key agencies including those listed above as well as experts from other agencies and non-government agencies, including key community organizations. This committee will provide "value-added" services by responding to findings at key points in the study.

1.3 Report Content

The overall document includes an Executive Summary, Technical Document, and a series of Appendices. Provided below is an overview of the content for the Technical Document.

Chapter 1 - Background information is provided together with study purpose, approach, and organization.

Chapter 2 - An overview of the Study Area is provided as is a summary of the rationale for defining the study limits. Key findings from previous or ongoing studies are also provided.

Chapter 3 - This chapter summarizes relevant background information and describes the key findings from the technical assessments.

Chapter 4 - This chapter brings together the key findings from Chapter 3 and summarizes the key data gaps.

Chapter 5 - The conclusions and recommendations are provided in this chapter.

2 STUDY AREA AND BACKGROUND

2.1 Study Area

Although the geographic extent of the Study Area varies for each discipline, the areas of most interest extend from 6 km offshore in Lake Ontario to 2 km inland within the jurisdiction of Credit Valley Conservation and 5 km inland within the Credit River watershed (see Figure 2.1). It is acknowledged that while some of the issues can be addressed from within the formal study boundaries, many will require working within the full extent of the watershed boundaries (e.g. water quality) and within the context of broader lakewide initiatives (e.g. coastal processes).

These boundaries were generally derived from the Peel-Caledon Significant Woodlands and Significant Wildlife Habitat Study (North-South Environmental et al 2009), Significant Wildlife Habitat Technical Guideline (MNR 2000), and from an extension to CVC's boundaries to include a four mile (6.4 km) offshore limit (Order-in-Council, 1971).

The following watercourses from west to east were included in the study:

1. Clearview Creek
2. Avonhead Creek
3. Sheridan Creek
4. Turtle Creek
5. Birchwood Creek
6. Moore Creek
7. Lornewood Creek
8. Tecumseh Creek (including Port Credit West subwatershed)
9. Credit River (including the following subwatersheds: Port Credit East, Loyalist Creek, Wolfedale Creek, Mary Fix Creek, Kenolli Creek, Sawmill Creek, and Stavebank Creek)
10. Cumberland Creek
11. Cooksville Creek
12. Cawthra Creek (including Cawthra Creek subwatershed)
13. Serson Creek
14. Applewood Creek
15. Lakeside Creek

Within the Fluvial Geomorphology component of the study, Cooksville and Sheridan Creeks were omitted as it was indicated by CVC that sufficient information had already been collected for these watercourses. Data from these separate studies will be integrated into LOISS as part of the Shoreline Characterization and Impact Analysis.

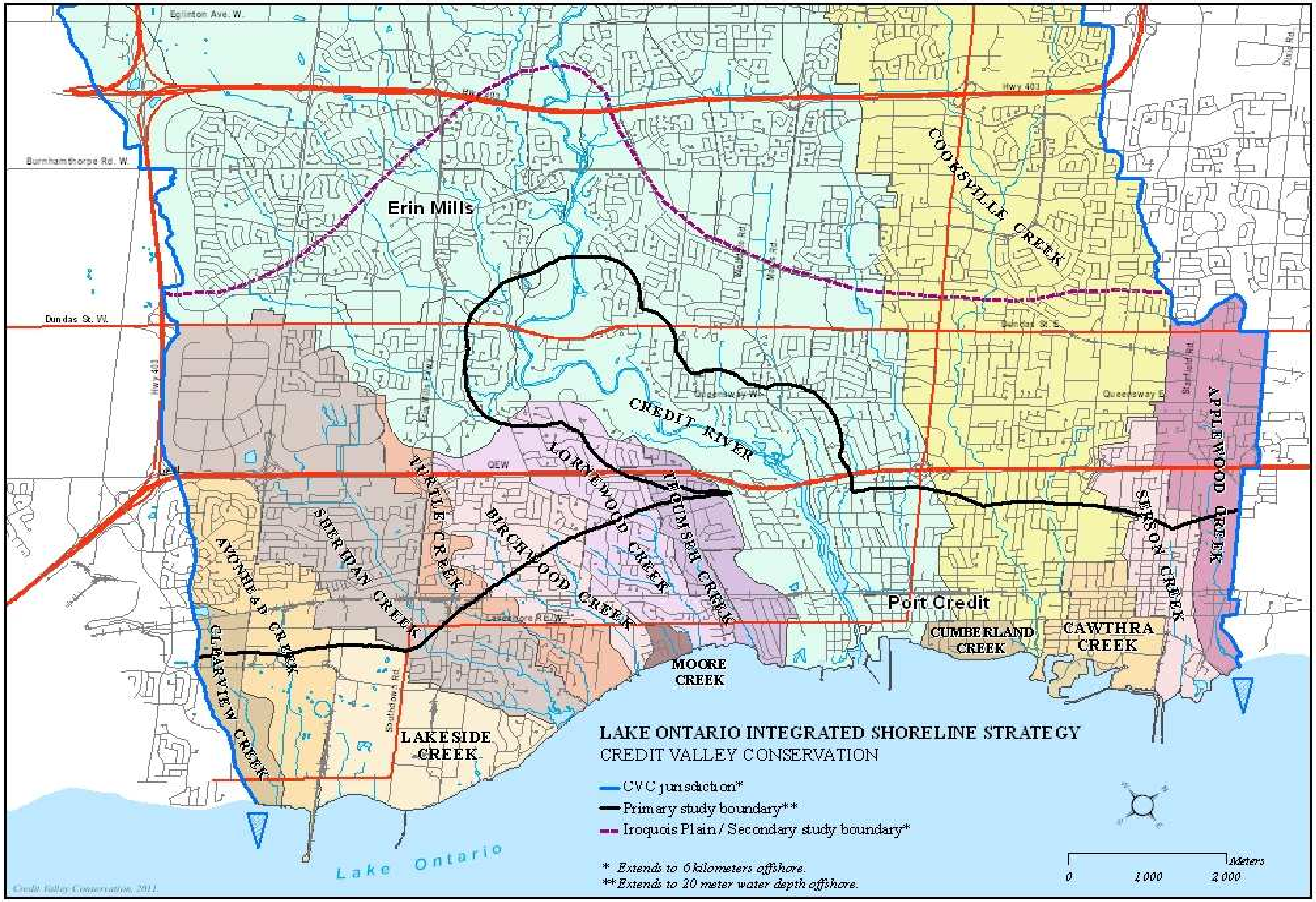


Figure 2.1: Study Area

A summary of watershed characteristics for the Credit River and the 13 other watercourses is provided in Table 2.1. After the Credit River, Cooksville and Sheridan Creeks have the largest watershed areas. The remaining creeks all have watersheds less than 1,000 ha in area.

Table 2.1: Summary of Watershed Characteristics

Watercourse	Drainage Area (ha)	Approximate Watercourse Length (km)	Land Uses	Key Features
Applewood Creek	597	2.9	Residential, commercial, and open space	N/A
Avonhead Creek	233 (-32 diverted to Clearview) (85 after additional diversion to Clearview)	3.4	Industrial	N/A
Birchwood Creek	340	4.4	Residential, commercial, institutional, and open space	Fudger's Marsh
Cawthra Creek	604	Conveyed in storm sewers except for 0.3 km	Residential, industrial, commercial, institutional	N/A
Clearview Creek	314 (within Oakville) 68 (within Mississauga) (+ 32 diverted from Avonhead)	1.8 (within Mississauga)	Residential, commercial, agricultural	Environmental Policy Area B and Habitat Restoration Area (City of Mississauga), woodlot on west edge of subwatershed on waterfront classified as Environmental Policy Area A
Cooksville Creek	3390	16	Residential, commercial, industrial, and open space	Woodlots designated Environmental Policy Area A
Credit River	93,000	90	Residential, commercial, open space	Credit River Marshes
Cumberland Creek				
Lakeside Creek	250 (95 Petro Canada)	Conveyed in storm sewers except for 0.2 km	Industrial	N/A
Lornewood Creek	411	2.4	Residential	N/A
Serson Creek	204	2.0	Residential, industrial	N/A
Sheridan Creek	1,035	5.6	Residential, commercial	Rattray Marsh
Tecumseh Creek	167	1.7	Residential	N/A

Watercourse	Drainage Area (ha)	Approximate Watercourse Length (km)	Land Uses	Key Features
Turtle Creek	213	3.3	Residential, commercial, industrial	Turtle Creek Wetland

2.2 Summary of Relevant Documents

Various documents were reviewed to provide background information for the LOISS. A summary of the relevant documents is provided below by discipline.

Documents used for the Hydrology and Hydraulics component of the study were floodline mapping reports, drainage studies, and flood remediation plans. A list of these documents is provided in **Appendix A**. Information gained from these documents included watershed characteristics, existence of hydrologic and hydraulic models, watercourse return period flows, and lists of flooded buildings and structures.

For the Fluvial Geomorphology component of the study, documents reviewed included reports regarding channel restoration and design works, and meander belt assessment for creeks within the Study Area. Additionally, watershed studies for Sheridan and Cooksville Creeks were reviewed as was the Credit River Adaptive Management Strategy report. From these documents, information was gleaned regarding creek morphological parameters.

In the Coastal Processes component of the study, a review was carried out of existing background information including various data sources, past study reports, published papers and shoreline work applications. These sources provided information on lake levels, winds, waves, nearshore sediment and currents, shoreline recession rates, bathymetry, and sediment transport.

Documents reviewed for the Water Quality component of the study included reports and data sources from Environment Canada, the Ontario Ministry of the Environment, the U.S. Environmental Protection Agency, municipalities, conservation authorities, and Ontario Power Generation. A list of the documents is provided in Table 3.14: Sources of Information on Water Quality in the LOISS Study Area.

The Terrestrial Natural Heritage component of the study included the review of a range of faunal and floral surveys, habitat inventories including Ecological Land Classification mapping, and management, stewardship, and restoration recommendations. Both the Sheridan Creek and Cooksville Creek watershed studies were also reviewed as part of this study. This information was compiled to form the basis for the Terrestrial Natural Heritage background report.

The Hydrogeology component of the study included the review of CVC's water budget modelling framework, geological, hydrogeological, stream flow data, and water well records. Both the Sheridan Creek and Cooksville Creek subwatershed studies and baseflow data, were reviewed as part of this study. This information was compiled as part of the Hydrogeology background report.

The Aquatic Natural Heritage study was largely based on a review of fish collection records, environmental assessments, and other technical reports. This information was used as the basis for developing a list of both historically and currently occurring fish species, in addition to contributing to a characterization of the habitat found within the Study Area.

The Ecological Goods and Services study was based on an extensive literature review, although much of the information was focused on coastal shorelines. Of those studies that specifically examine the Great Lakes region, many were found to focus on commercial and trade implications rather than on non-market values per se.

The Stewardship, Education and Communications study was based on an extensive review of existing programs and initiatives occurring within the Study Area and efforts made to identify all those that directly complement the LOISS. This information was used as a basis for the development of the Communications Strategy for the LOISS, with attempts made to build on existing programs and initiatives.

The Conservation Lands study drew from the Conservation Areas Strategy, the Greenlands Securement Strategy, the Terrestrial Ecosystem Enhancement Model, and the Lands Monitoring Program. Information was summarized for all eight CVC-owned properties within the Study Area.

3 SUMMARY OF TECHNICAL FINDINGS

3.1 General

This chapter provides a summary of the technical findings for each of the disciplines that were considered. Chapter 4 integrates the key findings and discusses potential data gaps. An overview of the findings for each of the disciplines is provided below for the following disciplines:

- Hydrology and Hydraulics,
- Fluvial Geomorphology,
- Coastal Processes,
- Water Quality,
- Terrestrial Natural Heritage,
- Hydrology,
- Aquatic Natural Heritage,
- Stewardship, Education and Communications, and
- Ecological Goods and Services.

Additional detail concerning Conservation Lands can be found by referring to **Appendix I**.

For each of the above noted disciplines the following is generally provided:

- **Section 1** - Introduction- a description of the discipline together with the relevance to this project

- **Section 2** - Background Information - a summary of the existing information and the relevance to this project

- **Section 3** - Technical Assessment - a summary of the technical assessments (e.g. fields work to define stream characteristics) undertaken as part of this study together with the results

- **Section 4** - Conclusions - a summary of the key findings and knowledge gaps together with content as to the relevance.

3.2 Hydrology and Hydraulics

3.2.1 Introduction

Hydrology is the science that deals with the interaction of water, land, and the processes by which precipitation is transformed into runoff to the receiving watercourses or infiltrated into the groundwater system. One of the most dramatic changes brought about by urbanization is the change in stream hydrology. For example, the replacement of vegetation and undisturbed terrain with impermeable surfaces (i.e. pavement, roof tops, and graded surfaces) and the provision of an underground storm drainage network results in greater interception of water that would naturally infiltrate into the ground, and instead, provides a direct and rapid transport of surface runoff to streams.

As a result, groundwater recharge diminishes which could, in turn, potentially affect baseflows in streams relying on groundwater discharge. A more rapid rate of stormwater runoff from rainfall events can result in an increase in the total volume, peak flow, and frequency of runoff occurrences. Uncontrolled, these hydrologic changes can result in increases in flooding, channel erosion, sediment transport, and pollutant loadings. These changes can also cause deterioration in natural channel morphology, fish and wildlife habitats, recreational opportunity, and aesthetics.

It is important that the existing hydrologic characteristics of the Study Area and its watercourses be established. This information is critical in providing key information on the selection and design of stormwater management facilities for future urban development lands. Additionally, flows determined from hydrology are used as the basis for hydraulic studies. In the context of this study, hydraulics deals with the movement of water through streams and rivers. Thus, the combination of hydrology and hydraulics allows for the definition of existing flood characteristics and the Regulatory floodplain limits.

The purpose of this portion of the LOISS was to summarize the existing hydrologic and hydraulic information on the watersheds within the Study Area. This information included the following:

- Drainage area,
- Imperviousness,
- Availability and date of hydrologic model,
- Return period flows,
- Availability of stream gauge,

- Nearest meteorological station,
- Availability and date of hydraulic model,
- Availability of floodline mapping, and
- Summary of flood-susceptible buildings and roadways within the Study Area.

Additionally, the meteorological and water level information available within the Study Area was collected and summarized. Any data gaps have been identified.

3.2.2 Background Information

Floodline mapping studies, flood remediation studies, and other documents relating to hydrology and hydraulics in the Study Area were reviewed to provide information relating to watershed characteristics, flood flows, floodlines, and inundated structures and buildings. A list of these documents is included in **Appendix A**.

In general, the information from these reports included watershed characteristics, the hydrologic and hydraulic model availability, return period flows, and floodline mapping. The remaining information was acquired from the City of Mississauga precipitation gauging record, the Water Survey of Canada Lake Ontario level records, and the Environment Canada Climate Normals.

3.2.3 Technical Assessments

The Hydrologic and Hydraulic component of this study involved summarizing watershed and watercourse characteristics from existing documents and data sources (see Figure 2.1 for the watercourses within the Study Area). Additionally, precipitation data (see Table 3.1) were supplied by Credit Valley Conservation or obtained from the Environment Canada climate normals while the water level record of Lake Ontario at Toronto was acquired from the Water Survey of Canada archives. Any missing data have been identified for the data gaps component of the report.

Table 3.1: Precipitation Data for the Study Area

Gauge	Operator	Mean Annual Precipitation (mm)
Station 2	City of Mississauga	626
Station 9	City of Mississauga	692
Oakville Southeast WPCP	Environment Canada	809
Pearson International Airport	Environment Canada	793

Since the climate normals are based on a thirty-year record while those from the City contain many gaps, the precipitation depths associated with the Environment Canada gauges are likely better representative of the long term mean in the Study Area. Thus, the Study Area receives a mean annual precipitation of about 800 mm. However, for individual precipitation events, there can be significant spatial variation. For individual events, the Station 2 gauge, located within the Study Area, would provide more appropriate data.

The Water Survey of Canada lake level gauge at Toronto has been recording water levels since 1906. The water level in Lake Ontario at Toronto has a range of about 2 m over the period of record from a minimum of 73.7 m in 1934 to a maximum of 75.8 m in 1973. The mean water surface elevation over the period of record is 74.8 m. Over the past decade, the mean yearly water surface elevations have been close to the mean for the period of record.

General watershed characteristics are summarized in Table 2.1. More detailed information on the watersheds within the Study Area (including imperviousness, associated stream gauges, nearest meteorological stations) is provided in **Appendix A**.

Hydrologic and hydraulic models as well as flood hazard mapping have been developed for all watersheds within the Study Area except for Cumberland and Moore Creeks. The dates of these models vary and further details are provided in **Appendix A**.

There are CVC installed and maintained impact monitoring stations that are regulated under CVC's Integrated Watershed Monitoring Program (IWMP). There are a total of three impact monitoring stations regulated by the CVC within the Study Area (CA-1, CO-1b, and SH-2). CA-1 is found in the Cawthra Creek watershed and is located at the corner of Atwater Avenue and Cawthra Road. CO-1b is found in the Cooksville Creek watershed and is located at the corner of Lakeshore Road East and Beechwood Avenue. SH-2 is found in the Sheridan Creek watershed and is located near the Rattray Marsh. It is important to note that the monitoring stations CO-1B and CA-1 were monitored from 2007 – 2009 but were discontinued in 2011 due to a shortage of funding. Presently, only temperature is measured at station CO-1B.

There are no Water Survey of Canada gauging stations within the Study Area. Thus, a frequency analysis was unsuitable for determining return period flows within the subwatersheds. Instead, flows were compiled from the documentation provided. These flows are given in **Appendix A**. However, values for Cumberland and Moore Creeks were not available in the material provided, nor were values for return periods less than 50-years for Avonhead and Clearview Creeks or Regional flows for all locations on the Credit River.

Through the review of the available flood studies, a list of the structures overtopped and the return period at which they first overtop was compiled. This list is provided by watercourse in **Appendix A**. Information regarding the number of houses flooded was also compiled by watercourse and is also provided in **Appendix A**.

For the following watersheds, information regarding overtopped structures and flooded buildings is unavailable or insufficient:

- Avonhead Creek,
- Clearview Creek,
- Cumberland Creek, and
- Moore Creek.

3.2.4 Conclusions

For the most part, the information required for the hydrology and hydraulics component of the study was found within the documentation provided. Missing information has been summarized in Section 4.2.

3.3 Fluvial Geomorphology

3.3.1 Introduction

Fluvial geomorphology is the study of watercourse-related landforms and the processes shaping these landforms. Numerous variables define the channel form of a watercourse. These variables can be defined as controlling factors (geology, climate, physiography) or modifying influences (boundary material, stream flow, channel slope, vegetation, human activity, and land cover). A quasi-equilibrium state is reached within a channel when the modifying and controlling variables remain relatively constant. However, when changes occur to the modifying variables, the balance is upset and the channel form adjusts until a new quasi-equilibrium state is reached.

One common example of a change in the modifying variables arises due to urbanization within a watershed. The increase in impervious land cover results in a change in flow regime (flow volume, shape of hydrograph, frequency of flows, peak flows, etc.). In response, the channel enlarges its cross-sectional capacity and planform configuration. The channel response is not immediate and may take several decades to complete.

Watercourse form is also linked to the characteristics of the receiving waterbody. Water and sediment that discharge from a watercourse into a receiving waterbody are derived from the upstream portion of the watershed. Similarly, the base level control and backwater influences exerted by a waterbody at the outlet of the watercourse affect upstream channel conditions and processes. Thus, there is a connection between fluvial geomorphology and coastal processes.

The goals of the fluvial geomorphology component of the LOISS are threefold:

- To gain insight into interaction between tributaries and the shoreline,
- To identify watercourses that are most sensitive to Lake Ontario backwater influences, and
- To identify watercourses that may yield the highest sediment load to the shoreline.

These goals were achieved through review of background information, field walks, and baseflow measurements. These elements of the study are described in the following sections.

3.3.2 Background Information

Documents provided by CVC as background material for the Fluvial Geomorphology component of the LOISS are listed in **Appendix B**. The reports included meander belt width assessments and channel stabilization and restoration for watercourses including Applewood Creek, Birchwood Creek, and Clearview Creek. The reports were reviewed and relevant geomorphic information (including study purpose and channel parameters) is summarized in **Appendix B**.

Aerial photography from 1954 to 2006 was retrieved from the City of Mississauga's e-Maps (http://www.mississauga.ca/portal/services/maps). Photographs from 1954, 1966, 1975, 1985, 1995, and 2006 were reviewed. Details of the changes observed in the Study Area from 1954 to 2006 are provided in **Appendix B** while Table 3.2 provides a summary of these changes. Watercourses are grouped by their location from west to east.

Table 3.2: Summary of Changes in Land Use from 1965 to 2006

Watercourses	Land Use Changes
Clearview Creek Avonhead Creek Lakeside Creek	• Industrial development from 1954 to 2006 • Residential development from 1965 to 1975 • Piping of Avonhead Creek between 1954 and 1975 • Channelization of Clearview Creek completed by 1954
Sheridan Creek Turtle Creek Birchwood Creek Lornewood Creek Tecumseh Creek	• Change from industrial, residential, agricultural, and wooded land uses in 1954 to primarily residential land use in 2006 • Most residential development from 1954 to 1966
Credit River	• Construction of pier and marine at the mouth of the Credit River between 1954 and 1966 • Industrial development from 1854 to 1985 • Replacement of industry by residential land use from 1985 to 2006
Cooksville Creek Serson Creek Applewood Creek	• Elimination of agricultural land use by 2006 • Infilling of Lake Ontario for the Lakeside Generating Station, the wastewater treatment plant, and the parklands at the mouth of Cooksville Creek • Piping of Serson Creek between 1966 and 1975

3.3.3 Technical Assessments

To assess the existing conditions of the watercourses within the Study Area, literature review, reconnaissance level field walks, and baseflow measurements were undertaken.

Data on the condition of the Credit River, Sheridan Creek, and Cooksville Creek were obtained from reports since the RFP indicated that sufficient data had already been collected for these three watercourses and field walks were not necessary. Additional geomorphic information on these watercourses is provided in **Appendix B**.

Field walks were carried out for the following watercourses within the Study Area:

- Applewood Creek,
- Avonhead Creek,
- Birchwood Creek,
- Cawthra Creek,
- Clearview Creek,
- Cumberland Creek,
- Lakeside Creek,
- Lornewood Creek,
- Serson Creek,
- Tecumseh Creek, and
- Turtle Creek.

Each creek was walked from its mouth at Lake Ontario to a distance of one reach upstream of the first fish barrier or one reach upstream of the historic lake effect, whichever was greater. During the walk, reach breaks were identified, a photographic inventory was collected, the reaches were characterized using rapid assessment tools, notable channel features were mapped, and baseflow measurements were collected. Summaries of reaches are included in **Appendix B** as are descriptions of the watercourse mouths at Lake Ontario.

The key results from the RGAs and the RSATs are presented in Table 3.3. Additional information from the RGAs and RSATs is presented in **Appendix B**. This information includes cross-sectional, planform, substrate, and bank data. Average slopes by reach were calculated based on the 1-m contours.

Table 3.3: Key Results from the Rapid Geomorphic Assessments and Rapid Stream Assessment Tools

Watercourse and Reach	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
Applewood Creek	R1	N/A	7	Tree, shrub, grass	0.64	U	W/A	15	Poor
	R2	N/A	5	Tree, shrub, grass	0.42	MS	P	23	Fair
	R3	N/A	6	Tree, shrub, grass	0.48	MS	D	17	Fair
	R4	0.0110	3.3	Tree, shrub	0.11	S	A	23	Fair
Avonhead Creek	R1	N/A	5	Tree, shrub	0.18	S	A	19	Fair
	R3	0.0099	0.4	Grass	0.35	MS	W	12	Poor
Birchwood Creek	R1	N/A	2.25	Tree, shrub, grass	0.18	S	A	24	Fair
	R3	N/A	2.5	Shrub, grass	0.25	MS	A	23	Fair
Cawthra Tributary 1	R1	N/A	1	Some trees, shrub, grass	0.07	S	P	18	Fair
Cawthra Creek	R2	N/A	7	Tree, shrub, herb	0.40	MS	A/W	17	Fair
Clearview Creek	R2	0.0119	3.5	Tree, shrub	0.52	U	D	19	Fair
Cumberland Creek	R2	N/A	5	Tree, shrub, herb	0.33	MS	W	16	Fair
Lakeside Creek	R1	0.0213	2.5	Tree, shrub	0.42	MS	A	21	Fair
	R2	0.0044	3	Tree, shrub	0.29	MS	D	19	Fair
Lornewood Creek Tributary	R1	0.004	2.5	Shrub, grass	0.21	MS	A	29	Fair
Lornewood Creek	R2	N/A	0.75	Tree, shrub, grass	0.28	MS	W	19	Fair
Serson Creek	R2	N/A	4	Tree, shrub, some grass	0.46	MS	P	12	Poor
	R3	0.0039	1.75	Shrub, grass	0.35	MS	P	10	Poor
Tecumseh Creek	R1	0.0060	3	Tree, shrub	0.33	MS	D	25	Fair
	R2	0.0270	2.5	Tree, shrub	0.22	MS	A	23	Fair
	R4	0.0085	1	Shrub, grass, some trees	0.26	MS	A	25	Fair
Turtle Creek	R1	0.0100	1.75	Shrub, herb	0.31	MS	A	22	Fair
	R2	0.0028	2.1	Tree, shrub	0.32	MS	A	26	Fair
	R3	0.005	2.9	Tree, grass	0.25	MS	W	22	Fair

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

Certain reaches were omitted from the above table since they are conveyed by stormsewer. These reaches and their lengths are listed in Table 3.4. The reaches of Birchwood and Lornewood Creeks that are conveyed through stormsewers are located within Jack Darling Memorial Park and Richard's Memorial Park respectively. Consideration could be given to daylighting these two reaches through the parks to restore channel connectivity and improve stream health.

Table 3.4: Watercourses Conveyed by Stormsewer

Watercourse	Reach	Length (m)
Avonhead Creek	2	390
Birchwood Creek	2	450
Cumberland Creek	1	75
Lornewood Creek	1	340
Serson Creek	1	500
Tecumseh Creek	3	550

Reach 1 of Clearview Creek (455 m) was also omitted from Table 3.3 as it is conveyed through a trapezoidal concrete channel. Consideration should also be given to restoring this reach through natural channel design.

The baseflows are summarized in Table 3.5 in descending order of baseflow magnitude. Also shown in this table are the average velocities in the cross-sections where the baseflows were measured. As seen in the table, Birchwood Creek has the highest baseflow while Cumberland and Avonhead Creeks have the lowest baseflows. The cross-section where baseflow was measured on Birchwood Creek is shown in Figure 3.1.

Table 3.5: Baseflow and Velocity Measurements

Watercourse	Baseflow (m^3/s)	Average Velocity (m/s)
Birchwood Creek	0.0323	0.047
Applewood Creek	0.0255	0.020
Lornewood Creek	0.0229	0.059
Cawthra Creek	0.0196	0.084
Turtle Creek	0.0152	0.144
Tecumseh Creek	0.0045	0.176
Lakeside Creek	0.0043	0.072
Serson Creek	0.0020	0.039
Clearview Creek	0.0017	0.158
Cumberland Creek	0.0006	0.032
Avonhead Creek	0.0002	0.090

Figure 3.1: Location of Baseflow Measurement on Birchwood Creek

Using the findings from the field walks, the three goals of the fluvial geomorphic study were addressed. Insight into the interaction between the tributaries and the shoreline was gained from observations of the creek mouths at Lake Ontario. Interaction between the tributaries and shoreline is minimal for the creeks that are conveyed in stormsewers to the lake (Cawthra, Lornewood, Cumberland, and Serson Creeks). Interaction is also minimal for Clearview Creek which is conveyed to the lake in a concrete-lined channel. For the remaining watercourses, there is some interaction between the beach form (as determined by ice heave and wave action) and the forms of the creek mouths.

Figure 3.2 shows the mouth of Tecumseh Creek at Lake Ontario. The creek crosses a gravel and cobble beach prior to discharging into Lake Ontario. The form of the channel across the beach is dictated by the beach form which is in turn dictated by the wave energy of Lake Ontario. On the day of the field walk, the creek formed a pool at the upstream end of the beach followed by a meandering riffle-pool cascade to the lake. Photographs and descriptions of the outlets of the other watercourses within the Study Area are included in **Appendix B**.

Figure 3.2: Mouth of Tecumseh Creek at Lake Ontario

Watercourses most sensitive to backwater effects from Lake Ontario were determined through field observations; the watercourses identified were Applewood Creek, Lakeside Creek, and Turtle Creek. The dominant process in the downstream-most reach of all three of these creeks is aggradation (see Table 3.3). Backwater effects from the lake reduce velocities in these reaches and as a result, transported sediment is deposited. Low biological indicator scores in these reaches (see **Appendix B**) also indicate the low velocity, depositional nature of the backwater conditions in these reaches.

Figure 3.3 shows the backwater conditions in the downstream end of reach 1 of Applewood Creek. The channel is wider and has lower velocities than it does farther upstream. Backwater conditions in Applewood Creek were observed for a distance of 150 m upstream of the lake. Information and photographs of the backwater conditions in Lakeside and Turtle Creeks are provided in **Appendix B**.

Figure 3.3: Backwater Effect from Lake Ontario in Reach 1 of Applewood Creek

The third goal of the LOISS was to identify watercourses that may yield the highest sediment load to the Lake Ontario shoreline. Predicting and controlling sediment loads requires extensive knowledge and quantitative assessment of soil erosion and the sediment transport process.

A review of provided literature for sediment transport analysis and sediment loading data was performed; however, data predicting sediment loading to Lake Ontario are available only for the Credit River. These data, provided within the CRAMS study (Aquafor Beech Limited, 2004), are summarized in Table 3.6. Based on these data, the estimated total sediment yield to Lake Ontario is more than 174,000 tonnes/year composed mainly of medium sand-sized particles. It is predicted that sediment yield of medium sand may increase substantially under future development scenarios.

Table 3.6: Sediment Loading to the Credit River

	D50 ave	**D50 fine**	**Medium gravel**	**Medium sand**
Grain Size (m)	0.0483	0.0142	0.0120	0.0005
Sediment Yield (tonnes/yr)	0	278	853	172954

D50 fine = average particle size of the matrix materials (i.e., sand, silt)
D50 ave = average of D50 fine and D50 coarse
Medium sand = the grain size representative of fine sediment on the channel bed
Medium gravel = the grain size that is used by salmonids for spawning.

Further study and analysis of sedimentation at the mouth of the Credit River was performed by Baird and Associates within the "Preliminary Assessment of Sedimentation – Port Credit Harbour Marina" (2006). Sounding analysis was performed to estimate aggradation rates of the channel bed following two dredging events. A summary of sedimentation within the Credit River following two dredging events is provided in Table 3.7.

Table 3.7: Depth of the Credit River channel between Port Credit Harbour Marina basin and Lake Ontario

Event	Depth (m)*
Dredging (approx 1984)	-1.6
Sedimentation (1984-89)	-1.3
Sedimentation (1989-95)	-1.3
Dredging (approx 1996)	-2.3
Sedimentation (1996-2005)	-1.3
Sedimentation (after 2005)	-1.3

*Referenced to the International Great Lakes Datum 1985

The results indicate that the channel responses to the two dredging events were similar and suggest that a span of approximately 5 years is required to reach a depth that is roughly in equilibrium at approximately -1.3 m. Factors which may affect this equilibrium include river discharges, velocities (associated with discharge and channel form), sediment balance within the watershed, wave climate, and lake levels.

Review of subwatershed reports for the watercourses within the Study Area other than the Credit River did not provide results of sediment loading to Lake Ontario. Without further detailed data and analysis, predictions cannot be made as to which watercourses within the Study Area may provide higher sediment yields to Lake Ontario. Campbell (1992) asserts that the processes of erosion and sediment production within any basin, no matter its size, are spatially and temporally discontinuous; thus, basin-specific studies are recommended to accurately predict sediment loadings.

3.3.4 Conclusions

Based on observations during the field walks and analysis of data collected, it was found that most watercourses within the Study Area are “moderately stable” and their condition can be classified as “fair”. Aggradation and widening are the dominant processes acting on the downstream-most reaches of these watercourses. Except where watercourses are conveyed to their outlet at Lake Ontario through stormsewers or concrete channels, there is an interaction between the beach form and the watercourse mouths.

Of the creeks evaluated during the field investigation, Applewood, Lakeside, and Turtle Creeks were the most sensitive to backwater effects from Lake Ontario. Aggradation dominated within the downstream-most reach of these creeks and biological indicator scores were low.

Sediment loading within the Study Area was available only for the Credit River where expected loads exceed 174,000 tonnes per year. Further detailed analysis is required to determine sediment loading from the remaining watercourses within the Study Area. These data gaps have been summarized in Section 4.3.

3.4 Coastal Processes

3.4.1 Introduction

Coastal processes can be generally defined as the natural forces and processes that affect the shoreline zone. The current shoreline of Lake Ontario has formed over the last approximately 10,000 years since retreating glaciers allowed Lake Iroquois to outlet through the St. Lawrence River. Erosion from wind, waves and water level fluctuations formed the shoreline zone that exists today. Protection structures have hardened most of the lake shoreline within the CVC watershed and natural processes are generally restricted to the few unprotected reaches of shore and the nearshore lakebed fronting the structures. This section is to present an overview of the coastal processes within the limits of Credit Valley Conservation's watershed.

3.4.2 Background Information

A review was carried out of existing background information including various data sources, past study reports, published papers and shoreline work applications. Relevant findings are presented in the sections below.

Water Levels

Water levels on Lake Ontario fluctuate on short-term, seasonal and long-term bases. Briefly, seasonal fluctuations reflect the annual hydrologic cycle which is characterized by higher net basin supplies during the spring and early part of summer with lower supplies during the remainder of the year. Figure 3.4 is a hydrograph for Lake Ontario showing recent and long-term mean monthly water levels with respect to chart datum. It can be seen from Figure 3.4 that water levels generally peak in the summer (June) with the lowest water levels generally occurring in the winter (December). The average annual water level fluctuation is approximately 0.5 metres. Although water levels below chart datum are rare, the lowest monthly mean on record is approximately 0.4 metres below chart datum.

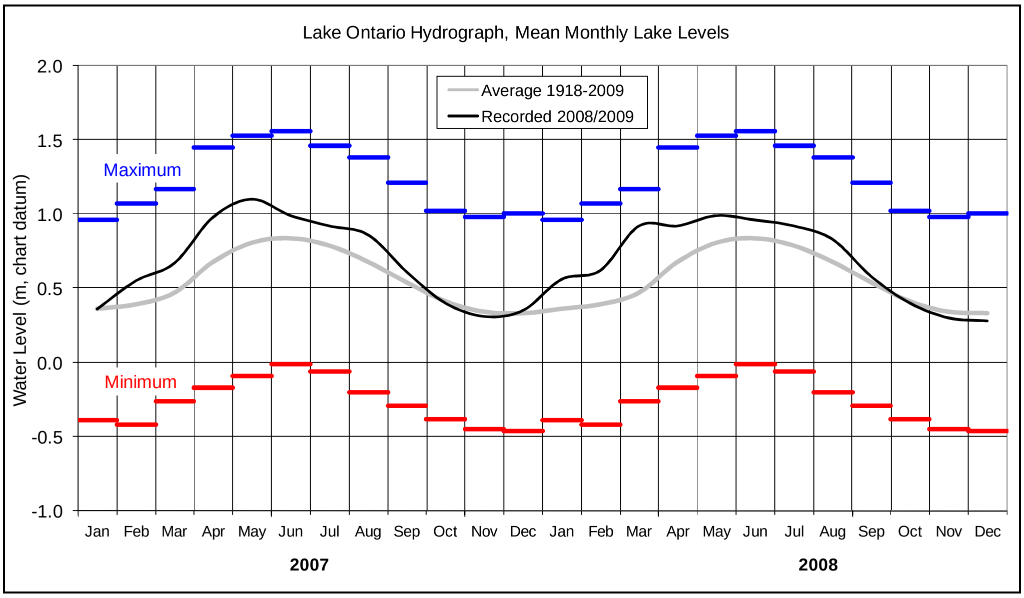


Figure 3.4: Lake Ontario Hydrograph

Short-term fluctuations last from less than an hour up to several days and are caused by local meteorological conditions. These fluctuations are most noticeable during storm events when barometric pressure differences and surface wind stresses cause temporary imbalances in water levels at different locations on the lake. These storm surges, or wind-setup, are most noticeable at the ends of the Lake, particularly when the wind blows down the length of the Lake. Because of the depth of Lake Ontario, storm surge is not as severe as occurs elsewhere on the Great Lakes (like Lake Erie).

MNR (1989) investigated storm surges throughout the Great Lakes as part of their analysis of extreme water levels for design conditions. Table 3.8 shows the 1:100-year mean monthly water levels, storm surges and instantaneous water levels for the shoreline reaches relevant to this study. The boundary between the Oakville and Mississauga reaches was the Clarkson refinery pier, which is actually located in Mississauga. This therefore gives two MNR (1989) shoreline sectors within the boundaries of the CVC watershed.

Table 3.8 100-Year Water Levels and Storm Surge Heights

MNR (1989) Sector	instantaeous water level (m IGLD85)	storm surge (m)	mean monthly water level (m, IGLD85)
Burlington (sector O-2)	76.06	0.94	75.59
Oakville (sector O-3)	75.96	0.81	
Mississauga (sector O-4)	75.86	0.72	
Toronto (sector O-5)	75.74	0.34	

Long-term water level fluctuations on the Great Lakes are the result of persistently high or low net basin supplies. More than a century of water level records show that there is no consistent or predictable cycle to the long-term water level fluctuations. Figure 3.5 shows Lake Ontario's mean monthly water levels from 1918 to 2009. Both long-term and seasonal fluctuations can be seen in Figure 3.5.

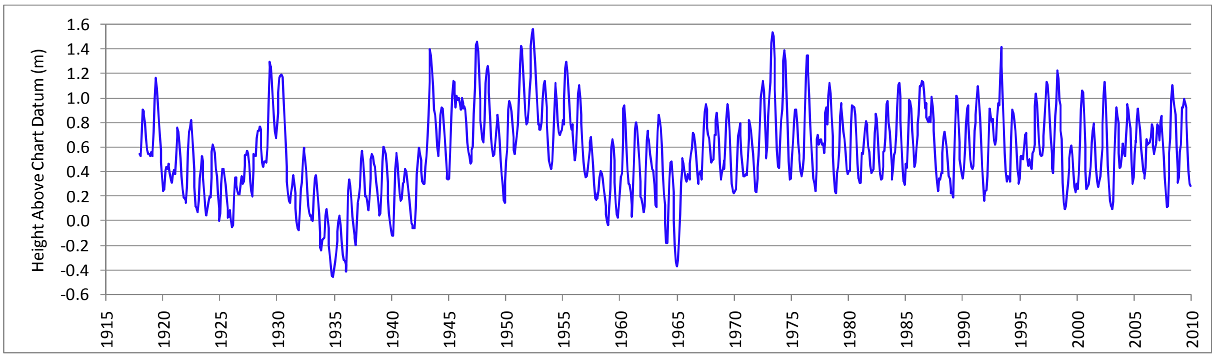


Figure 3.5: Lake Ontario Mean Water Levels, 1918 - 2009

Some climate change studies that examine the impact of global warming have suggested that long term water levels on the great lakes will be lower than they are today. Those changes, however, are expected to have a lesser impact on Lake Ontario than on the upper lakes because the Lake Ontario water levels are regulated. The International Joint Commission has been considering possible changes to those regulations but no final decision has been made. For the time being most approving agencies, including CVC, require that the 100-year instantaneous water level be used for the design and assessment of shoreline protection structures. The 100-year instantaneous water level determined by MNR (1989) is typically used.

The Surface Water Monitoring Centre of the Ontario Ministry of Natural Resources carries out wave and water level forecasts as part of the Great Lakes Operational Storm Surge System (GLOSS). They currently produce 60 hour forecasts, twice daily, for all of the Great Lakes. The GLOSS is relatively new and is still considered to be operating in “test mode” (as of November 2009). Briefly, GLOSS is a two-dimension circulation model coupled with a two-dimensional wave model. The models are driven by forecast winds and measured water levels assuming static bathymetry and lake boundaries. The bathymetry is represented by a flexible grid that allows the grid spacing to be tailored to specific areas of interest. The current grid has a spacing of approximately 5 kilometres in the offshore and in the order of 200 to 300 metres in the nearshore. It is possible to utilize much finer nearshore grid spacing to better represent significant flow barriers like the large breakwaters and piers found within the Study Area. MNR does not have any specific plans to increase the bathymetric resolution within the Study Area, but they seem willing to incorporate finer grids if they are supplied by others. The benefit of including a more refined GLOSS setup as part of the LOISS should be considered during the shoreline characterization phase of this study.

Winds

Knowledge of wind conditions is important to an analysis of coastal conditions because it is the winds that generate the waves that drive much of those processes. Winds are also the primary cause of storm surges, which are the short-term water level fluctuations described in Section 3.4.2.1. There are many sources of relatively long-term wind data around the lake, including both local and distant sources. Whether or not local or distant wind data is required depends upon how that wind will be used. For a lake-wide wave or circulation model it is preferable that multiple wind sources be used to define the varying conditions across the lake but it is important that the different wind sources be verified as being representative of the over-water winds before they are used. The authors of this report have found that winds measured at the Toronto Island airport are suitable for modeling coastal processes along the western end of Lake Ontario. Toronto Island has suitable wind data measured from 1957 to present although we tend to exclude winds from prior to 1973 due the higher percentage of missing data during that period.

Waves

There are a number of sources of wave data available in the general Study Area including hindcasts with data within the limits of the CVC jurisdiction and measured wave data from western Lake Ontario. The Marine Environmental Data Service (MEDS) of Environment Canada has online wave data from buoys located at Toronto, Burlington and Grimsby although the Burlington data is limited. While it is outside the CVC jurisdiction the measured wave data is valuable for calibrating hindcast and forecast models that include the immediate Study Area.

Online wave data is also available from a lake-wide hindcast prepared for the International Joint Commission (IJC). That study produced hourly wave data from 1961 to 2000 on a grid encompassing all of Lake Ontario. Data were archived for 307 locations around the perimeter of the Lake. Figure 3.6 shows the location of the archived data sets closest to the Study Area. Some of the measured wave data sites for the western end of the lake are also shown on Figure 3.6. The WIS wave data is offshore data, meaning that it must be transferred inshore if it is to be used in a coastal processes analysis. As waves propagate inshore, changing water depths cause the waves to refract to shoal, which changes both the wave height and wave direction. Waves in the lee of structures or those subjected to strong refraction effects will also undergo diffraction, a lateral transfer of energy along the wave crest. Nearshore wave transformation models typically consider a number of processes including refraction, diffraction, shoaling, wave breaking and bottom friction losses. Depending upon the specific modeling circumstances it may also be necessary for the transformation model to consider wave reflection.

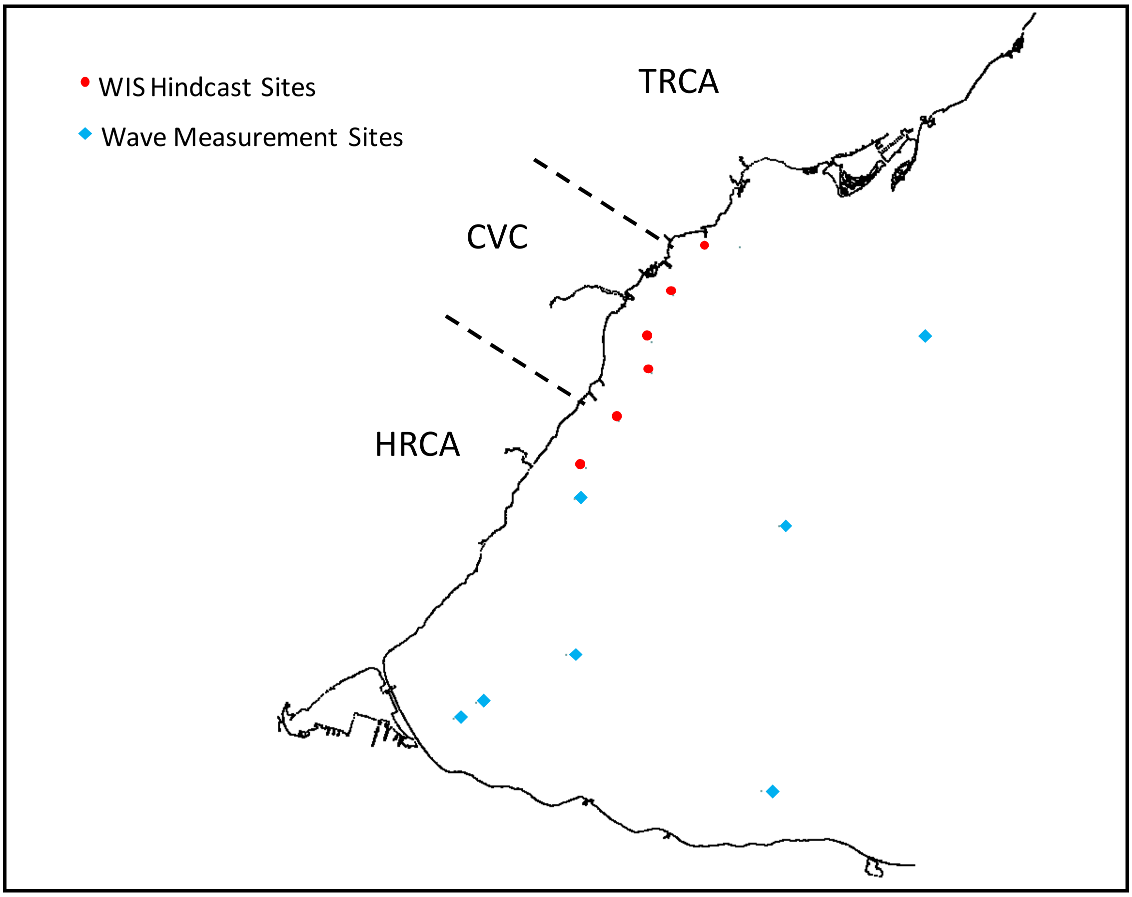


Figure 3.6: Offshore Wave Data Sites

The Great Lakes Operational Storm Surge System (GLOSS), which was mentioned in the Water Levels section, includes a 2D wave model that applies from deep-water in to the nearshore. It is both a wave generation and wave transformation model and could be used to produce nearshore waves throughout the study site.

As parts of different studies, Shoreplan has prepared site specific wave hindcasts and estimated nearshore conditions through much of the Study Area. An example of offshore and nearshore wave conditions within the Study Area can be demonstrated using the results of a study for a site on Watersedge Road. Figure 3.7 shows the highest hindcast wave heights and total wave energy distribution by direction for a 33 year hindcast. Figure 3.8 shows the difference in wave energy distributions for the nearshore and offshore wave data. The nearshore wave energy distribution is much more weighted towards the easterly peak than the offshore. Approximately 90% of the nearshore wave energy comes from the easterly direction. This is because the easterly waves undergo relatively little refraction compared to the south-westerly waves.

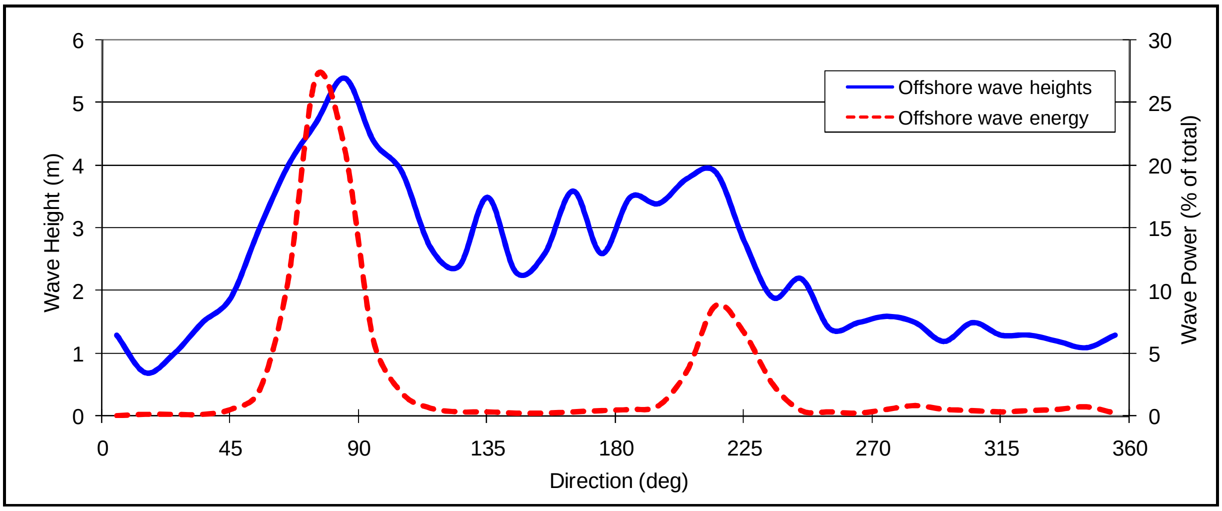


Figure 3.7: Deep-Water Wave Height and Wave Energy Distributions

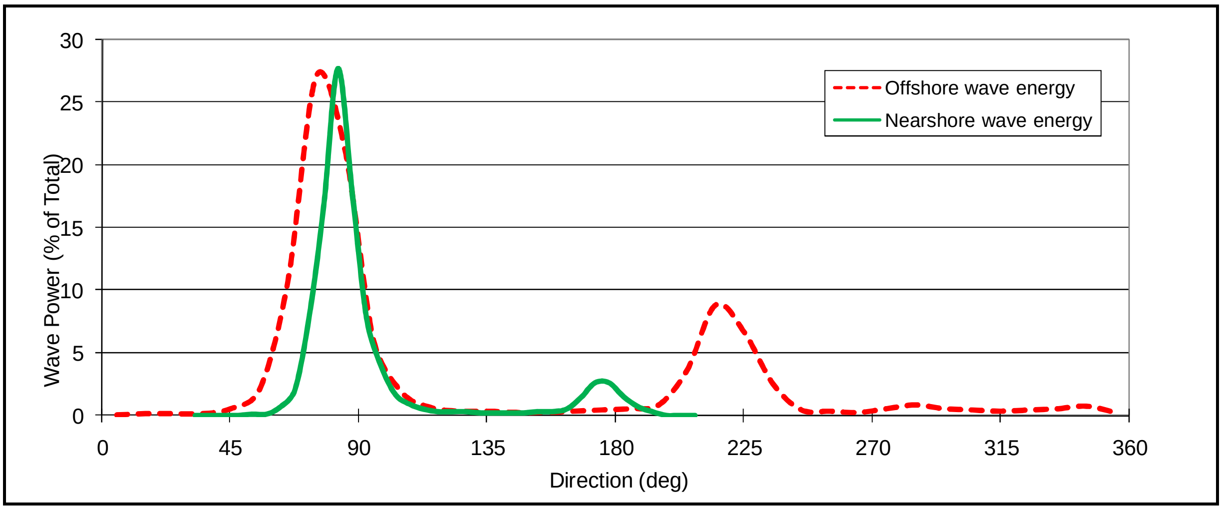


Figure 3.8: Offshore and Nearshore Wave Energy Distributions (Watersedge Road)

Some studies into the effects of climate change on the Great Lakes have estimated that the frequency of occurrence of severe storms will increase in the coming years. It has also been suggested that there could be an increase in wind speeds and changes in typical storm tracks. As nearshore waves are generally depth limited within the Study Area a small increase in wind speeds is not expected to be significant. Nearshore bathymetry and the overall geometry of the lake play a major role in nearshore wave directions so changing storm tracks are not likely to affect the nearshore wave climate. An increase in the frequency of severe events would be noticeable on any shoreline subject to ongoing erosion.

Nearshore Sediments

The Great Lakes Sediment Database (also known as the NWRI Sediment Archive) is an archive of data on the sediments of the Great Lakes, their connecting channels, and the St. Lawrence River which was collected by the Environment Canada's National Water Research Institute (NWRI) and in cooperation with other agencies between 1968 and 2001. It is housed at the NWRI in the Canada Centre for Inland Waters in Burlington, Ontario.

The data has been subdivided into four groups according to location and purpose: contaminated sediments data; Great Lakes basin sediment data; miscellaneous sediment data; and nearshore sediments data. The nearshore sediments data includes descriptions of sediment and core properties, grain-size statistics, sediment patterns and x-radiographs of sediment cores. There is a limited amount of the nearshore sediments data available within the limits of the CVC watershed and that data is located far enough offshore that it will not provide significant benefit to a study of coastal processes. Figure 3.9 shows the location of nearshore sediment samples and cores in the vicinity of the Study Area.

Shoreline Recession Rates

The vast majority of the shoreline within the CVC watershed has been protected and there is little recession rate data available for the remaining natural shoreline. Environment Canada and MNR (1975) determined shoreline recession rates as part of the Great Lakes Shore Damage Survey, but Shoreplan (2005) found that data to be unsuitable for establishing recession rates within CVC's jurisdiction. CVC (1988) presents a number of shoreline recession rates but a number of those rates seem unrealistically high. The source of that data is not described.

Shoreplan (2005) used three average annual recession rates in their calculations of the erosion component of the Lake Ontario shoreline hazard limits. They used a rate of 0.1 m/yr for all beach shoreline and significant beach deposits, a rate of 0.3 m/yr for the large headland areas constructed out of moderately compacted fill material, and a rate of 0.2 m/yr for the remainder of the shoreline. The average annual recession rates used by Shoreplan (2005) can be used for an initial assessment of the coastal processes along the CVC shoreline. More accurate shoreline recession rate data on the Great Lakes is typically developed from analyses of surveys and aerial photography. Recession rates derived from aerial photography have limitations on beach shorelines without a distinguishable bluff and when recession rates are low. The best shoreline recession data is derived from shore perpendicular profiles surveyed for the purpose of documenting the current shoreline position.

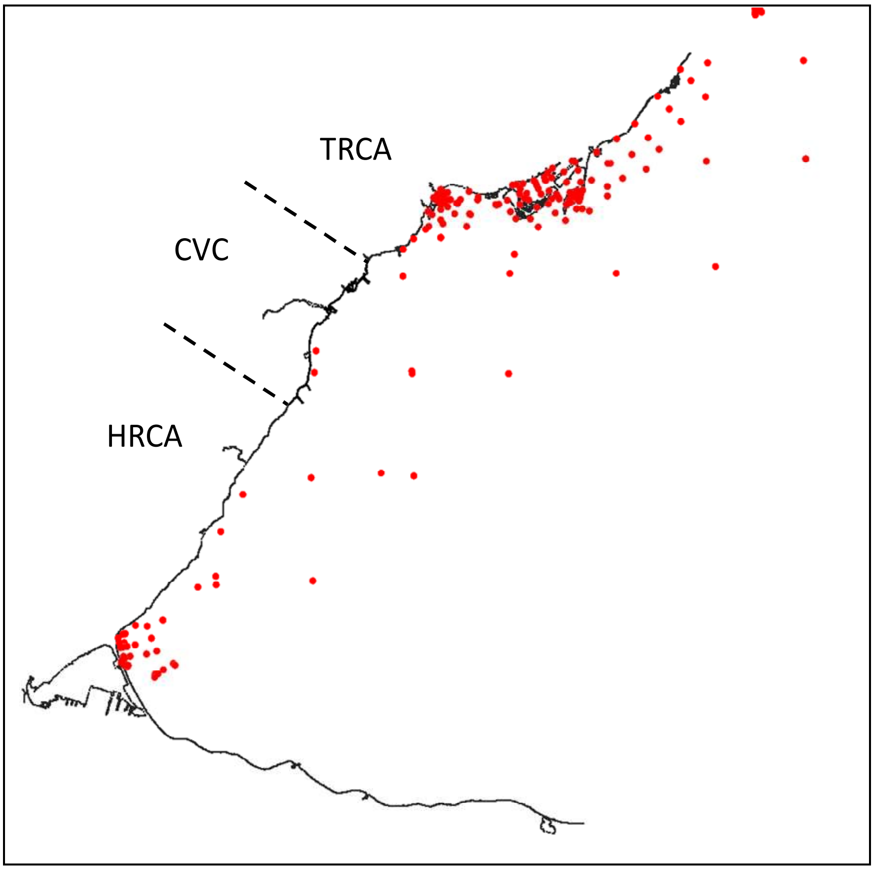


Figure 3.9: Nearshore Sediment Data Locations

Bathymetry

Figure 3.10 shows nearshore bathymetric contours within the Study Area at a contour interval of 2 metres. This figure was taken from a lake-wide bathymetric map produced as part of a cooperative program by the National Oceanic and Atmospheric Association (NOAA) of the U.S. Department of Commerce and the Canadian Hydrographic Service (CHS) of the Department of Fisheries and Oceans. (http://www.ngdc.noaa.gov/mgg/greatlakes/greatlakes.html). Bathymetric and topographic data is available on a rectangular grid with a resolution of 3 seconds of longitude and latitude. That corresponds to spacing of less than 100 metres for this location. That spacing is sufficient for most wave and circulation modeling as long as details are not required in the vicinity of features with a smaller spatial scale, such as a breakwater. The models may actually require smaller grid sizes but those grids can be generated by interpolating the NOAA data.

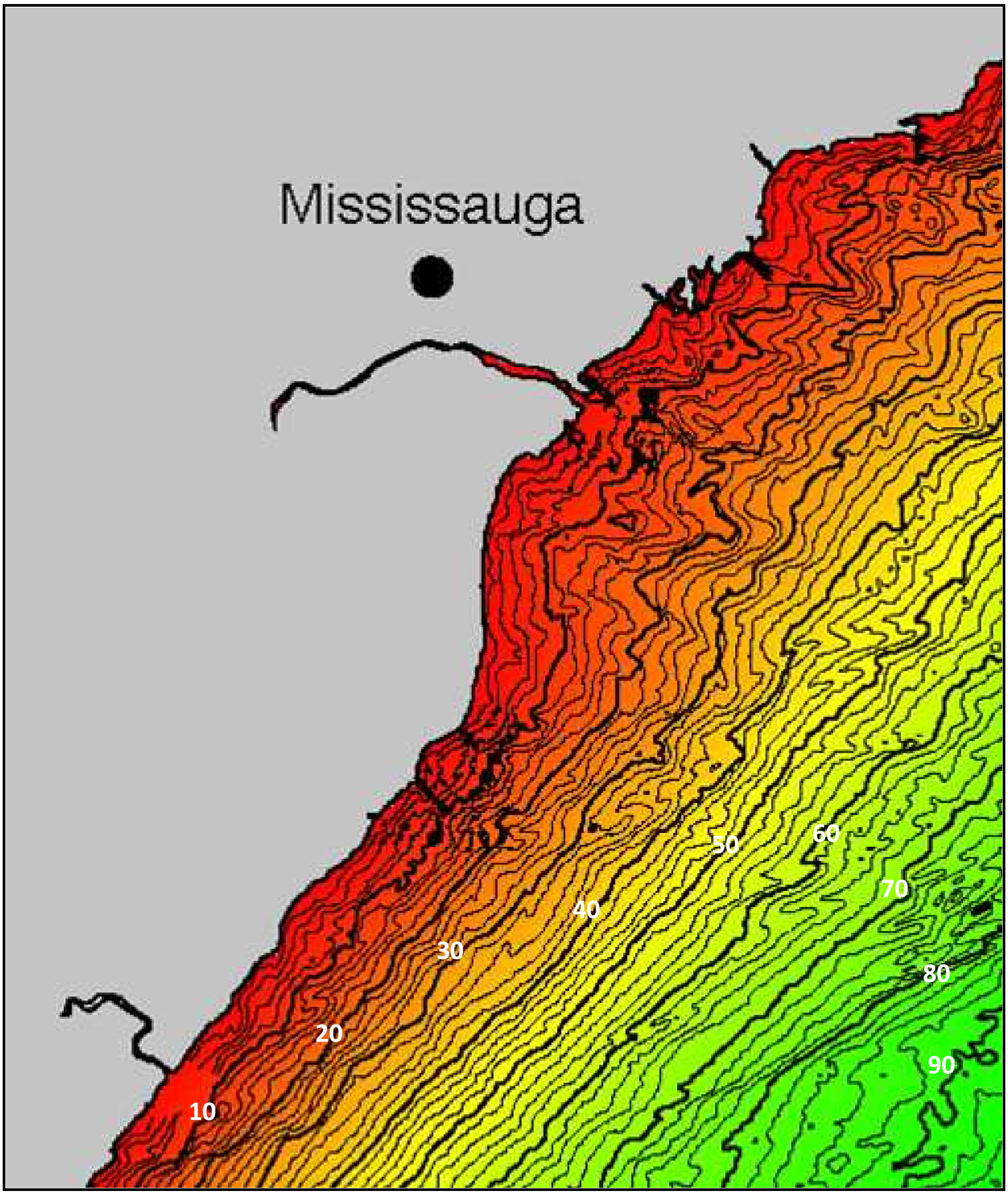


Figure 3.10: Nearshore Bathymetry

The NOAA data was compiled from multiple sources including CHS field sheets. On previous studies in the Toronto area we have found a discrepancy between the NOAA bathymetry and the actual field sheet soundings. We have also noticed significant differences between the shoreline interpolated from the NOAA data and the actual shoreline location. That has led us to question the accuracy of the NOAA data set in some locations. The interpolated shoreline position within this Study Area looks reasonable so there is no specific indication of a problem here, but it should be confirmed before it is used in any critical analyses.

There is also a significant amount of bathymetric data available from CHS. Digital field sheets are available at different resolutions throughout the Study Area. In some locations the resolution is finer than the resolution available from the NOAA data set.

Nearshore Currents

Nearshore currents play a significant role in coastal processes due to their capacity to transport littoral sediments and suspended and dissolved substances. Within a study such as the LOISS the analysis of dissolved and suspended sediments is usually treated as a water quality issue and the transportation of littoral sediments is treated as a coastal process. There is some overlap in dealing with the transportation of suspended sediments such as fine sand, silt and clay. The greatest proportion of sediment transport results from nearshore currents induced by breaking waves but non-wave-generated currents are important to water quality modeling and the transport of fine grained sediments.

Non-wave induced currents and circulation patterns on Lake Ontario are described by other disciplines within the LOISS study. Beletsky et al. (1999) report minimum, maximum and average mean current speeds on Lake Ontario during the summer as 0.1, 2.5, and 1.0 cm/s, respectively. The winter values were 0.4, 9.5, 2.8 cm/s, respectively. Those values do not consider the effects of waves. Breaking wave induced mean alongshore currents can exceed 100cm/s from moderate storm events. For most coastal processes studies wave induced nearshore currents are much more relevant than the ambient currents.

Sediment Transport

Assessing littoral sediment transport rates is typically a significant component of a coastal processes analysis but that is not necessarily the case for this study. The shoreline from Burlington to Toronto is generally referred to as a non-drift zone due to the lack of littoral sediments. On many shores of the Great Lakes, littoral sediment supply originates from erosion of shoreline bluffs and the nearshore lakebed. Within the LOISS Study Area the majority of the shoreline has been protected, essentially eliminating bluff erosion, and the nearshore lakebed is erosion resistant bedrock. Some sediment transport does take place because of nearshore bottom deposits, but there is no significant source of new littoral material. Some sediment is introduced via the watercourses that discharge into Lake Ontario, but that sediment is typically fine grained and tends to deposit in deeper water offshore of the nearshore zone.

In the discussion of wave conditions in the Waves section we referenced a Shoreplan project for a site on Watersedge Road. As part of that project we also investigated the average sediment transport characteristic at the site by modeling the potential sediment transport rates. Figure 3.11 shows typical results from the alongshore sediment transport modeling. The plots show positive, negative, net, and gross transport rates. These are potential transport rates and represent the volumes of sediment that could be moved by the available wave energy. Actual transport rates are dictated by the supply of nearshore sediments and the potential rates will not be realized if there is not a sufficient supply. The lack of substantial beach deposits along this section of shore shows that the actual transport rates are much lower than the potential transport rates.

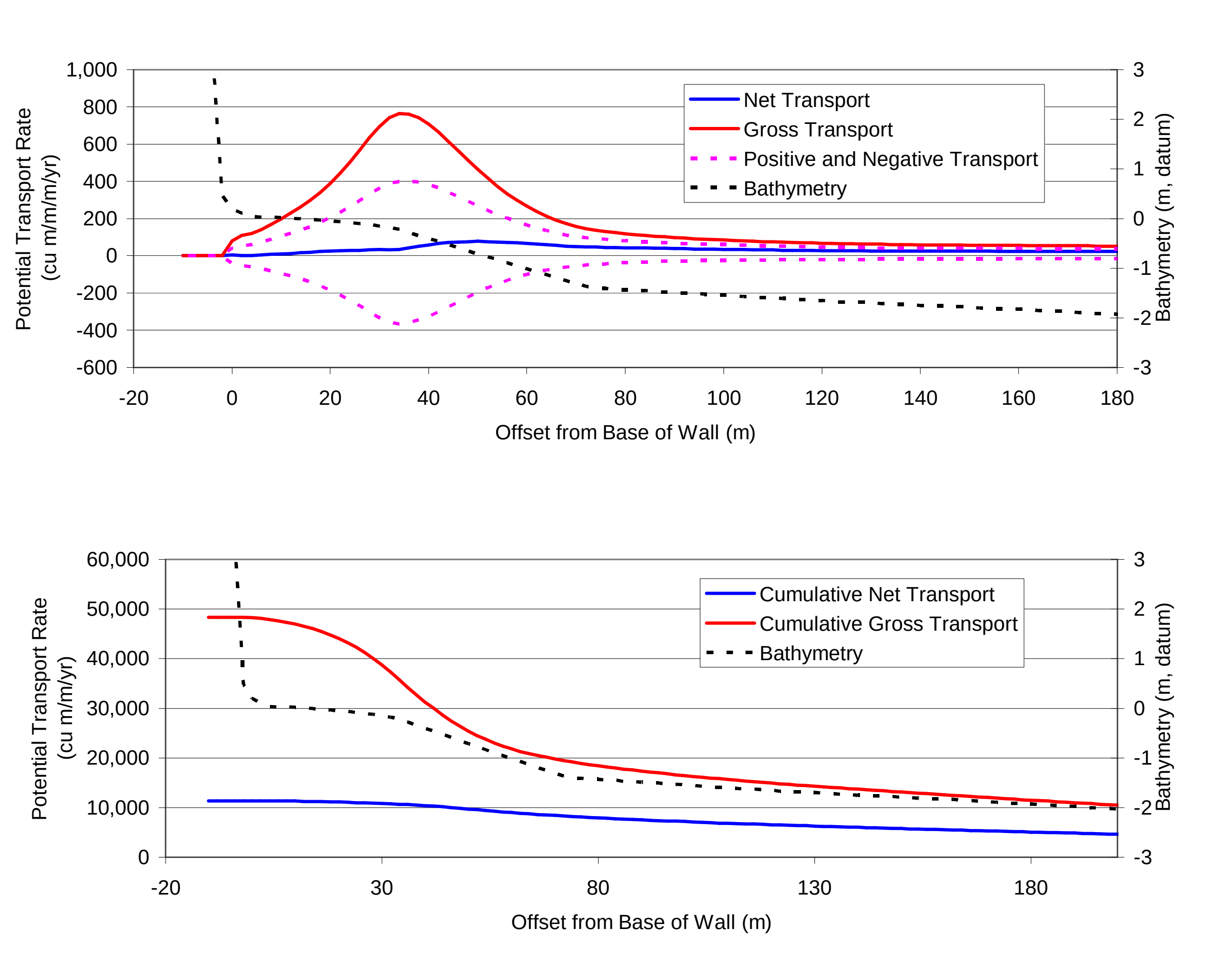


Figure 3.11: Potential Alongshore Sediment Transport Rates (Watersedge Road)

By examining Figure 3.10 and knowing that the net alongshore transport rate at the Watersedge Road site is close to zero it can be surmised that the net transport direction for the majority of the Study Area will be from northeast to southwest. The shoreline near the Watersedge Road site is generally oriented towards the east but most of the remaining shore within the study site is oriented in a more southeasterly direction. That change in orientation will lead to a net transport direction from northeast to southwest for any new littoral sediment introduced to the nearshore zone. As noted above, however, that supply is very low. That in turn means that the total sediment transport rate will be relatively low along the sections of shore with a net transport direction. Total transport rates will be higher on the section of shoreline with a low net transport rate as the littoral sediments are moved back and forth.

It was noted that the shoreline from Burlington to Toronto is generally referred to as a non-drift zone due to the lack of littoral sediments. That means there will be little sediment supply from the updrift and downdrift shorelines outside the CVC jurisdiction as those shores are also within the non-drift zone. There are significant obstructions to alongshore littoral drift near each of the CVC watershed limits including the breakwaters for the intakes to the old Lakeview Generating station to the east and the St. Lawrence Cement Company wharf to the west. The virtual lack of littoral sediment deposits adjacent to those structures confirms the very low littoral transport rates across the CVC jurisdiction boundaries.

It is important to note, however, that even a small amount of sediment moving along this "non-drift" shore can have significant long-term impacts on the function of outfalls, intakes, and other structures like launch ramps and harbour or marina entrances. It is equally important to recognize the role of sediment transport in biophysical processes, for example, the replenishment of systems such as Rattray baymouth bar coastal wetland, etc.

3.4.3 Shoreline Protection

The majority of the shoreline within the LOISS Study Area has been protected with either formal or informal shoreline protection structures. Some sections of shoreline that have not been intentionally protected appear to be experiencing reduced erosion rates due to the influence of adjacent structures. An example of this is the sand beach shoreline fronting the Lorne Park Estates, immediately adjacent to the northern most headland at Jack Darling Park.

As part of the CVC Lake Ontario Shoreline Hazards study, Shoreplan (2005) defined a total of 87 shoreline reaches within the CVC watershed. Amongst other attributes, a general shoreline type and shoreline protection type were assigned to each reach. Table 3.9 and Table 3.10 were developed from that data. The shoreline length values were determined from digital mapping provided by the City of Mississauga and exclude major structures such as piers and breakwaters but include the shoreline within the Port Credit marinas and Lakefront Promenade Park.

Table 3.9: General Shoreline Statistics

Shoreline Type	Length (m)	% of Total Length
all reaches	20,145	
artificial shoreline	9,003	45%
cohesive shore with protection structure	7,779	39%
cobble beach	1,454	7%
sand beach	834	4%
cohesive shore with protective beach or rubble	799	4%
unprotected cohesive bank or bluff	276	1%

Table 3.10: General Shoreline Protection Statistics

Shoreline Protection Type	Length (m)	% of Total Length
revetment	6,072	30%
wall	4,332	22%
beach	3,495	18%
wall and revetment	2,924	15%
rubble	1,417	7%
headland-beach (artificial)	904	4%
none	858	4%
rip-rap berm	143	< 1%

This information is derived from typical characteristics per reach from Shoreplan (2005).
Figure 3.12 illustrates the shoreline treatments in the Study Area. A more accurate accounting of the shoreline types and protection types could be obtained from a detailed inventory of the shoreline.

The expected life-span of a shoreline protection structure is dependent upon a number of conditions including the structure's material condition and quality, the construction quality, the controlling substrate where the structure is located, and how well the structure is maintained. For a properly designed, constructed and maintained structure the actual type of structure is of secondary importance for the life and risk of failure of that structure.

Maintenance of any structural protection is a fundamental requirement if that structure is to have a significant design life. Even structures designed to withstand 1:100 year design conditions will not last anywhere close to 100 years if they are not maintained. The life expectancy of a typical structure can only be generalized because of the specific nature of the need for maintenance.

CVC Lake Ontario Integrated Shoreline Study
Shoreline Characterization

Legend

Shoreline Characterization

- Armour Stone
- Boulder and Broken Rock
- Breakwall
- Broken Brick or Concrete
- Cobble
- Eroded Bluff
- Natural
- Retaining Wall (Concrete, Sheet Pile)
- Sand (Public Beach, Private Beach, Natural)

3.4.4 Technical Assessments

The Lake Ontario shoreline within the CVC watershed is located mainly in the City of Mississauga and has a total length in the order of 28 kilometres. For this study the shoreline was divided into 7 reaches based on littoral transport characteristics. Reach limits were defined where there were either total or near total barriers to the alongshore transport of littoral sediments. Most reaches were further divided into sub-reaches based on shoreline characteristics. Separate sub-reaches were established to differentiate between protected and unprotected sections of shoreline and between publically and privately owned shoreline. The protection and ownership designations were adopted from the CVC Lake Ontario Shoreline Hazards study (Shoreplan, 2005). Within the 7 shoreline reaches a total of 46 sub-reaches were defined. Figure 3.13 shows the location of the 7 reaches and 46 sub-reaches.

Whether or not the 46 sub-reaches provide a sufficiently detailed division of the shoreline within the CVC watershed will ultimately depend upon the Shoreline Characterization and Impact Analysis phase of the LOISS. A distinction was made between publically and privately owned shoreline because it was assumed that CVC would have to apply different processes or procedures to implement the long-term goals of the LOISS on public and private lands. A distinction was made between protected and unprotected shoreline as it is reasonable to initially assume that there will be no supply of littoral sediments from the erosion of the protected shores. That assumption can be re-examined during the Shoreline Characterization and Impact Analysis if the quality and longevity of individual protection structures is considered. The shoreline reach attributes, described in Section 3.4.3, include a protection effectiveness factor to facilitate desired changes.

A framework for a descriptive model of coastal processes within the Study Area was established by emulating the setup for a coastal sediment budget. Sediment budgets are frequently used to estimate littoral sediment transport rates when the littoral transport is supply limited. This occurs when the supply of sediment to the nearshore zone is less than that which could be transported by the available wave energy. When this is the case, alongshore transport rates are estimated through a sediment budget, which is an accounting of the sediment sources and sinks within the nearshore zone.

For a sediment budget, the shoreline is divided into a number of segments or reaches and the sediment sources and sinks of each segment are determined. The volumetric difference between these sources and sinks is assumed to be transported alongshore. The net alongshore sediment transport rate at any point is found by summing the alongshore transport rates from all shoreline segments updrift of that point. If sufficient data exists the total sediment supply can be subdivided by grain size because the behaviour of nearshore sediments is governed by its size.

A Microsoft excel spreadsheet was setup to record the attributes of reaches within the descriptive model. At this stage the spreadsheet is considered to be a work in progress because all of the attributes that might eventually be required have not yet been identified. It is anticipated that more attributes will be identified during the shoreline characterization phase of the LOISS as the critical coastal processes are identified.

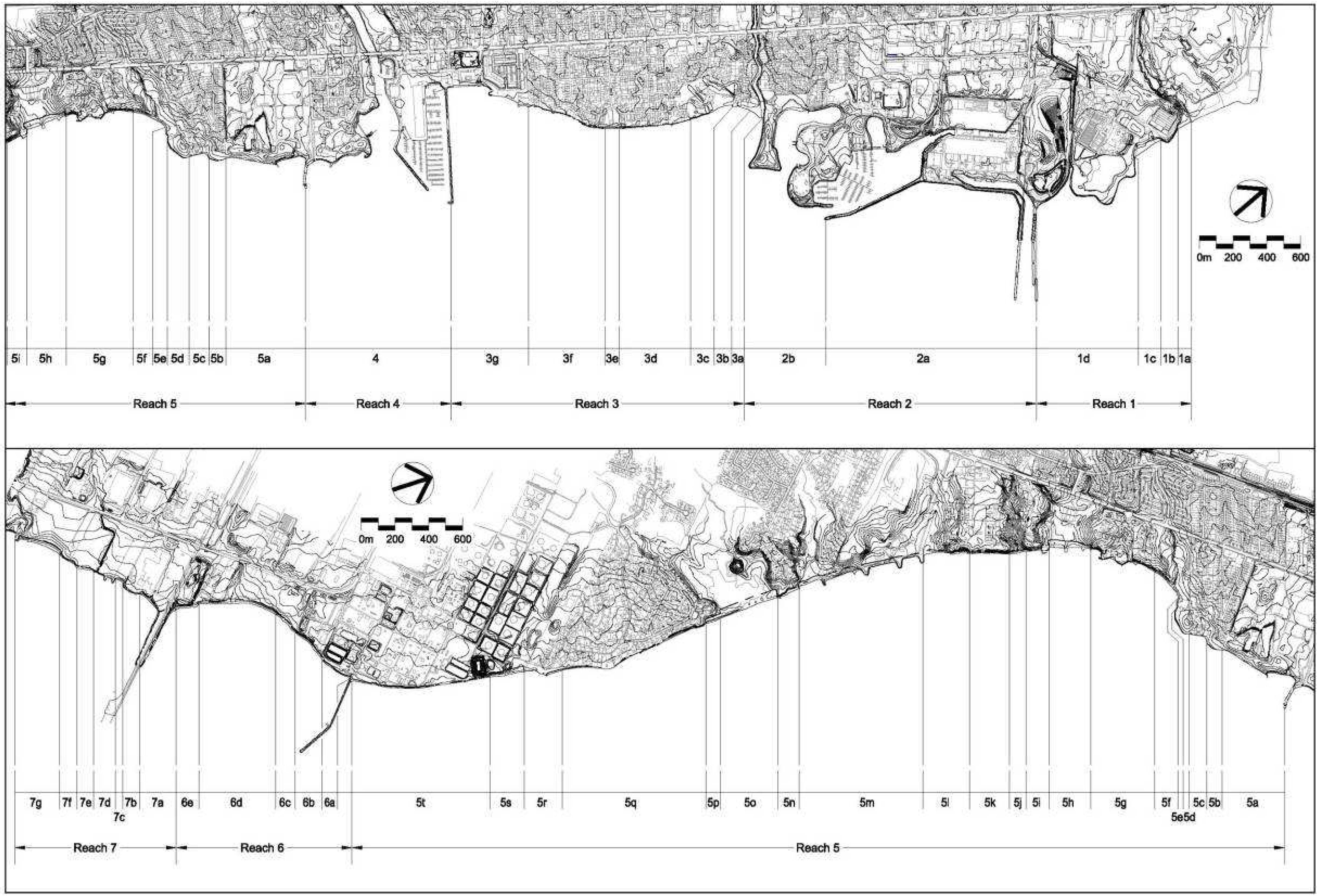


Figure 3.13: Shoreline Reaches and Sub-Reaches

Table 3.11 presents a list and description of the reach attributes that have been considered to date. The reach attribute list includes all of the elements required to construct a crude sediment budget but it is acknowledged that much of the sediment budget data does not exist (such as nearshore deposit volume changes) or must be approximated (such as the comminution loss %). It is anticipated that during the shoreline characterization phase of the LOISS decisions can be made about whether to collect that data or to exclude it from the sediment budget analysis.

It is also not uncommon for sediment budgets to divide the supply into different categories based on their grain size. The list of shoreline reach attributes could be modified to allow sediment size distinctions within the reaches where that is relevant. A possible scenario where this could occur is where contaminants have attached to sub-littoral sediments and the behaviour of the littoral and sub-littoral sediments must be tracked separately.

Table 3.11: Shoreline Reach Attributes

REACH ATTRIBUTE	DESCRIPTION
Reach	reach number
Location description	name of shoreline reach, property or nearby street
Reach length	Reach length in metres measured along the lakeward most contour line from the City of Mississauga 2002 digital mapping (taken from Shoreplan 2005)
Controlling substrate	estimated controlling substrate– the controlling substrate is the underlying material which makes up the main body of the lakebed and tends to control the long-term recession of the shoreline
General shore type	estimated shore type – general description of the shoreline includes protected and artificial shores
Surficial substrate	estimate of material that forms the surficial nearshore substrate
Ownership	estimated ownership
Protection status	estimate % of reach length that is protected
Protection effectiveness	estimated effectiveness of existing structures
Bluff height	estimated erodible bluff height for sediment supply volume
Nearshore depth of closure	depth to which erosion of the nearshore bottom profile occurs
Shoreline erosion rate	long term average annual recession rate used in sediment supply volume calculation
Nearshore downcutting rate	rate of vertical erosion of the nearshore bottom
Erosion supply volume	volume of sediment introduced through shoreline erosion calculated from recession rate, bluff height, protection status and protection effectiveness
Nearshore sediment supply rate	volume of sediment introduced through downcutting of the nearshore lakebed calculated from depth of closure and downcutting rate
Watershed supply rate	volume of fluvial sediment introduced to the nearshore zone
Offshore sediment loss rate	estimated % sediment lost to sinks
Comminution loss percentage	estimated % of littoral sediment lost to comminution of soft grains
Nearshore deposit volume change	changes in the volume of nearshore deposits like bypassing shoals
Net sediment transport direction	positive (left to right when facing offshore), negative or neutral

3.4.5 Conclusions

Wind generated waves and water levels have the greatest effect on coastal processes within the Study Area. Sediment transport is not viewed as a major issue because of the high percentage of shoreline that has been protected and the lack of beaches that rely on an ongoing supply of littoral sediments. However, any significant shoreline development should include a review of the potential impact on sediment transport as even a small amount of sediment moving along this shore can have significant long-term impacts on the function of outfalls, intakes, and other structures like launch ramps and harbour or marina entrances. A comprehensive review of potential impacts may require a sediment budget type approach where all sources and sinks with a littoral cell are considered. The extent to which this type of analysis may be required is related to the size of the proposed development.

3.5 Water Quality

The objective of this section is to review the sources, concentrations and quantities (loadings) and impacts of key water quality parameters discharged into Lake Ontario along the LOISS waterfront. Sources include the Credit River and 13 other watercourses along with the storm sewer network of the City of Mississauga. The Clarkson and Lakeview wastewater treatment plants (WWTP) discharge treated effluent within the LOISS Study Area.

Key parameters are nutrients (phosphorus and nitrogen), suspended solids and metals (copper, lead and zinc). Loadings are developed to gauge their relative contributions to the nearshore environment of Lake Ontario. In this section, “nearshore” refers to that portion of the lake extending from shoreline to approximately 30 metres water depth and generally within several kilometres from shore. The 30-metre contour corresponds to the depth of the thermocline during the summer and fall stratified period.

Once the loadings and sources of pollutants are established, the following questions are envisaged:

- What happens to pollutants discharged in Lake Ontario – how are they dispersed, assimilated, recycled, transported by currents or exchanged with deeper waters?
- What are the health issues of these discharges? These issues include source water protection for the Lakeview and Lorne Park water treatment plants, whose intakes extend 2,000 and 1,230 metres into the lake (at depths of 18 and 10 metres, respectively).
- Is there a relationship between water quality, invasive mussels (Dreissenids), the resurgence of nuisance algae (*Cladophora*), and taste & odour episodes?
- Where is it best to direct efforts to mitigate water quality impacts?
- What are the data gaps and how should they be addressed?

The 14 watercourses draining into Lake Ontario along the LOISS waterfront are listed in Table 3.12 with their catchment areas, listed from west to east and illustrated in Figure 3.14.

Table 3.12: LOISS Watercourses and Catchment Areas Draining into Lake Ontario

Watershed	Watershed area (ha)	Comments
Clearview Creek	134	+ 314 ha in Town of Oakville
Avonhead Creek	166	
Sheridan Creek	1,035	
Turtle Creek	257	
Birchwood Creek	352	
Moore Creek	19	
Lornewood Creek	422	
Tecumseh Creek	330	Incl. Port Credit West (167 ha)
Credit River	100,000	Incl. Port Credit East (97 ha)
Cumberland Creek	205	
Cooksville Creek (incl Cawthra Creek)	3,529	
Serson Creek	235	
Applewood Creek	450	

Within the City of Mississauga, 17 storm sewersheds have been identified with outfalls both into watercourses and directly into Lake Ontario. The sewersheds are listed in Table 3.13 (from west to east).

Table 3.13: City of Mississauga Sewershed and Sewershed Areas Draining into Lake Ontario

Storm Sewershed	Sewershed area (ha)	Storm outfalls direct into Lake Ontario
Clearview Creek	116	
Avonhead Creek	166	
Lakeside Creek	438	8 outfalls into Lake Ontario
Sheridan Creek	774	
Turtle Creek	249	
Birchwood Creek	338	
Moore Creek	22	1 outfall into Lake Ontario
Lornewood Creek	426	3 outfalls into Lake Ontario
Tecumseh Creek	168	
Port Credit West	78	2 outfalls into Lake Ontario
Credit River	11,000	2 outfalls into Lake Ontario
Port Credit East	78	4 outfalls into Lake Ontario
Cumberland	136	4 outfalls into Lake Ontario
Cooksville Creek	3,316	1 outfall into Lake Ontario
Cawthra	202	2 outfalls into Lake Ontario
Serson Creek	245	
Applewood Creek	438	

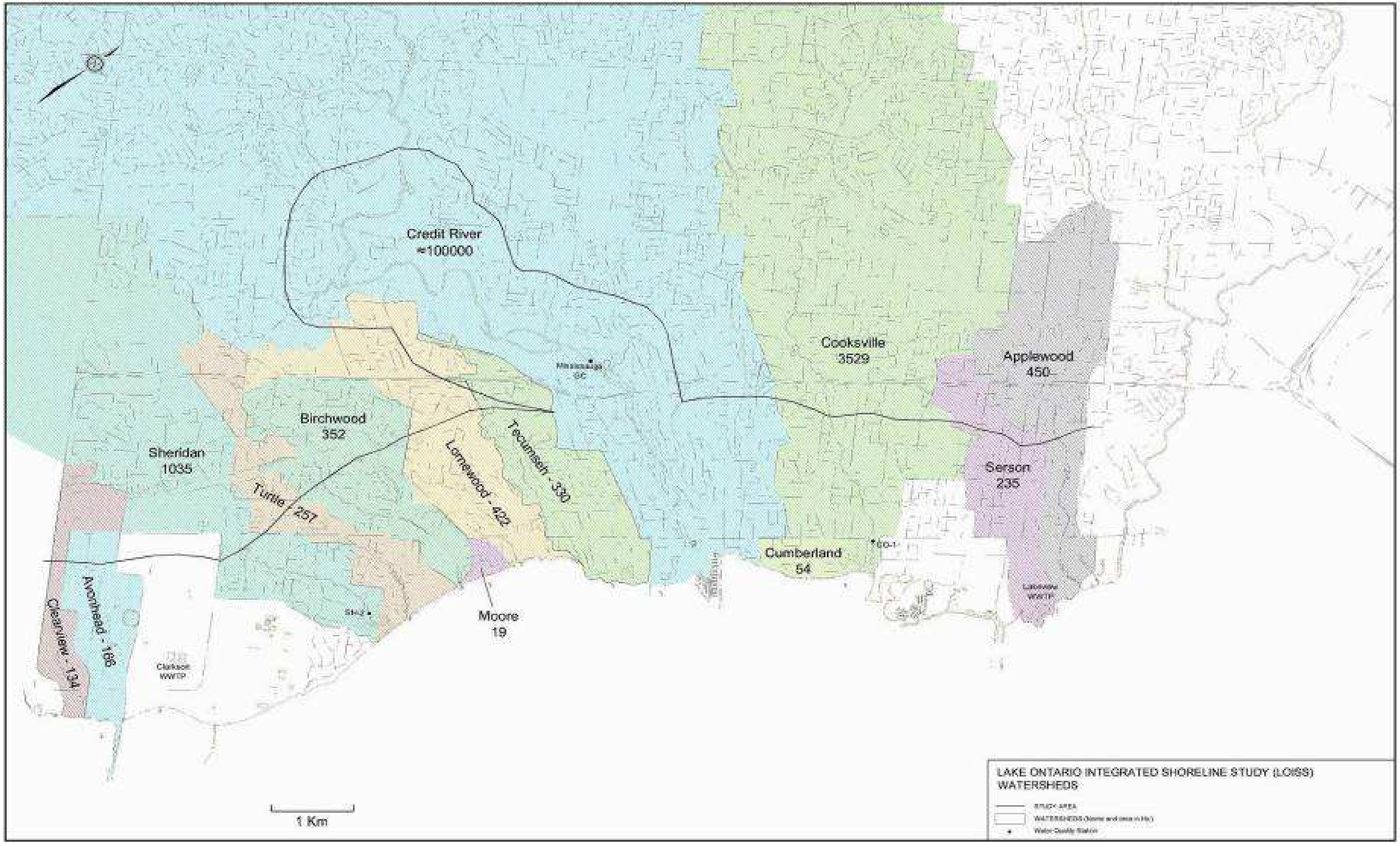


Figure 3.14: Watersheds in the LOISS Study Areas.

3.5.1 Background Information

The available reports and data sources are listed in Table 3.14 including relevant studies extending to the west (Tuck Creek and Sheldon Creeks in Halton) and to the east (Duffins Creek in Ajax). A detailed review of these data sources is presented in **Appendix D**.

Table 3.14: Sources of Information on Water Quality in the LOISS Study Area.

Program	Participants	Date	Available Data
Provincial Water Quality Monitoring Network (PWQMN)	MOE	1964 – present	From MOE (on-line since 2003)
Pollution from Land Use Activities Reference Group (PLUARG)	EPA, EC, MOE,	1972 – 1978	Reports Internet access
Cooksville Creek Subwatershed	CVC	2007-2008	In Preparation
Sheridan Creek Subwatershed Study	CVC	2007-2008	In Preparation
Clean Up Rural Beaches (CURB)	CVC – MOE	1991	NA
State of the Lakes Ecosystem Conference (SOLEC)	EPA, EC, MOE, NYSDEC	1994 – present	Background reports Internet access
Lakewide Management Plan (LaMP)	EPA, EC, MOE, NYSDEC	1987 – present	Reports Internet access
Enhanced Tributary Monitoring Programs (ETMP)	MOE	1982 – present	MOE (by request). Lake Ontario tributaries include Humber and Don Rivers only
Large Volume Sampling of Six Lake Ontario Tributaries	MOE	1999	Appended to Report (internet access)
Surface Water Monitoring and Assessment 1997 Lake Ontario	MOE	1999	MOE
Integrated Water Management Program (IWMP)	CVC	2003	CVC
Ontario Water Works Research Consortium (OWWRC)	Ontario Utilities and MOE	1999 – present	Internet
Effects of Watershed Management within the City of Toronto on the Toronto Waterfront	City of Toronto	2003	City of Toronto
Waterfront Water Quality Response	City of Toronto	2003	Modelling Surface Water Limited
LOSAAC Water Quality Study	Lake Ontario Algae Action Committee (LOSAAC) for Conservation Halton	2005	Aquafor Beech Ltd. Conservation Halton
Modelling and Analysis of Cladophora dynamics and their Relationship to Local Nutrient Sources in a Nearshore Segment of Lake Ontario Generating (OPG)	OPG	2006	U. of Waterloo (Dr. Ralph Smith)

Program	Participants	Date	Available Data
Sediment Quality in Lake Ontario Tributaries: Part One (West of the Bay of Quinte)	EC	2003	EC Environmental health Division
Clearview Creek Subwatershed Study	CVC	2005	McCormick Rankin
Wastewater Treatment Plant Reports	Region of Peel	1998-2008	Region of Peel
Southern Ontario Stream Monitoring and Research Team (SOSMART)	DFO, MNR, MOE, EC, TRCA, CAs, NGO	2005	Wet and dry data from Beth Gilbert (MOE)
Water Quality in Ontario 08	MOE	2009	Internet access
Lake Ontario Collaborative Intake Protection Zome Studies	Stantec	Jan. 2008	Vol. 2: Peel Water Supply System
Nearshore Areas of the Great Lakes 2009	SOLEC	2009	Internet access
Cooperative Monitoring of Lake Ontario in 2008 – The Coast Zone Component	MOE	2009	Town of Ajax – Region of Durham – TRCA
Lake Ontario Collaborative Study - Watershed Loadings	EC and TRCA	2009	Submitted to Journal of Great Lakes Research
Managing Watersheds for Great Lakes: Technical Workshop on Nutrients in the Nearshore	Conservation Ontario and EC	2009	Workshop
Great Lakes Phosphorus Forum	University of Windsor	2009	Workshop Proceedings
Lake Ontario Collaborative Study to Protect Lake Ontario Drinking Water	Status Update	Nov. 2009	Powerpoint Presentation to CTC Source Protection Committee

MOE	Ontario Ministry of the Environment
EC	Environment Canada
CVC	Credit Valley Conservation
EPA	United States Environmental Protection Agency
NYSDEC	New York States Department of Environmental Conservation
OPG	Ontario Power Generating
DFO	Department of Fisheries and Oceans
MNR	Ontario Ministry of Natural Resources
TRCA	Toronto Region Conservation Authority
CA	Conservation Authorities
NGO	Non-Governmental Organizations

As early as the 1970s, the Pollution from Land Use Activities Reference Group (PLUARG) concluded that phosphorus was the most important water quality parameter in Lake Ontario. Phosphorus is the rate-limiting nutrient for the growth of aquatic microorganisms, some of which are beneficial, such as phytoplankton (the basis of the lake food web). Other microorganisms are nuisances, such as the filamentous algae (*Cladophora*) that foul beaches, cyanobacteria blooms (blue-green algae) that affect the taste and odour in drinking water sources. Other effects are more indirect, such as fish kills and a resurgence of Type E botulism in fish-eating birds.

The main sources of phosphorus to Lake Ontario have been mitigated over the past 20+ years as a result of several initiatives:

- With the signing of the 1972 Great Lakes Water Quality Agreement, the U.S. and Canada agreed to reduce phosphorus in WWTP effluents to 1 mg/L for plants discharging more than 1 million gallons per day.
- In 1973, the Canadian government lowered that allowable phosphorus content of detergents to 2.2%.
- The initiation of watershed planning, stormwater management and increased public awareness minimized the water quality impacts from continued development.

These efforts are reflected by the decrease and stabilization of annual mean concentrations of total phosphorus within the main Credit River, based on compilations of the Provincial Water Quality Monitoring Network (PWQMN) from 1965 to 2000, illustrated in Figure 3.15. Total phosphorus (TP) is defined as the sum of all forms of phosphorus in a water sample, including particulate, dissolved, and organic forms). The combined efforts throughout the Lake Ontario basin is reflected in the trend of phosphorus in the offshore waters (i.e. at depths >30 metres) in Lake Ontario (Figure 3.16).

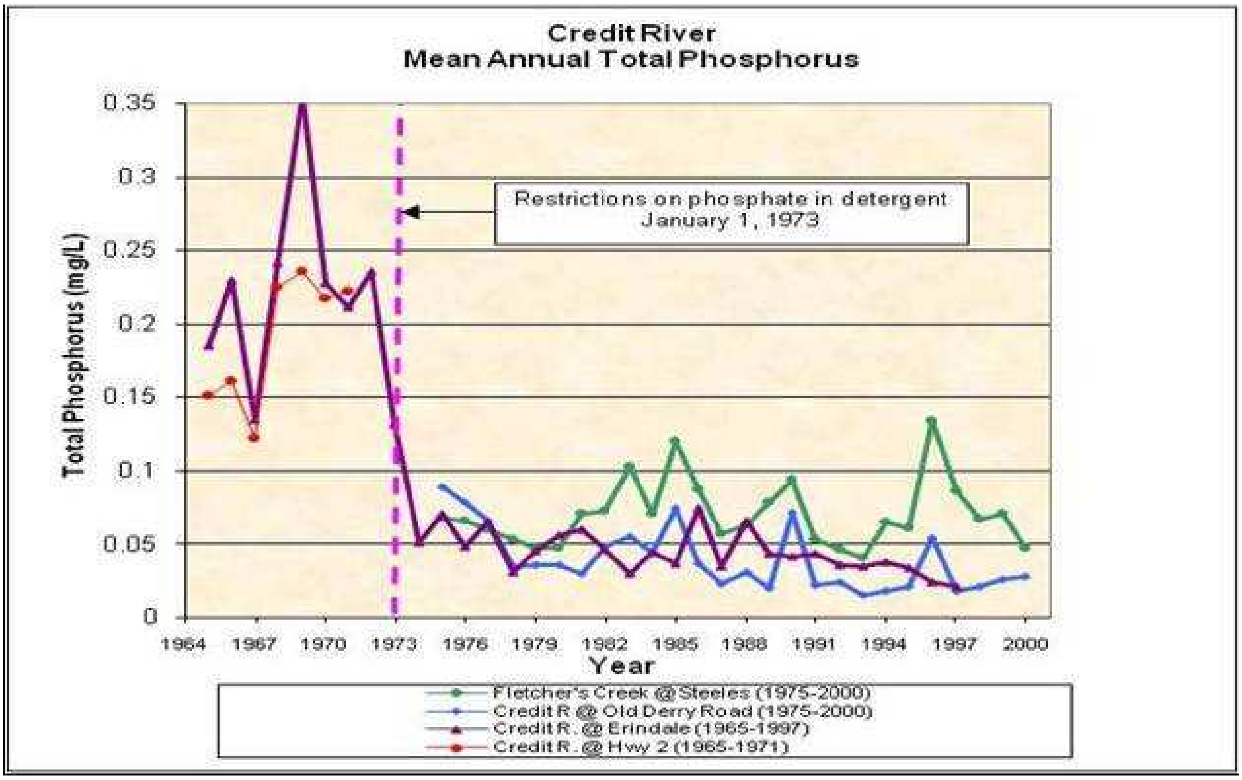


Figure 3.15: Time Trends in mean annual phosphorus in the Credit River and Fletcher's Creek (1964-2000). Date from Ontario Provincial Water Quality Monitoring Network (PWQMN).

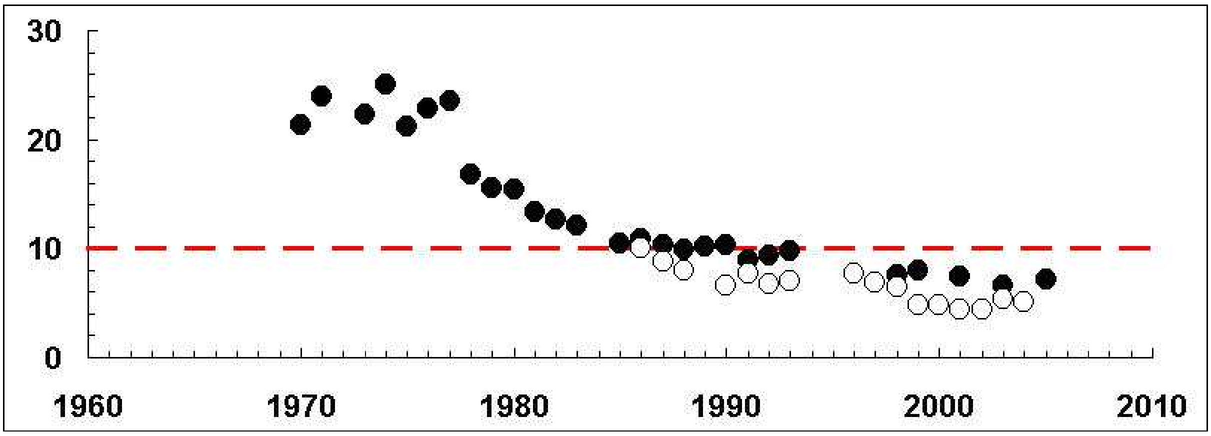


Figure 3.16: Mean spring TP concentrations (µgP/L) for the offshore waters of Lake Ontario. The filled and open circles represent Canadian and U.S. data, respectively. The dashed line represents the target water quality objective of 10 µgP/L. From DePinto, J.V., Lam, D., Auer, M., Burns, N., Chapra, S., Charlton, M., Dolan, D., Kreis, R., Howell, T. & Scavia, D. (2007). Appendix 1 RWG D Technical Subgroup Report Examination of the Status of the Goals of Annex 3 of the Great Lakes Water Quality Agreement. In GLWQA Review Report: Volume 2, pages 373-403).

Paradoxically, while the concentrations of TP in Lake Ontario are at or below the IJC objective of 10 µg/L TP, there has been a resurgence of nuisance algae fouling shorelines. This paradox required a re-examination of the phosphorus cycle in lakes.

Firstly, the downward trend in concentrations of TP in the Credit River does not necessarily reflect the trend in loading to the entire LOISS Study Area (loading being the concentration multiplied by flow volume).

Secondly, the introduction of zebra and quagga mussels (*Dreissenids*) in the Great Lakes in the early 1990s was a major ecosystem disruption that altered the food web and presented a new paradigm phosphorus cycle within the Great Lakes. Whereas TP concentrations are decreasing, it appears that the proportion of dissolved phosphorus may be increasing. The mussels ingest organic and inorganic phosphorus by filter-feeding phytoplankton and fine particulate matter and excrete biologically-available dissolved phosphorus (commonly referred to as Soluble Reactive Phosphorus or SRP). The combination of improved water clarity and abundant SRP favours algae growth.

On a lake-wide perspective, as part of the Ontario Drinking Water Collaborative, a “first-pass” estimate of contaminant loadings for all watercourses along the north shore of Lake Ontario from the Welland Canal to Ajax was developed by Bill Booty at Environment Canada and Gary Bowen (Toronto Region Conservation Authority). The EMCs were derived from PWQMN sources and flows were estimated from Water Services of Canada gauges. The purpose was to identify priority watersheds for more detailed study. The results are summarized in **Figure 3.17** for the portion of Lake Ontario that includes the LOISS Study Area. The Credit River (and Humber) provides the largest loads of TP on the north shore of Lake Ontario, of the order of 50,000 kilograms per year.

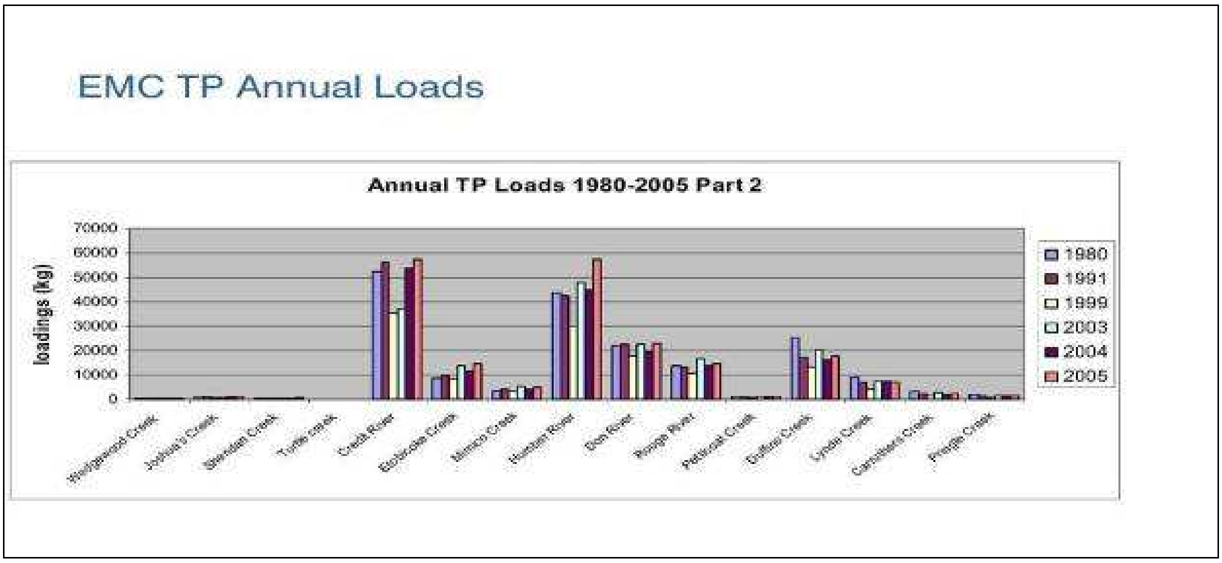


Figure 3.17: Estimated Total Phosphorus Loadings to Lake Ontario from Wedgewood Creek (Region of Halton) to Pringle Creek (Region of Durham). Courtesy of Bill Booty (Environment Canada).

3.5.2 Technical Assessments

As expected, the larger the watershed, the larger the phosphorus loads and thus, the Credit River is one of the largest contributor of total phosphorus (TP) to Lake Ontario. More detailed studies (described below) indicate that average loads are under-estimated, as they fail to account for rarer and severe flow events ("spikes"). Other sources of phosphorus must be accounted for, such as WWTPs and direct discharges from storm sewers.

In the 2005 study for the Lake Ontario Shoreline Algae Action Committee (LOSAAC) for the Region of Halton, Aquafor Beech Limited showed that WWTP effluent loads of TP and ammonia were of the same order of magnitude as wet-weather loadings from streams and are significantly greater than all storm sewer discharges (Figure 3.17).

In the Duffins Creek watershed, the University of Waterloo sought to determine that causes of prolific nuisance algae clogging of the intake for the Pickering Nuclear Generating Station (PNGS). Water quality data from Duffins Creek, WWTP effluents and nearshore locations were analyzed for a range of parameters (nutrients, suspended solids, chloride and chlorophyll). When WWTP plant effluent and storm events are included, the overall load of total phosphorus to Lake Ontario approaches 70,000 kg/year (more than three times greater than the earlier first-pass estimate). More than half of the phosphorus and nitrogen (nitrate and ammonia) comes from the WWTP, whereas more than 80% of suspended sediment inputs to Lake Ontario are from the Duffins Creek itself.

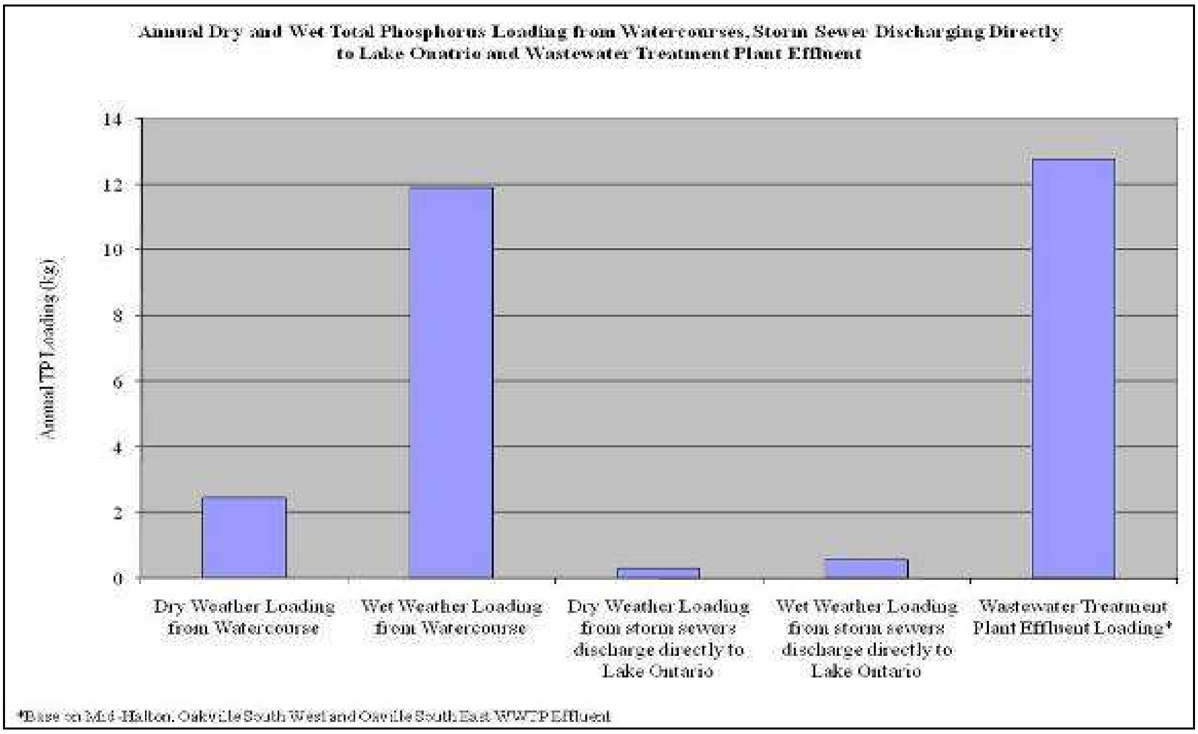


Figure 3.18: Annual TP Loadings from watercourse (Tuck Creek, Sheldon Creek and Bronte Creek) and 3 storm sewers discharging into Lake Ontario. From Aquafor Beech Limited (2005).

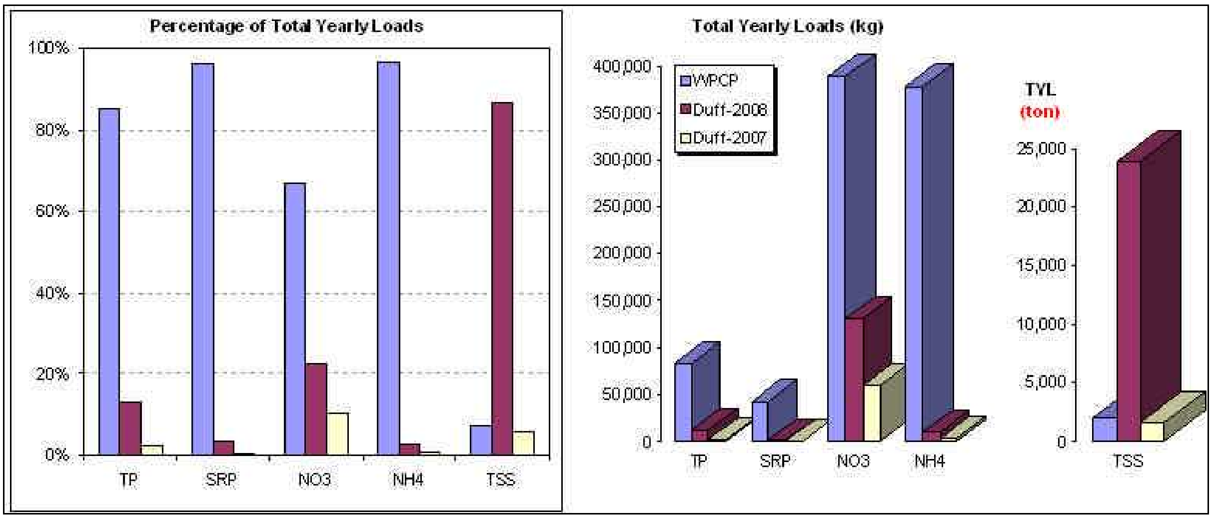


Figure 3.19: Annual Nutrient Loadings to Lake Ontario from Duffins Creek and WWTP for 2007 and 2008 (University of Waterloo 2009)

3.5.3 Lake Hydrodynamics

Lake hydrodynamics govern the fate of pollutants discharged into Lake Ontario from streams and the two WWTPs. Hydrodynamic processes include exchange with deeper water in summer and fall, the seasonal disconnect between nearshore and offshore waters due to the thermal bar, transport by wind-driven along-shore currents and associated down-welling or up-welling episodes. This has consequences when Intake Protection Zones (IPZ) and assumptions as to the source of contaminant plumes (Figure 3.20). In this case, ascribing the ammonia plume to WWTP effluents alone appears to be more justified than the phosphorus plume.

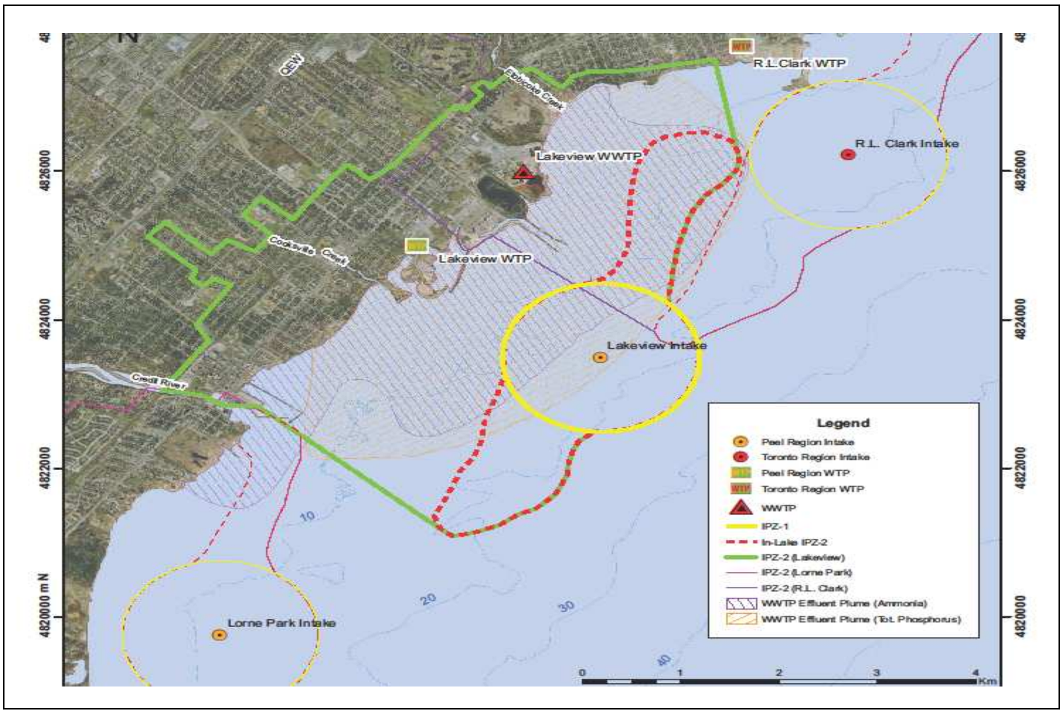


Figure 3.20: Intake Protection Zone (IPZ) for Lakeview and Clark Water Treatment Plants showing WWTP plumes for ammonia and total phosphorus (Lake Ontario Collaborative presentation to CTC Source Water Protection Committee, November 24, 2009).

3.6 Terrestrial Natural Heritage

3.6.1 Introduction

"Natural Heritage" is the sum of the ecological features and functions that exist or are maintained by natural process in a certain area. Natural heritage in this report will refer to the terrestrial and wetland ecosystems, plant and wildlife species, populations and communities, habitats and sustaining environments that are found within the Lake Ontario Integrated Shoreline Strategy area. Aquatic (and benthic) communities are described separately in Section 3.8.

Terrestrial natural heritage features and functions are described at three distinct ecological scales: **species, ecosystem** and **landscape**. The information presented at each scale will form the foundation for future natural heritage system planning and the conservation of the natural heritage within the Study Area.

3.6.2 Background Information

While many surveys and studies have been conducted along isolated sections of the Study Area, a detailed natural heritage assessment of the features and functions it represents has not been previously undertaken. This background report summarizes the existing information on natural heritage currently available for the Study Area, identifies areas of deficiency and makes recommendations to fill knowledge gaps in order to best characterize the shoreline and aid in its management.

Documents reviewed by CVC as background material for the Terrestrial Natural Heritage component of the LOISS are listed in **Appendix E** and cover a range of reports related to floral, faunal and habitat surveys.

3.6.3 Technical Assessments

Landscape Scale

Physiography and climate interact to create the conditions which influence vegetation types and species assemblages. The LOISS Study Area is primarily associated with the Lake Iroquois Plain sub-region of the South Slope physiographic region (Chapman & Putnam, 1984). Considering this, and as well as geology and soil types, the LOISS Study Area can be further characterized into three physiographic units: Sand Plain, Shale Plain and Till Plain (with additional areas of non-natural origin such Lakeside Promenade, JC Saddington, RK Macmillan Park, and a portion of Lakeside Park). The predominant cover is Sand Plain with small pockets of Shale Plain in the western edge of the Study Area along Sheridan Creek, and extending along the Credit River at the QEW. The Till plain is most evident in the western Study Area along Avonhead Creek and Clearview Creek.

The LOISS Study Area falls completely within ecological Site Region 7E, and Site District 7E-4. Site Region 7E is the Lakes Erie-Ontario Site Region, and occupies the southern- most portion of Ontario in what is also termed the Deciduous Forest Region or Carolinian Forest Zone. The region is dominated by deciduous trees species such as Sugar Maple, White Elm, Beech, Black Cherry, White Ash, Red Oak, White Oak, Red Ash, and Butternut (Lee, 1998) with other less common tree species more characteristic of the species found throughout the eastern United States and down into the Carolinas (such as Sassafras and Sycamore). There are a variety of habitat types found within the Study Area including forested vegetation communities, wetlands including coastal wetlands (e.g. Rattray Marsh), and beaches.

Sassafras - *Sassafras albidum*
Sassafras is a small tree that in CVC's jurisdiction reaches it's northern limit in Mississauga.
The leaves can grow in a variety of different shapes, and when crushed smell of spice.

Photo: Scott Sampson, CVC

Witch-hazel – *Hamamelis virginiana*
This large woodland shrub is of limited distribution in the CVC jurisdiction and restricted to the Carolinian forest zone.
Flowers with long, thin, yellow petals open in the fall to add colour to native forests and residential yards where they are often planted as an ornamental.
Photo: Scott Sampson, CVC

The proximity of the area to the Lake Ontario moderates the micro-climate and combined with sandy soils, created favourable conditions for settlement, agriculture and ultimately urban development. Despite the rapid pace of development in the Study Area and the relatively low natural cover, urban areas such as this are capable of supporting a wide range of biodiversity.

Ecosystem Scale
Natural land uses cover only 22.7% of the LOISS area. Of the entire area, terrestrial (forest/forest related) cover only amounts to 8.7%. What forest habitat exists is often small in size, fragmented and isolated from one another. Interior forest conditions do not appear to be frequent in the Study Area, and those that may exist based on size parameters may be impacted by trails, human disturbance, and past encroachment.

Pine, and Oak-Pine forests used to cover approximately 29% of the LOISS area (based on 1806 surveyor notes – see Appendix E). Today, not much remains; although the oak forest community in the vicinity of Moore Creek (shown here) and scattered veteran pines growing atop the Credit River valley slopes speak to a once more common presence.
Photo: Paul Tripodo, CVC

Successional communities reflect the stage of natural succession from field (i.e., cultural meadow) to sparse forest (i.e., cultural woodland). These communities are important sources of food and shelter for wildlife. 11.4% of the Study Area is in a stage of succession. The most dominant type of successional community is the cultural meadow, reflecting a landscape that has experienced abandonment of farmland in the relatively recent past, or as is the case in many commercial/industrial/employment zones, results when sites left vacant or fallow during the development process.

Present mapping indicates that wetland ecosystems amount to less than 1% of the Study Area. Wetlands provide important ecological goods and services on many levels and support the health of the many watersheds that make up the LOISS area.

Marshes, like these cattail (*Typha* sp.) communities in the Credit River north of Port Credit (Mississauga) provide important habitat for many species of wildlife that depend on wetlands. Habitat loss, invasive species, pollution and climate change are among the many threats that impact these rare ecosystems.
Photo: Paul Tripodo, CVC

Unique to the shores of the Great Lakes and their tributaries, Coastal Wetlands are ecosystems whose hydrology and ecology are dictated in part by the dynamics of the lake water levels. This is especially true at Rattray Marsh, where small changes in lake water levels, storm and wave action, have a profound effect on the connection between Sheridan Creek and Lake Ontario.

Shoreline and riparian areas encompass the interface between open water aquatic and terrestrial habitats. It is a vital ecological and hydrological link between the water and the land. Typically these areas support diverse plant and animal species, and allow for the movement and cycling of organisms, nutrients, and energy. It is also the area where humans (and their activities) can have a great impact.

Natural stretches of beach can be found along the Lake Ontario shoreline especially in public parks but several sections of waterfront are natural within privately owned property (residential or industrial areas).

Natural shorelines, like the one pictured in the photo above, account for only approximately 16% of the shoreline in the LOISS Study Area.
Unlike hardened and non-natural substrates (middle photo), natural shorelines allow for easier species movement and the cycling of nutrients and energy between aquatic and terrestrial communities.
The beach bar ecosystem at Rattray Marsh Conservation Area (pictured on top and below) sustains the last remaining large shoreline marsh between Burlington and Toronto (Ecologistics, 1979).

Photos:
Top – Jon Clayton, CVC
Middle – Paul Tripodo, CVC
Bottom – Shoreplan Engineering Ltd., 2005

Significant Habitat and Special Features

A total of eight Environmentally Significant Areas (ESAs) are found in the Study Area as well as seven Life Science ANSIs, one Earth Science ANSI, and four evaluated wetlands. Finally, the City of Mississauga has identified 41 sites under their Natural Areas Survey within the Study Area boundary. Areas identified as part of the Natural Areas System are subject to periodic updates (every four years) that include a site visit component and floral and faunal inventories where reasons (such as adjacent development) and landowner permission permits. A full listing and discussion on natural areas and special features is provided in **Appendix E**.

The Lake Ontario shoreline area is expected to support habitat that has the potential to meet several Significant Woodland and Significant Wildlife Habitat criteria within the Region of Peel (see: North-South Environmental et al., 2009). Of particular note, the area is expected to be of high importance for migration stopover and staging habitat for species of bats, butterflies, landbirds, waterfowl and shorebirds. Each of these groups of species may require specific habitat types close to the shore to rest and feed before or after their flights over large bodies of water including the Great Lakes. In urban areas, high quality habitat supporting abundant food resources for migrant species if often limited and in these cases the protection, restoration and stewardship of natural areas and natural features becomes increasingly important. These and several other Significant Wildlife Habitat criteria are described more in **Appendix E**. Only partial records of potential SWH have begun to be collected to-date. Field surveys are required to locate potential SWH, especially those of rare species. An analysis of potential SWH in the Study Area based on these criteria will be presented in a future phase of this report.

Lake Ontario presents a significant obstacle to some migratory species, like the Monarch butterfly (*Danaus plexippus*) – a species of special concern nationally and provincially.
Conserving and restoring natural habitat along the shoreline and enhancing areas where they may collect, feed and rest will help ensure that the urban matrix is more permeable to wildlife movement.
Photo: Victoria MacPhail, CVC

Species Scale

Flora

The most comprehensive survey of plants in the Lake Ontario shoreline area occurs as part of the

Mississauga Natural Areas Survey (NAS). Compared to other areas in the Credit River watershed, these areas have had relatively good botanical coverage since the NAS began surveying in 1996. No new site level botanical reconnaissance was conducted by the CVC as part of this study.

Based on the review of existing records, a total of 838 plant species have been recorded for the area (both current and historical records), of which the CVC has identified 18 Tier 1 species (Species of Conservation Concern), 247 Tier 2 species (Species of Interest) and 117 Tier 3 (Species of Urban Interest). These species and the Conservation of Concern project methodology are described in greater detail in **Appendix E**.

Fauna

Records of wildlife within the LOISS Study Area are limited, and have often been gathered incidentally rather than by directed surveys. Based on a review of the existing records, 46 Tier 1 species (Species of Conservation Concern), 82 Tier 2 species (Species of Interest) and 72 Tier 3 (Species of Urban Interest) currently or historically have used the LOISS Study Area for a part of their life cycle. These records are described in more detail in **Appendix E**.

Amphibians

The review of existing information and new (2009) amphibian surveys indicate that the LOISS Study Area appears to harbour 12 amphibian species (including historic and current observations), described in greater detail in **Appendix E**. It is possible that some of these species no longer occur in the area, or if present occur in higher abundances than indicated since amphibian studies are time/weather dependent. For amphibian surveys conducted in 2009, noise was a particular issue with all the sites in the LOISS Study Area. Proximity to major and minor roads, as well as proximity to the shoreline (wave action) contributed a great deal of background noise that made listening for amphibian calls difficult. Results from this survey suggest that wetlands, long-lasting vernal pools and other suitable habitat are lacking and the diversity and abundance of amphibian species in the LOISS area is low.

Yellow-spotted Salamander – *Ambystoma maculatum*
With current observations for only two sites within the LOISS Study Area, the yellow-spotted salamander is not a common species. The lack of other salamander observations in the LOISS Study Area may speak to the scarcity of suitable habitat (i.e.: undisturbed forests containing or near vernal pools) across the landscape.
Photo: Charlotte Cox, CVC

Green Frog – *Rana clamitans*
Amphibians are considerably sensitive to ecological stressors and the quality of the environment around them. Since they are often in contact with water, pollution and alterations to the hydrologic cycle can have significant impacts on their population size and health. Some amphibians are more resilient than others when faced with urban stresses. American Toads, Green Frogs (pictured here) and Northern Leopard Frogs can often persist where in disturbed or mildly impaired habitat.
Photo: Victoria MacPhail, CVC

Birds
Bird data was collected mostly through Breeding Bird Surveys completed by the Mississauga Natural Areas Survey; however, incidental observations from other field work endeavours contributed to bird species lists as well. Records of winter sightings of birds were also gathered in Rattray Marsh. Shoreline habitats are important to a number of different classes of birds including landbirds, shorebirds, and waterfowl. In total 214 bird species have been recorded here, though some of these records are historic. This information is described in greater detail in **Appendix E**.

The areas to the west of Port Credit as far as the mouth of the Niagara River on the south shore, and bounded on the west by Burlington Bar has been identifies as a globally Important Bird Area, primarily due to the concentrations of waterfowl particularly during the late winter and spring. Additional research is required within the Study Area to determine the significance of the shoreline as stopover habitat for various guilds including waterfowl; shorebirds; and, landbirds.

Hairy Woodpecker – *Picoides villosus*
A fairly common site in Ontario forests throughout the year, the hairy woodpecker is often a visitor in urban parks and backyard feeders. By excavating cavities in trees it's actions can also create necessary nesting, denning and storage space for other species of birds and mammals (Bavrlic, 2007)
The Hairy Woodpecker is a CVC Species of Urban Interest, since the loss of suitable forest habitat through urban development is a concern.
Photo: Dewitp, Wikipedia.org

Wetland habitats such as marshes are important sources of food shelter for many species of waterfowl and shorebirds.
Some species of waterfowl are present year round (i.e.: Mallard Duck) and others appear only during the migration and/or overwintering period, such as the common Goldeneye (*Bucephala clangula*) pictured here.
Natural areas in general along the shoreline of Lake Ontario play an important role by providing stopover and staging habitat for migrating species of birds that will make use of the area before or after their long flights over (or around) the lake.
Photo: Jon Clayton, CVC

Mammals
There has been no comprehensive study of mammal species within the Study Area. However, various reports and incidental records have helped to generate a list of 30 mammal species that use the LOISS Study Area for a portion of their lifecycle. These records are discussed in **Appendix E**.

The data suggest that common species of mammals are generalist species without strict habitat requirements and able to exploit urban environments. Examples of common mammals within the study are white-tailed deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*) and eastern Gray Squirrel (*Sciurus carolinensis*). Surprisingly, some not so common species such as Red Squirrel (*Tamiasciurus hudsonicus*) and Eastern Chipmunk (*Tamias striatus*) indicate that there are still some larger habitat patches supporting area-sensitive species.

American Mink (*Mustela vison*) have large home ranges and make use of both terrestrial and wetland communities. They rely on undisturbed shoreline areas for denning (OMNR, 2002) and are often sensitive to human disturbance and development.

Riparian areas along Lake Ontario, the Credit River and other creeks allow for the movement of these species and their ability to find adequate food and shelter.

Photo: http://toronto-wildlife.com

Reptiles

Similarly to mammals, no comprehensive study of reptiles has been undertaken within the Study Area. Data has been gathered from incidental reports and observations from many sources. A list of 13 reptile species using the LOISS Study Area for a portion of their lifecycle is recorded in Appendix E.

Snakes and turtles often fare poorly in urban environments, where loss of habitat and conflict with humans is high. Some species, such as the Eastern Gartersnake (*Thamnophis sirtalis sirtalis*) continue to persist in urban environments making use of marginal habitats, riparian areas and woodlands to find the necessary resources to survive.

3.6.4 Conclusions

A number of data gaps or opportunities for future work were identified through this background study, specifically:

- A landscape scale analysis will be conducted for the Study Area that will involve the identification and description of potential core areas, supporting areas and corridors. Micro and macro corridors will be mapped and assessed. As part of the landscape scale analysis, specific restoration opportunities will be identified which will require ground-truthing.

- Land use mapping will continue throughout the watershed based on ELC definitions and CVC's urban land use classification system to accurately characterize the land use of this highly urbanized Study Area. Small natural features that could potentially serve as habitat or corridors within the urban matrix should be identified.

- Detailed mapping of shoreline/nearshore vegetation is not complete, although coarse scale mapping was completed in 2009 (Natural Resource Solutions Inc., 2009). This would be beneficial to identify areas of wildlife habitat and to inform future development of shoreline and riverine areas.

- Any unevaluated wetlands identified through surveys or mapping should be evaluated.

- Terrestrial and wetland communities will be assessed to determine their relative significance in the watershed with regard to several standard parameters (for example: significant wildlife habitat, community rarity or presence of rare species, old-growth forests etc.).

- Species abundances and species of concern locations should be mapped and documented.

- Currently information provided by the Mississauga NAS and other incidental reports do not have this level of information or accuracy. This information will in many cases be necessary to evaluate against thresholds for Significant Wildlife Habitat criteria.

- Data to accurately and consistently identify Significant Wildlife Habitat across the Study Area is limited. Studies documenting the following parameters should be undertaken:
    - Migratory Waterfowl staging/stopover areas
    - Migratory Shorebird stopover monitoring
    - Migrant Landbird stopover monitoring
    - Migratory bat stopover monitoring
    - Butterfly and Odonate monitoring should be continued [long-term]
    - Turtle surveys should be undertaken on the Credit River, creek mouths and Rattray Marsh to update species at risk records and verify the presence of turtle species in the lakeshore area.

- Amphibian monitoring should continue in order to assess population changes over time.

- Surveying and monitoring for invasive species along the shoreline and Credit River should be undertaken to control pioneer populations of priority species.

- Restoration opportunities on-the-ground should be identified through field visits and site walks along the shoreline and the various riparian areas. Invasive species locations should be mapped for potential removal and monitoring; pollution or disturbance hot-spots identified and actions prioritized.

3.7 Hydrogeology

3.7.1 Introduction

Groundwater flow systems are largely controlled by topographic relief and the permeability of the subsurface geologic materials. The primary ground water function within the Lake Ontario Integrated Shoreline Strategy (LOISS) Study Area is assumed to be of support to surface water features and aquatic habitat, and contributions to stream baseflow in particular. Groundwater discharge to streams helps to maintain flow even during prolonged dry periods, and thereby contributes to aquatic habitat. As groundwater is generally of better quality than surface runoff, and is also a more consistent temperature, groundwater also adds to the overall quality of stream flow.

Considering the factors that govern groundwater flow and discharge to surface water features, there would appear to be a potential for groundwater discharge to streams to occur across much of the LOISS Study Area. There would likely be two different settings within the Study Area where significant groundwater discharge to surface water features could occur: to streams that overlay the glaciolacustrine sand deposit associated with the historical Lake Iroquois shoreline; and to the main Credit River where it intersects the Acton-Mississauga buried bedrock valley feature in the northern portion of the Study Area. These conditions are further described in the sections below.

3.7.2 Background Information

This background report summarizes the existing information on hydrogeology currently available for the Study Area, identifies areas of deficiency and makes recommendations to fill knowledge gaps in order to best characterize the Study Area and aid in its management.

Documents reviewed by CVC as background material for the Hydrogeology component of the LOISS are listed in **Appendix F** and cover a range of reports related to water budget, groundwater resources, and characterization reports.

3.7.3 Technical Assessments

Water Well Records

Figure 3.22 presents the locations of MOE Water Well Records and CVC groundwater monitoring wells within the Study Area and surrounding area up to Highway 403. CVC installed several monitoring wells for the Cooksville and Sheridan studies, although only one well in each of the subwatersheds is located within the Study Area. The CVC monitoring wells installed within the Study Area generally confirm the mapping of bedrock and overburden units presented in Figures 3.23 and 3.28, respectively.

As discussed later in this section, bedrock is at or near ground surface across much of the Study Area, and therefore MOE water well records for bedrock wells are more common within the Study Area. Overburden wells may be more prevalent where the Iroquois glaciolacustrine sand deposit is present, and where the Acton-Mississauga buried bedrock valley is interpreted to be present.

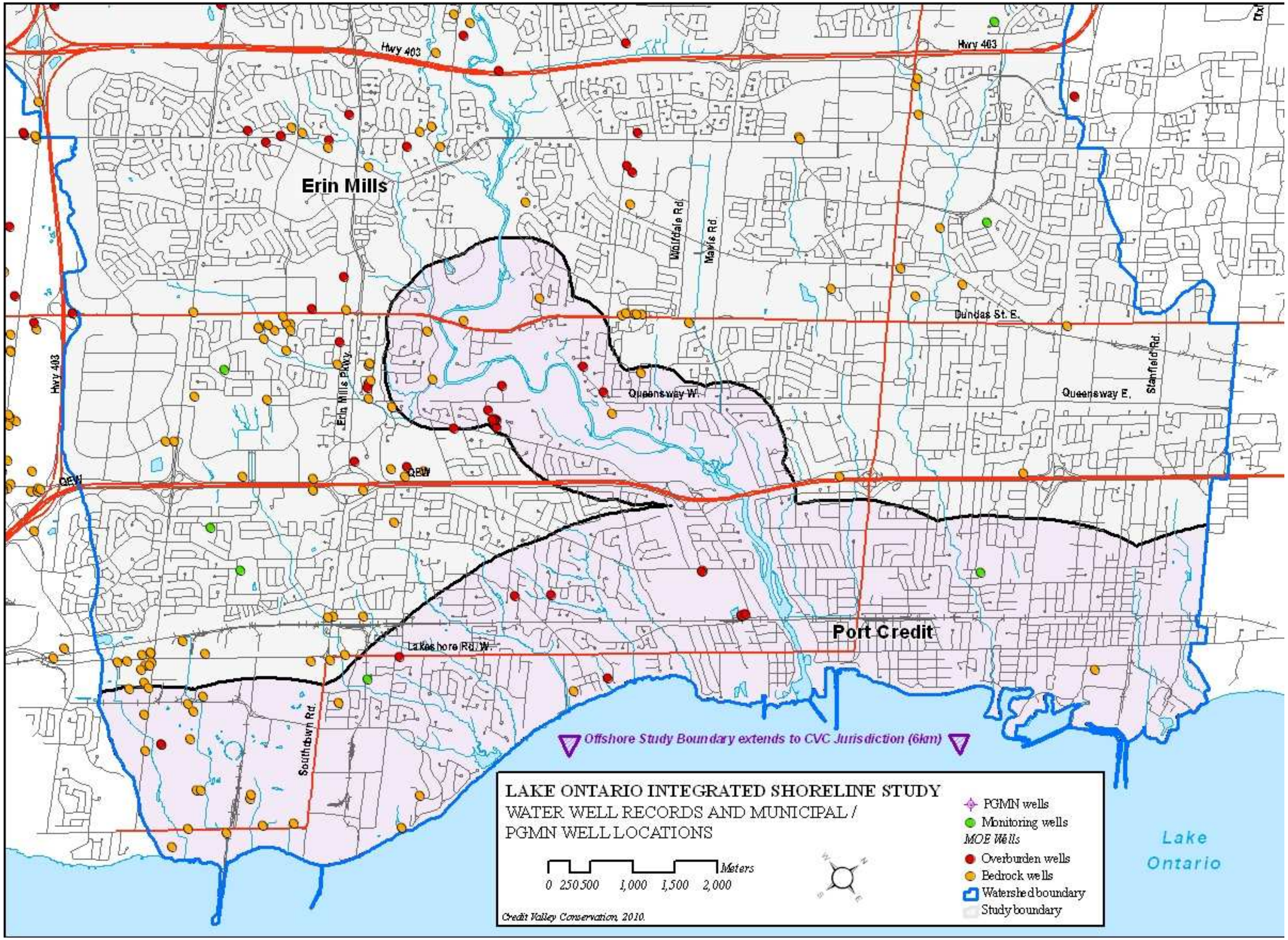


Figure 3.21: Water Well Records and Municipal PGMN Well Locations

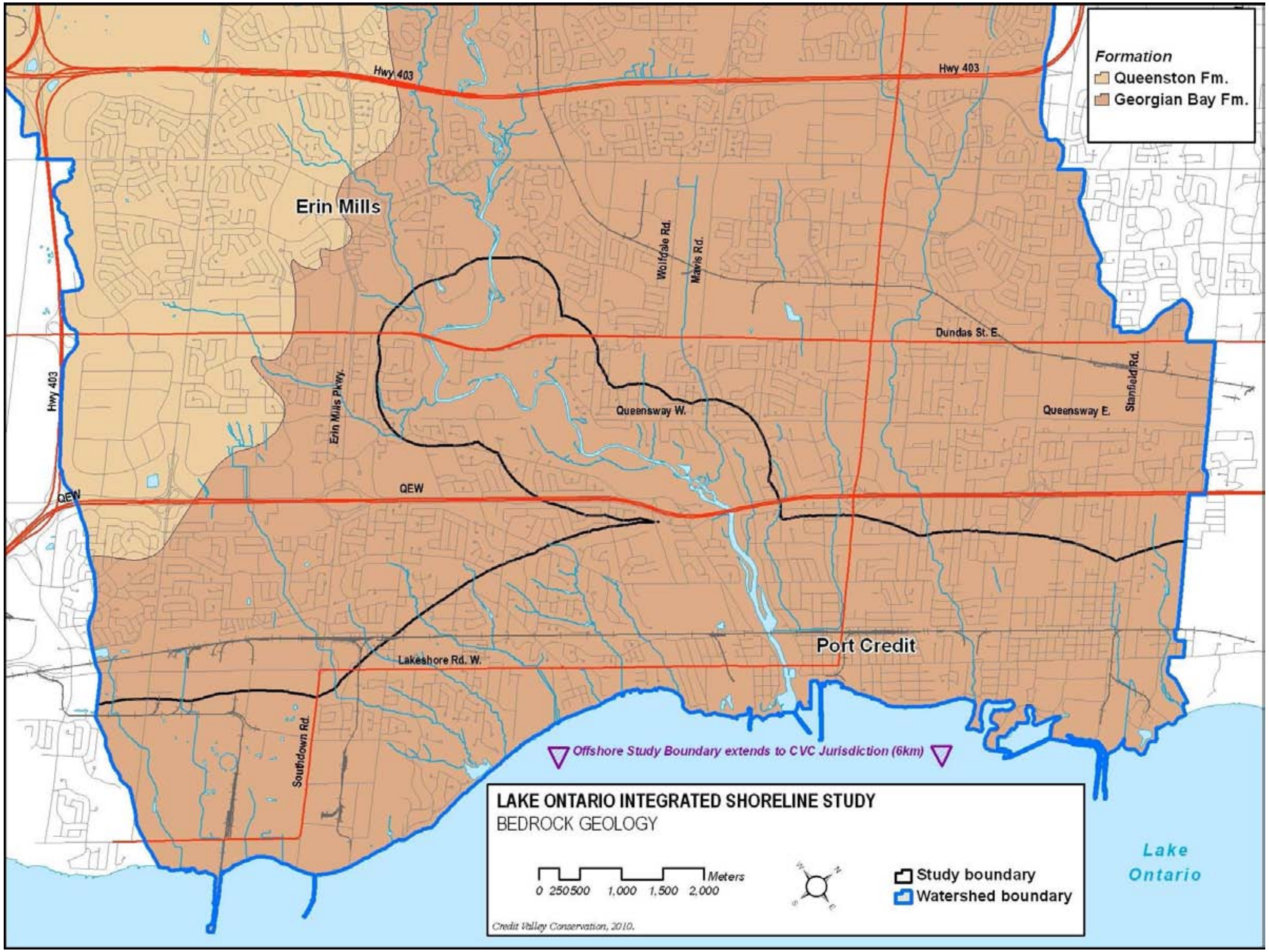


Figure 3.22: Bedrock Geology

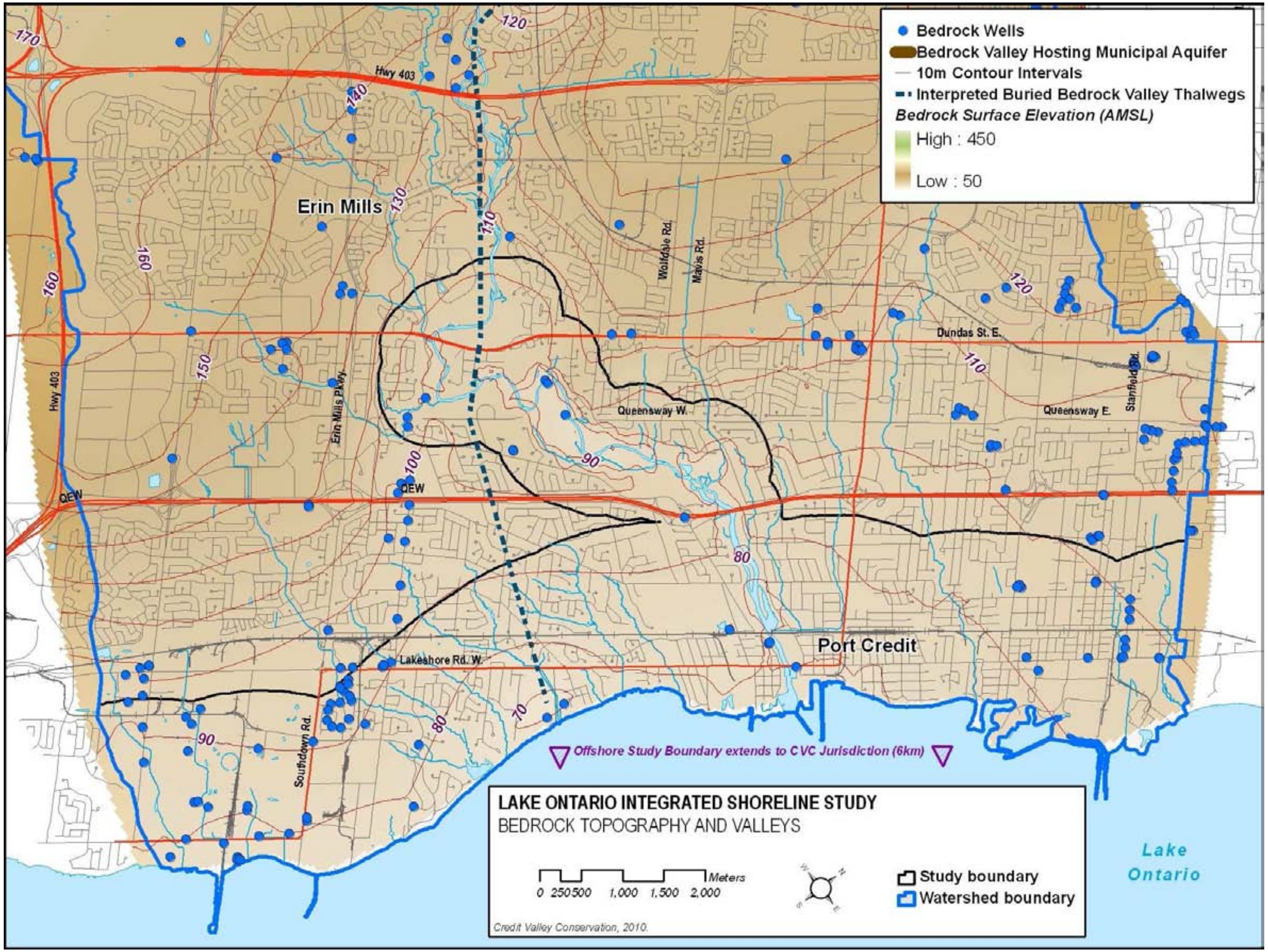


Figure 3.23: Bedrock Topography and Valleys

Geology

Figure 3.23 is taken from the *Integrated Water Budget Report—Tier 2, Credit Valley Source Protection Area"*, by AquaResource Inc., (April 2009), and presents the bedrock geology in the vicinity of the Study Area. The bedrock mapping indicates that the two uppermost bedrock formations in the vicinity of the Study Area are the Queenston and Georgian Bay Shale Formations. The Georgian Bay Formation underlies the entire Study Area, while the Queenston Formation underlies the area to the northwest of the Study Area, overlying the Georgian Bay Formation.

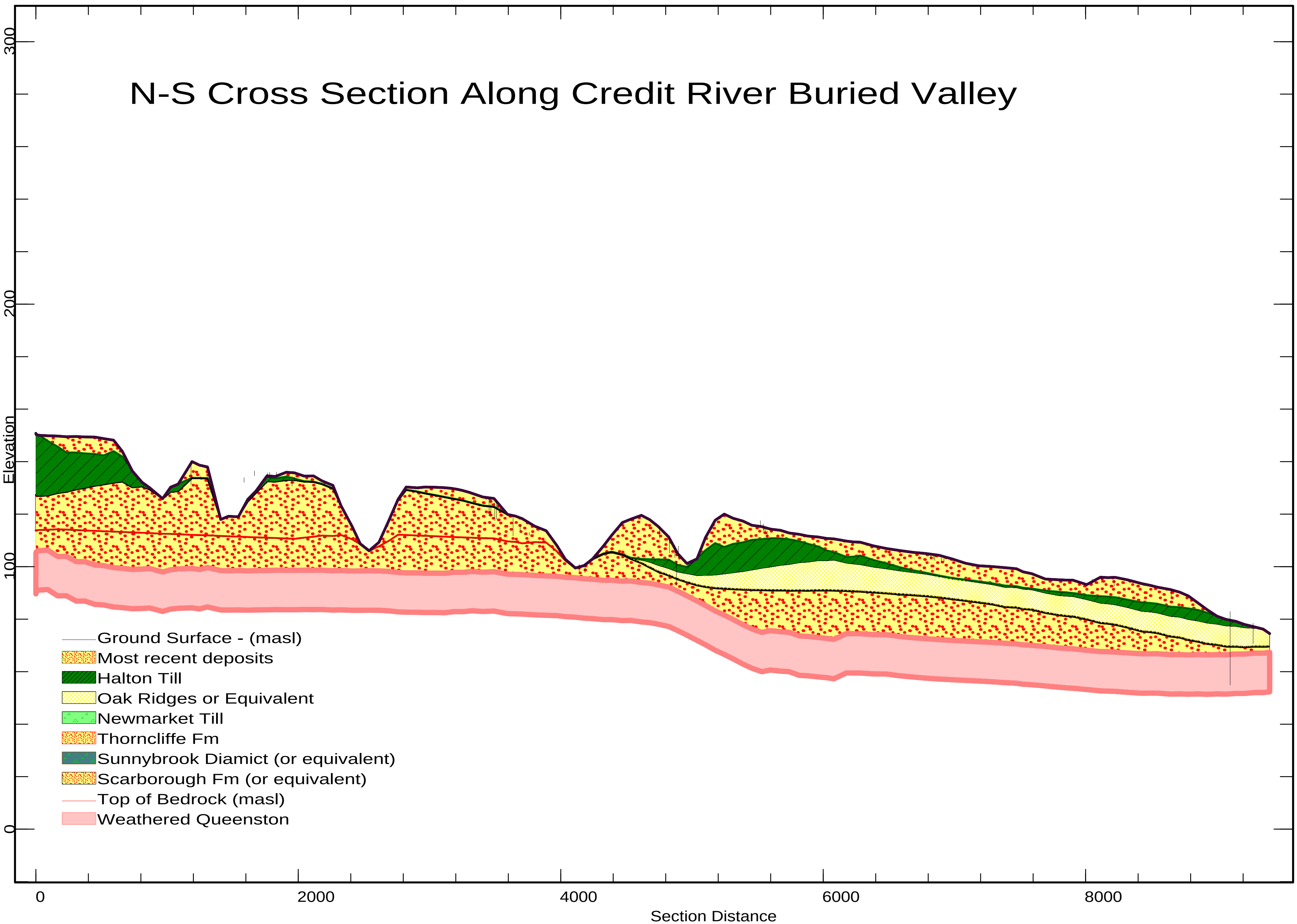
Figure 3.24 is taken from the *Integrated Water Budget Report* and presents the bedrock topography in the vicinity of the Study Area. Figure 3.24 also shows the interpreted location of the Acton-Mississauga buried bedrock valley that trends from north to south through the Study Area, generally following the path of the present Credit River through the northern half of the Study Area, and then occurring to the west of the Credit River closer to Lake Ontario. Review of Figure 3.24 indicates that the bedrock surface tends to slope downward from the northwest towards the interpreted buried bedrock valley, and that the direction of slope of the bedrock surface to the east of the interpreted buried bedrock valley is generally north to south.

Both the *Integrated Water Budget Report* and the *Groundwater Resources of the Credit River Watershed* (Davies Holysh study 2007) presented similar interpretations of the origin and infill material for the buried bedrock valley; however, due to the low number of water well records across the Study Area and in the vicinity of the buried bedrock valley, there is considerable uncertainty in terms of the precise location, alignment, depth, and infill material of the buried bedrock valley. Better understanding of the properties of the buried bedrock valley would require field investigation and detailed review of site-specific consultants reports for other projects (e.g., municipal infrastructure).

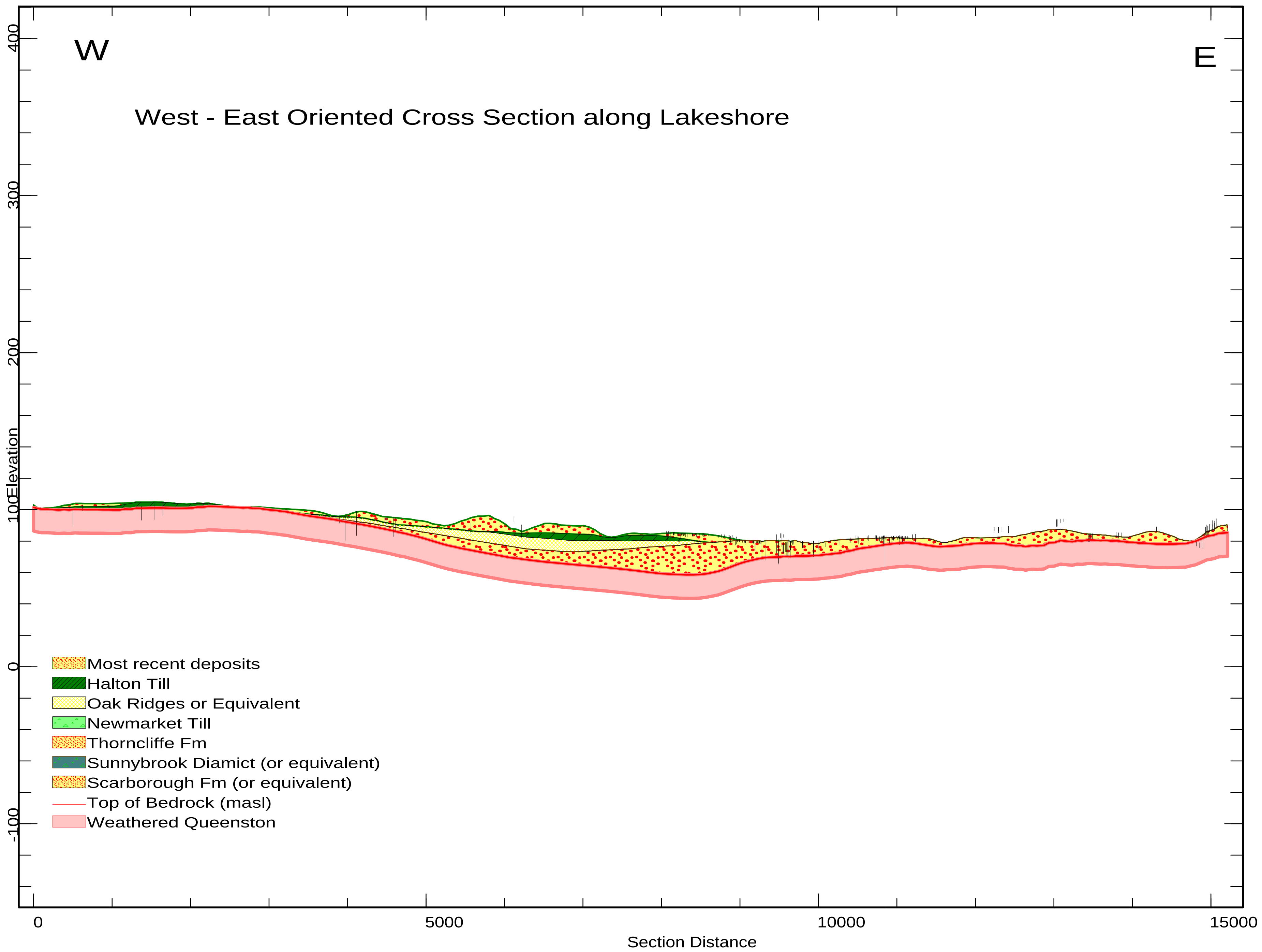
Figure 3.25 presents the locations of two interpreted geological cross-sections through the Study Area that were prepared by a consultant using the geological information contained in the YPDT database. Figure 3.26 shows the north-south cross-section that generally follows the alignment of the buried bedrock valley, and Figure 3.27 shows the west-east cross-section that approximately follows Lakeshore Blvd through the Study Area. Both cross-sections show that the depth of overburden within the Study Area, and in the vicinity of the buried bedrock valley in particular, is up to 50 metres. The cross-sections show that the buried bedrock valley is interpreted to be infilled by overburden materials, and these units are further described below. Further investigation of the exact nature of the valley infill deposits would be required to determine whether the valley deposits convey significant amounts of groundwater flow.

Figure 3.28 is taken from the *Integrated Water Budget Report* and presents the Surficial Geology in the vicinity of the Study Area. Review of Figure 3.28 indicates that there are three prevalent surficial geological units in the vicinity of the Study Area: bedrock or bedrock drift; Halton Till; and glaciolacustrine sand.

Cross Section Location Map



N-S Cross Section Along Credit River Buried Valley
300
200
100
0
Elevation
0
2000
4000
6000
8000
Section Distance
Ground Surface - (masl)
Most recent deposits
Halton Till
Oak Ridges or Equivalent
Newmarket Till
Thorncliffe Fm
Sunnybrook Diamict (or equivalent)
Scarborough Fm (or equivalent)
Top of Bedrock (masl)
Weathered Queenston


W
E
West - East Oriented Cross Section along Lakeshore
400
300
200
100
0
-100
Elevation
0
5000
10000
15000
Section Distance
Most recent deposits
Halton Till
Oak Ridges or Equivalent
Newmarket Till
Thorncliffe Fm
Sunnybrook Diamict (or equivalent)
Scarborough Fm (or equivalent)
Top of Bedrock (masl)
Weathered Queenston

The buried bedrock valleys within the Credit River watershed are infilled by different sediments that occur below the surficial overburden deposits described above. The three principal deeper overburden deposits that may occur within the Study Area and vicinity are:

- Oak Ridges Moraine (or equivalent) Deposits;
- Thornecliffe Formation Deposits; and
- Sunnybrook Drift and Scarborough Formation Deposits.

Additional detail regarding the geology of the Study Area is found in **Appendix F**.

Groundwater Levels

Figure 3.29 is taken from the *Integrated Water Budget Report* and presents the deep groundwater surface for the Study Area and vicinity. Review of Figure 3.29 indicates that there are relatively few MOE water well records for wells deeper than 25 m in the Study Area and vicinity, and therefore the deep groundwater level surface presented on Figure 3.29 should be considered to be only an approximation of the actual deep groundwater level surface in the vicinity of the Study Area. Additional refinement required to make the deep groundwater level surface more representative of local conditions would need to include a search for additional sources of deep groundwater level measurements and extending the groundwater level contours to the shoreline.

Review of the deep groundwater level surface contours on Figure 3.29 indicates that the highest deep groundwater levels occur to the northwest of the Study Area, where Highway 403 turns to the south and also intersects the western boundary of the Credit River watershed. Deep groundwater levels are up to 180 m AMSL to the northwest of the Study Area, but are somewhat lower (150 m AMSL) to the northeast of the Study Area. Deep groundwater surface contours indicate that deep groundwater flow is generally towards the interpreted buried bedrock valley that runs from north to south through the Study Area. South of Dundas Street the deep groundwater surface contours generally suggest that deep groundwater flow is from north to south towards the Lake Ontario shoreline.

Review of Figure 3.3, which is taken from the *Integrated Water Budget Report*, indicates that there are more MOE water well records for wells less than 25 m depth in and around the Study Area than there are well records for wells with depth greater than 25 m; however, much of the Study Area does not have any MOE water well records. The shallow groundwater level surface was generated using data from across the watershed, and therefore may not represent actual conditions at the local scale. Additional refinement required to make the shallow groundwater level surface more representative of local conditions would need to include a search for additional sources of shallow groundwater level measurements and extending the groundwater level contours to the shoreline.

Similar to the deeper groundwater surface contours shown on Figure 3.29, the highest shallow groundwater levels are found to the northwest of the Study Area, and the overall direction of shallow groundwater flow appears to be towards the interpreted buried bedrock valley and towards the Lake Ontario shoreline.

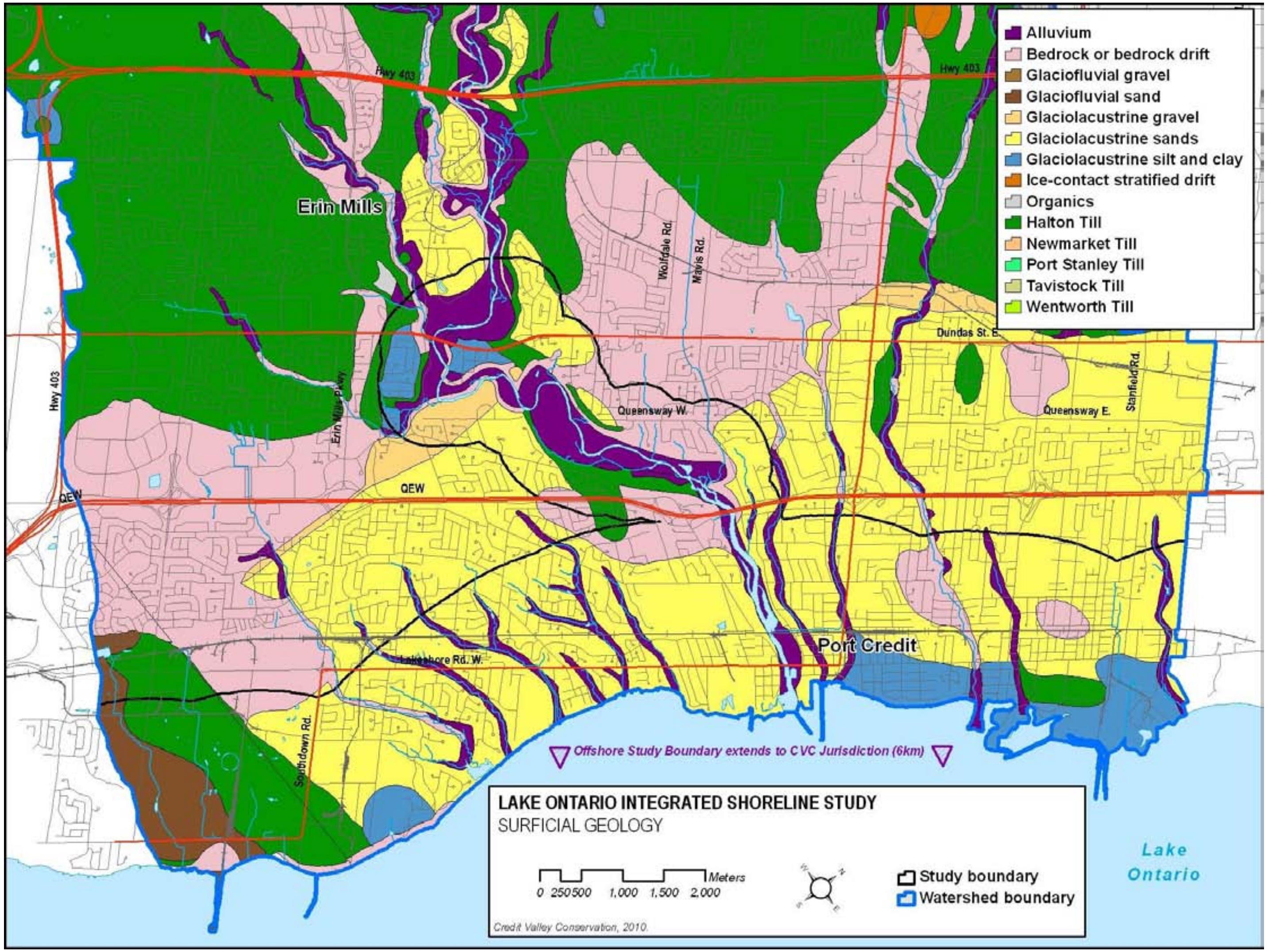


Figure 3.27: Surficial Geology

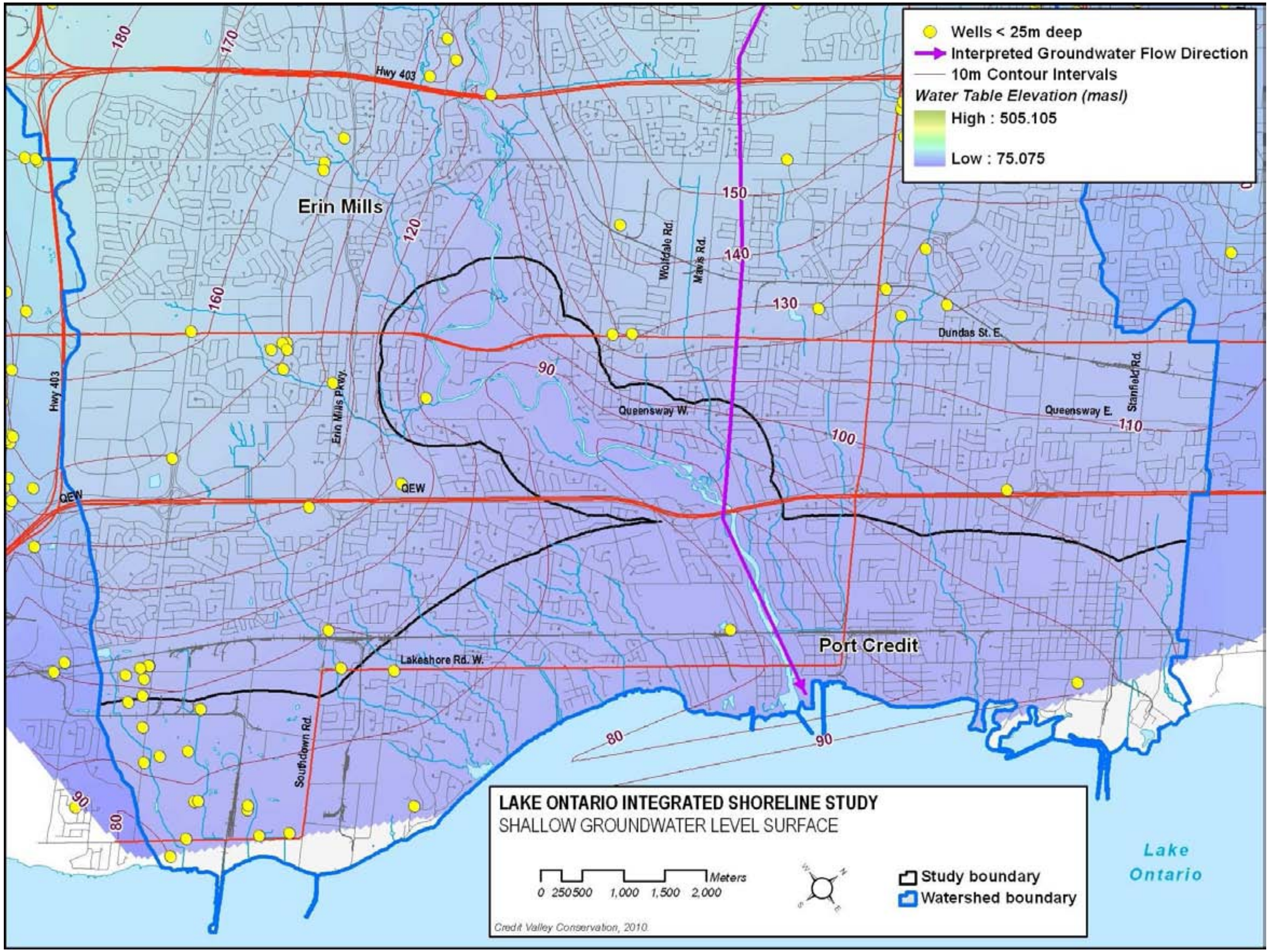


Figure 3.28 Shallow Water Level Surface

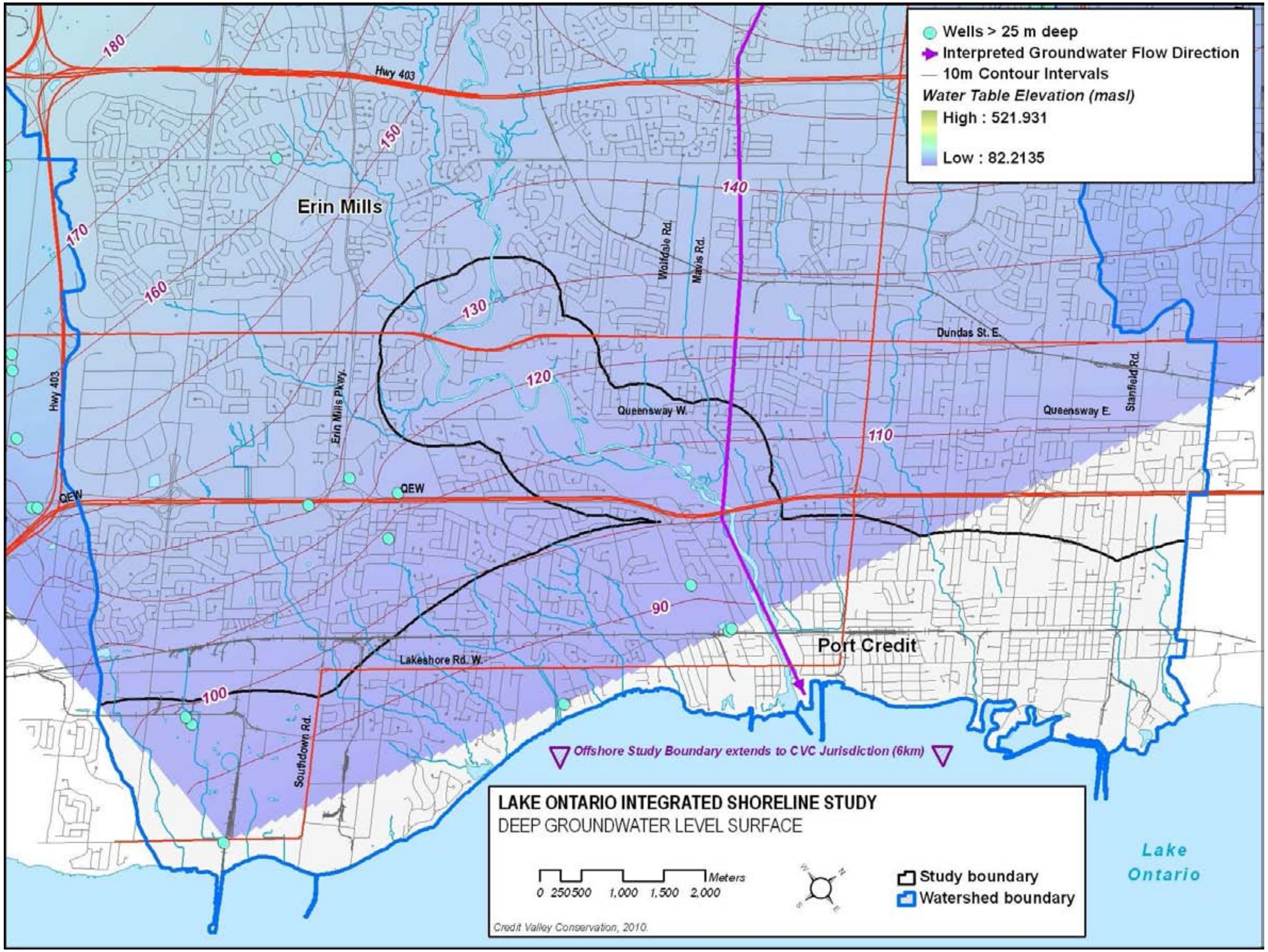


Figure 3.29: Deep Groundwater Level Surface

Water Takings
Figure 3.31 is taken from the *Tier 2 Report* and presents the locations of the long term Permits to Take Water (PTTWs) within and near the Study Area. Both of the PTTWs shown on Figure 3.31 are for surface water takings from the main Credit River for the purposes of golf course irrigation. There are no known long-term groundwater takings within or near the Study Area; however, it is likely that short-term groundwater takings for construction dewatering will occur from time to time in the Study Area.

Groundwater Recharge
Figure 3.32 is taken from the *Integrated Water Budget Report* and presents the estimated recharge rate in the vicinity of the Study Area. Groundwater recharge is the portion of precipitation that infiltrates to the groundwater system. Review of the recharge rates indicates that the recharge rates across most of the Study Area is in the range of 25 to 150 mm/year, with a zone of higher recharge rate along the northern boundary of the Study Area. North of the Study Area, the estimated recharge rate is lower, which is in part due to the presence of the lower permeability Halton Till at surface. The Iroquois glaciolacustrine sand and the upper weathered Georgian Bay Formation shale are more permeable than the clay-rich Halton Till, which contributes to the higher estimated recharge rate across much of the Study Area.

Groundwater Discharge
Baseflow in streams is generated by groundwater discharge and anthropogenic inputs (e.g., foundation drain discharges, leaking buried servicing). Groundwater discharge to streams occurs when the water table intersects the stream, and where upward vertical hydraulic gradients occur (indicating the potential for an upward flux of groundwater). Another important factor in determining the potential for groundwater discharge to streams is the permeability of the stream bed, which typically reflects the surface, or near surface, geological medium. High permeability material, such as sand and gravel, would allow for greater groundwater discharge to streams, while less permeable material, such as clay or competent bedrock, would allow for much less groundwater discharge, even in locations where upward vertical hydraulic gradients were present.

Both the *Integrated Water Budget Report* and the Davies and Holysh report (2007) indicate that upward vertical hydraulic gradients occur in the lower watershed, with Davies and Holysh also noting that vertical hydraulic gradients are predominantly upward within the Acton-Mississauga buried bedrock valley close to Lake Ontario. Therefore, vertical hydraulic gradients that are supportive of groundwater discharge to streams occur within the vicinity of the Study Area, and in areas where the streams are underlain by moderately to high permeability material, some significant groundwater discharge would be expected. Review of the surficial geology in the Study Area presented on Figure 3.28 indicates that the prevalent glaciolacustrine sand would be sufficiently permeable to allow significant groundwater discharge to streams, while the upper fractured Georgian Bay Formation shale could also allow groundwater discharge to occur. Lesser amounts of groundwater discharge would be expected in areas where the Halton Till or other fine grained deposits are present near ground surface.

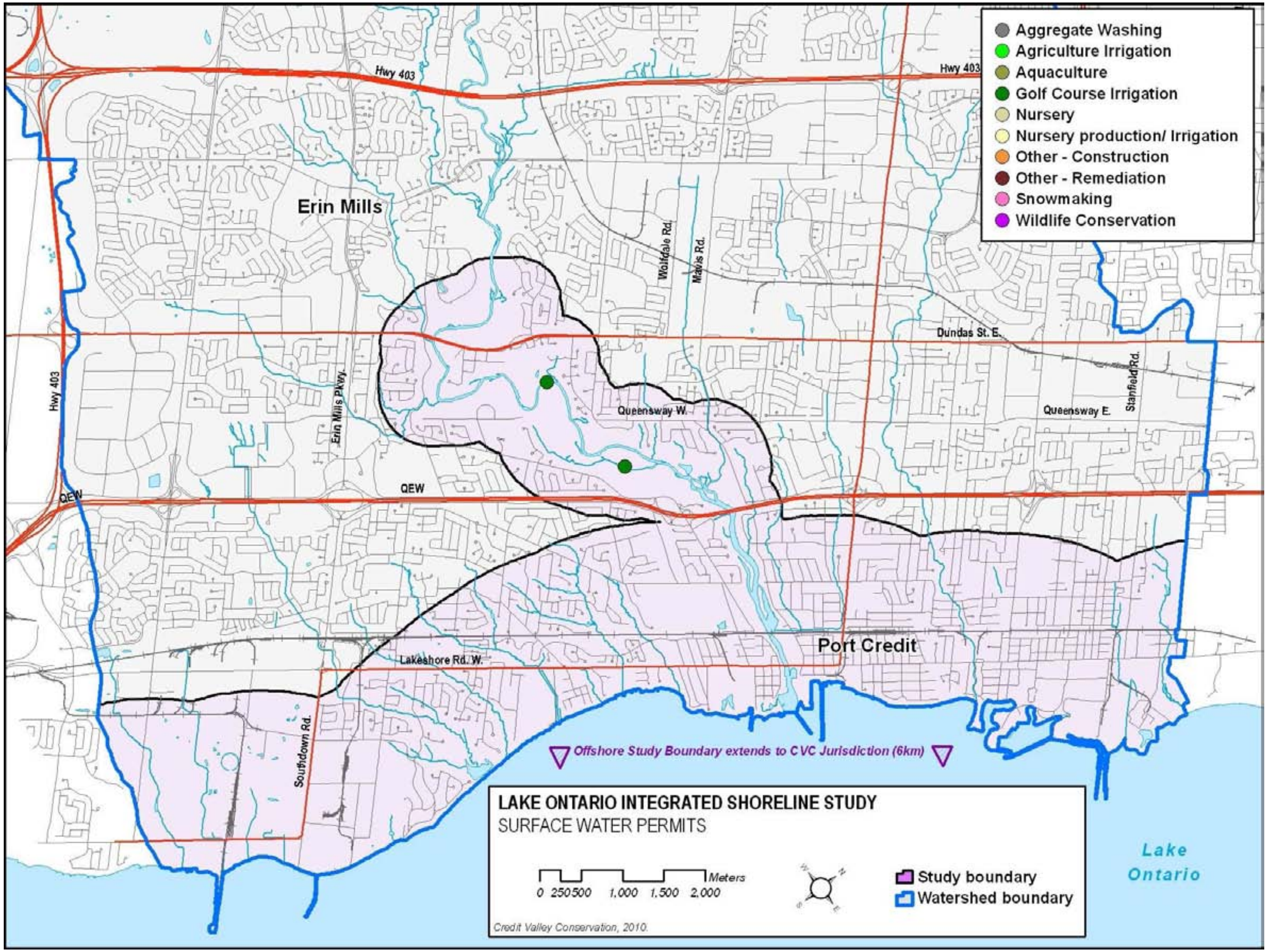


Figure 3.30: Surface Water Permits

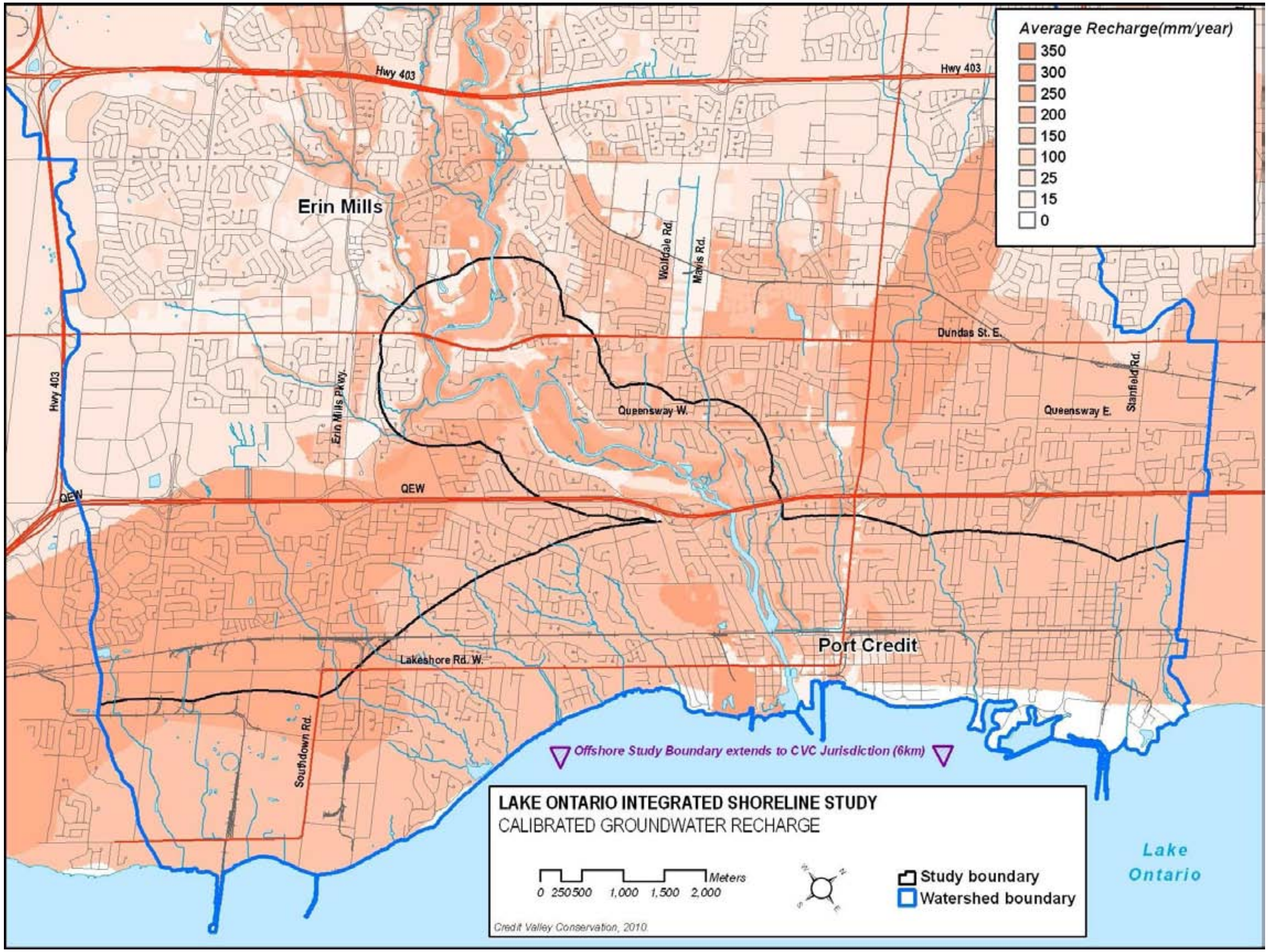


Figure 3.31: Calibrated Groundwater Recharge

Baseflow measurements collected in support of the LOISS and Cooksville and Sheridan Creek studies appear to confirm that groundwater discharge to streams is occurring within the Study Area. While some discharge was observed from sewer outfalls even after several days without precipitation, these contributions were estimated to be minimal relative to the overall baseflow in Cooksville and Sheridan Creeks at the time that the flow measurements were collected. Therefore, it is expected that groundwater discharge comprised most of the observed baseflow at that time.

Baseflow measurements were also collected from a number of the other streams in the Study Area in support of the Fluvial Geomorphology section (Table 3.5) of this report. While these measurements were collected at a single point along each stream, and there were no observations of potential discharge from sewer outfalls provided, it is possible that the majority of the measured flow represents groundwater discharge to the streams. The *Integrated Water Budget Report* estimates total groundwater discharge to streams and wetlands in the Lake Ontario tributary catchments (excluding the Credit River) to be approximately 10,000 m^3/day (115 L/s), which is about half of the measured stream flows described above.

The rates of groundwater discharge to streams in the Study Area as predicted by the *Integrated Water Budget Report* are presented on Figure 3.33. Review of Figure 3.33 indicates that rates of groundwater discharge to streams were generally in the range of 1L/s per kilometer of stream length, which would be equivalent to approximately 2 to 3 L/s for most of the streams. The modeled rate of groundwater discharge from the *Integrated Water Budget Report* is therefore an order of magnitude less than the measured baseflows described above.

The calibrated groundwater model results for discharge to streams described in the *Integrated Water Budget Report* may be less than the measured baseflows; however, for a groundwater model that was intended for analysis at the watershed and subwatershed scale, and considering the lack of an extensive database of hydrogeological and flow data for the Lake Ontario tributary catchments, the model-estimated groundwater discharge is a reasonable match to the measured flows. Also, the groundwater flow model discharges are intended to represent average annual conditions, which may not have been accurately captured by the baseflow measurements collected to date.

CVC's calibrated groundwater model estimates that there is about 17,000 m^3/day of direct groundwater discharge to the lake. Based on the comparison of the model-estimated stream baseflows to measured flows, it is reasonable to expect the model estimates of direct groundwater discharge to the lake to be accurate to the correct order of magnitude. Presently CVC does not monitor direct groundwater discharge to the lake, and it likely would be difficult to measure in the field. It may be possible to verify the presence of groundwater discharge to the lake that was previously identified by other means, such as by the presence of a certain type of aquatic habitat or by a water temperature survey that could show the difference between lake temperature and the temperature of direct groundwater discharge.

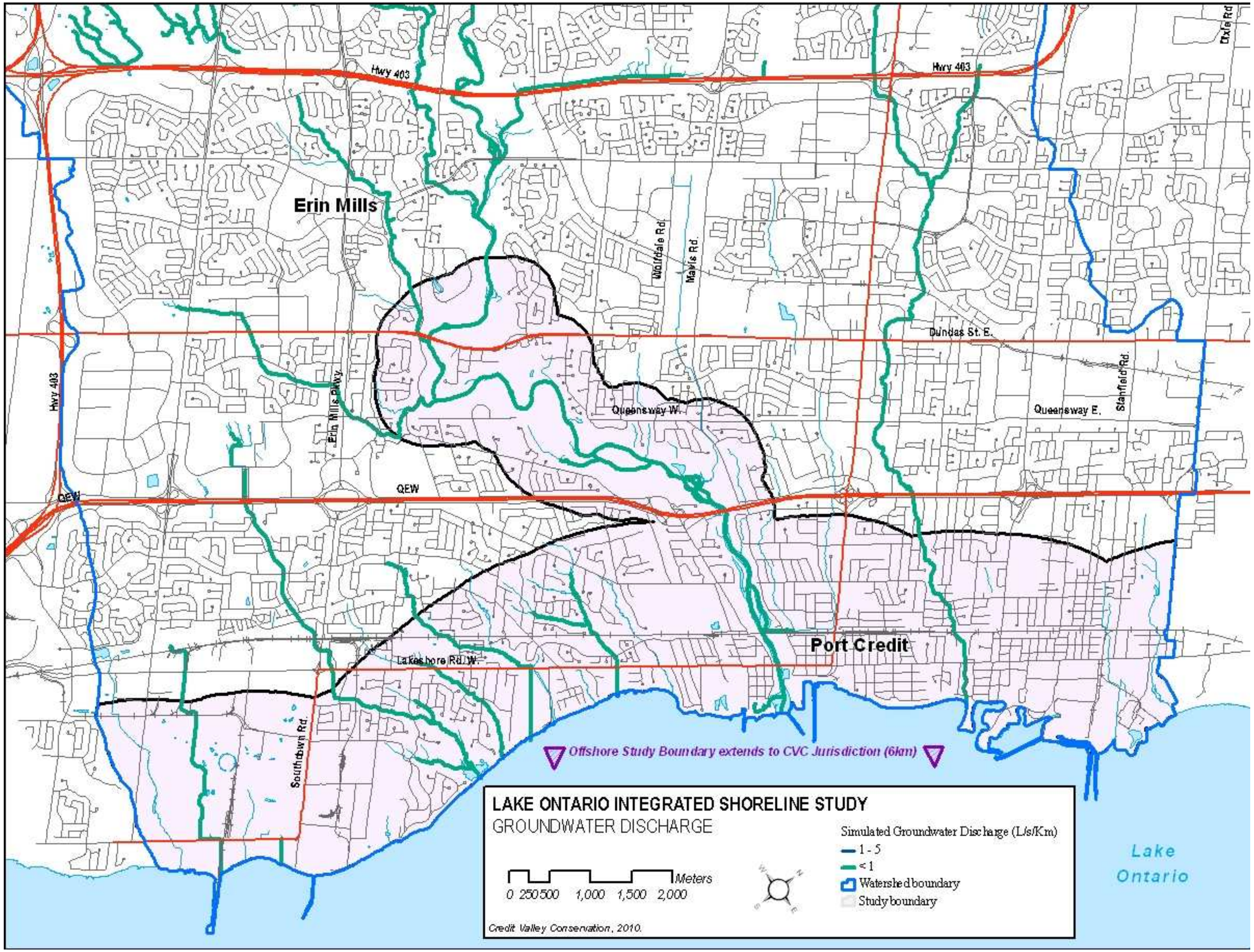


Figure 3.32: Groundwater Discharge

Groundwater Quality
CVC does not have long term groundwater quality monitoring data for the vicinity of the Study Area; however, the monitoring wells installed in the Cooksville and Sheridan Creek subwatersheds were sampled for general water quality parameters shortly after installation. The Cooksville and Sheridan monitoring well samples did not indicate any anthropogenic groundwater quality impacts; however, the ambient water quality is influenced by the composition of the overburden and bedrock units in which they are completed.

It is expected that there may be at least localized impacts to groundwater quality from urbanization, spills, etc. (historical and/or recent). A search for property-specific environmental assessment reports for the Cooksville and Sheridan studies discovered that there is a large database of reports, some of which could indicate historical or existing contamination of soil or groundwater.

3.7.4 Conclusions

The primary ground water function within the Study Area appears to be support of surface water features and aquatic habitat, and contributions to stream baseflow in particular, through groundwater discharge. Baseflow measurements suggest that groundwater discharge supports baseflow in streams across the Study Area. Additional baseflow measurements should be collected to confirm the groundwater contributions to baseflow and to improve our understanding of where the discharge occurs within the Study Area.

A preliminary assessment of groundwater quality information does not indicate any significant impacts; however, urbanization may have caused localized impacts that would only be discoverable through an extensive review of environmental assessment reports within the Study Area.

3.8 Aquatic Natural Heritage

3.8.1 Introduction

“Natural Heritage” is the sum of the ecological features and functions that exist or that are maintained by natural process in a certain area. The definition is often variable depending on the scope of the question and whether or not there are planning implications associated with it; often ecologists and planners have differing views of what the boundaries are to natural heritage features and functions. Aquatic natural heritage in this report refers to fish and benthic invertebrate species, populations and communities, and their habitats and sustaining environments. In this section only the aquatic features will be examined; terrestrial communities are described separately in Section 3.6.

The objective of this component of the study is to identify and characterize the aquatic habitat, fish and invertebrate communities throughout the Study Area. The sensitivity of the fishery, including habitat requirements, needs to be understood to prevent any degradation as stipulated by the Federal Fisheries Act and supported by MNR and CVC policy. Hydrological linkages associated with land use change upstream of and within the Study Area, infrastructure/servicing (water and sewage) or other stressors (e.g. barriers) on fish and other aquatic biota also need to be documented to predict potential impacts based on future scenarios and planning applications. Similarly, mitigation and restoration of aquatic habitat can be better implemented at the landscape, reach, and site levels, and fish and invertebrate community monitoring will confirm any long term trends in the health of the LOISS Study Area.

3.8.2 Background Information

A number of reports including subwatershed studies, environmental assessments, fisheries assessments, and master drainage plans were reviewed to provide background information related to aquatic natural heritage features and functions within the Study Area; however, there is very little current aquatic habitat and fish community information for the tributaries found within the Study Area. A list of these documents is included in **Appendix G.**

Presence/absence data were found for many of the tributaries. However, some streams, such as Moore and Serson Creeks, appear to have no data. The only watercourses where biomass data has been collected are the Credit River and Sheridan and Cooksville Creeks. For these stations, CVC uses an Index of Biotic Integrity to assess the health of the fish community. A total of four biomass stations are used in the analysis.

3.8.3 Technical Assessments

The Aquatic Natural Heritage component of this study involved a compilation of data from existing documents and data sources, with any data gaps identified in section 4.8.

Lake Ontario is at the downstream end of the five Great Lakes, and as such is the recipient of all the water draining from the Upper Great Lakes. Approximately 80% of the water flowing into Lake Ontario comes from Lake Erie, with the remainder coming from direct tributary drainage and precipitation (MOE, 1997).

Historically, the tributaries flowing into Lake Ontario played a significant role as spawning and nursery areas for numerous lake-resident fish. Most of the fish species would be warmwater species; however, the mid-sized systems like Sheridan and Cooksville Creeks may have supported small runs of Atlantic Salmon or Brook Trout. The Credit River was renowned for its fall Atlantic Salmon migration, with an 1856 report that 200,000 salmon were taken at Port Credit (Morrison, unpublished). In addition to Atlantic Salmon, other federally/provincially designated species at risk found currently or historically within the Study Area include: Paddlefish, Shortnose Cisco, Deepwater Sculpin (Great Lakes-Western St. Lawrence population), Blackfin Cisco, Shortjaw Cisco, Kiyi, Lake Sturgeon, and American Eel.

The Lake Ontario fishery provides both commercial and recreational benefits to anglers and the economy. In 2005, Lake Ontario was third-most fished water body in Ontario (MNR, 2005). At the western end of the lake, the dominant fishery is an offshore boat fishery for trout and salmon. The lake also contributes to a large tributary fishery for trout and salmon in the spring and fall, of which the Credit River is one of the premier destinations in Southern Ontario. Lake Ontario is also a source for the many resident or short-term resident fish species using the lower reaches of the tributaries.

There are a large number of current and historic threats affecting the habitat and fish community including:

- Invasive alien species (e.g. alewife, common carp, rainbow smelt, white perch, and round goby, zebra and quagga mussels, fishhook and spiny water fleas, rusty crayfish, bloody red shrimp, yellow floating heart (Port Credit), Eurasian milfoil, curly-leaved pondweed, purple loosestrife, European frog-bit, fanwort and flowering rush);
- Intentional introductions of other species such as Chinook Salmon, Coho Salmon, Rainbow Trout and Brown Trout have also disrupted the food chain as these fish compete with other species.
- Diseases that have affected fish populations in other bodies of water and may have future implications for fish in Lake Ontario - Viral Hemorrhagic Septicemia and Koi Herpesvirus;
- Water Quantity, such as deliberate lake level manipulation at Moses Saunders dam near Brockville that reduces the range and timing of water level fluctuations in the lake, likely impacting wetland function and fish and invertebrate communities;
- Water Quality affected by discharges from treated wastewater, untreated stormsewer outflow, as well as inputs from waterfowl, and significant algae growth;
- Habitat Loss such as stonehooking where historically rock and cobble were removed along the shoreline to facilitate development and this resulted in a loss of spawning grounds and an increase in shoreline erosion; and,
- Harvest and Angling wherein activities such as ommercial harvest and angling have greatly affected fish communities in the lake.

The shoreline within the Study Area measures a total of about 28 km and includes 9 different types as summarized in Table 3.14, with armourstone being the predominant shoreline treatment (NRSI, 2009).

Table 3.14: Shoreline Condition

Shoreline Protection Type	Length (m)	% of Total Length
revetment	6,072	30%
wall	4,332	22%
beach	3,495	18%
wall and revetment	2,924	15%
rubble	1,417	7%
headland-beach (artificial)	904	4%
none	858	4%
rip-rap berm	143	< 1%

There are three main aquatic habitat types in the Study Area – open coast, embayment and wetland, and rivermouth and these are described in further detail below:

Open Coast
Open coast sites are unprotected shorelines that are directly subjected to the thermal conditions, wave action, sediment transport and other functions of the main part of Lake Ontario. The majority of the nearshore habitat in the Study Area is considered to be open coast. Due to the nature of these habitats, the fish community found at these sites is generally more transitory and less productive and diverse than the other two habitats. Substrates in these habitats are generally sands, rip-rap or cobbles. The shoreline types associated with these habitats within the Study Area are beach, armourstone or some other type of retaining wall. As noted in Section 3.4, the majority of the shoreline has been protected, essentially eliminating bluff erosion, and the nearshore lakebed is erosion resistant bedrock largely as a result of historic stonehooking. Habitat diversity in the nearshore area is generally quite limited.

Embayment and Wetland
Embayment and wetland habitats are found in the Credit River from the first riffle upstream of the QEW to the CN line, the Port Credit Harbour Marina and the two inner basins of the Lakefront Promenade Park. These habitats are sheltered from the direct influence of Lake Ontario and as such, allow for the growth of aquatic vegetation. These sheltered areas have relatively stable thermal regimes, which in the summer, is sufficiently warm to allow for the survival of warmwater fish species. Due to the warmer water, fish productivity and diversity is high.

Rivermouth
For the purposes of this study, the two rivermouth sites are Cooksville Creek and the Credit River. The sites are essentially open coast. However, the proximity to a nearby river likely influences the fish community. Due to the size of most of the other tributaries relative to the lake, or in the case of Sheridan Creek where there is a barrier beach and coastal marsh, other rivermouths are not considered in this category.

Rivermouth habitats are mixing zones, where flowing streams combine with the more static levels in Lake Ontario. Substrates found here are generally finer sands and silts, which have been carried as bedload by the river and deposited in a delta at the confluence with the lake. The habitat is subject to both the influence of Lake Ontario and the upstream watercourse. Due to the changing conditions and turbidity, aquatic vegetation is not present and shoreline types are armourstone or sheetpiling.

Nearshore/Warmwater Fish Community
Numerous surveys of the lower Credit River in the 1980's were reviewed; however, only a few historic sampling events in Lake Ontario were located. While the majority of these events found species that would be expected or were found in 2008 and/or 2009, a few uncommon species were also recorded. Of note is the collection of walleye in 1990 by Fisheries and Oceans Canada (Brousseau et al., 2005) and an anecdotal record by an angler in 2006.

CVC has been undertaking fish sampling within these habitats since 2005, and in combination with historic records, a total of 37 species have been recorded in the nearshore Lake Ontario environment. No data on mussel surveys was found. Informal data indicates high numbers of zebra and quagga mussels and likely very few native mussels. The following is a summary of the aquatic conditions for the watersheds coincident with the LOISS Study Area from west to east:

Clearview Creek

The lower end of this stream is a convex concrete channel with a 15% diagonal drop of approximately 1 m from the channel into Lake Ontario. The mouth itself is protected by armourstone on both sides of the channel. The concrete channel extends almost 400 metres upstream from the lake, where it goes under Lakeshore Road. During a site visit on June 1, 2009 and May 6, 2010, no fish were seen in the channel.

The only records of fish in this system are Bluntnose Minnow collected in 1999 and Creek Chub and Fathead Minnow collected in 2003 up and downstream of Winston Churchill Boulevard.

Avonhead Creek

This stream enters Lake Ontario through a cobble beach on the eastern side of the cement plant pier. The channel soon goes underground and then emerges upstream of the cement plant on the east side of Hazelhurst Road. A 2004 report (Hindley, 2004) reported the best section on the cement plant property to contain overhanging banks, instream debris and good riparian cover, with substrates consisting of silty sands with some organic materials.

Two fish sampling records were found for this tributary. In 2004, the reach located within the St. Lawrence Cement Processing facility (Holcim Canada) was electrofished and no fish were recorded (Hindley, 2004). A second sampling record from 2005 also recorded no fish.

Lakeside Creek

Very little information was found for Lakeside Creek. This brief section is from site visits to the creek. The creek flows through the western end of Lakeside Park and is often blocked at the mouth by materials forming the beach. Fish access from the lake is therefore limited. In Lakeside Park, the stream is contained within a wooded area and is mostly natural. At Lakeshore Road, the stream goes underground. No fish data was found for this tributary.

Sheridan Creek

This report summarizes the aquatic habitat and fish communities information presented in the Sheridan Creek Subwatershed Study - Phase 1 Report (CVC, 2009).

There are two main habitats in the Sheridan Creek watershed – Rattray Marsh and the tributaries upstream of the marsh. Most of the headwaters have been piped or channelized and only a short length of the original stream channel remains. There are more than 25 instream barriers which limit upstream fish movement. A small natural barrier to fish passage exists downstream of Clarkson Road while the first significant barrier is the culvert under Clarkson Road. Aquatic habitat is poor, with many concrete or armourstone sections. Though narrow and full of non-native species, the riparian corridor is fairly intact and provides some degree of shading. A total of 6 fish species are currently found in the watershed and their presence is limited to the reach downstream of the GO station. All of the species found in the watershed are considered tolerant warmwater species such as creek chub and blacknose dace. Sheridan Creek also continues to support a large migratory run of white sucker in the spring. Evidence of successful reproduction, however, is lacking.

Though degraded, highly turbid and lacking submergent vegetation, Rattray Marsh continues to support a fairly diverse tolerant warmwater fish community as documented by sampling collected since 2005. Common carp is the dominant species (**Appendix G**). A total of 19 species have been found in Rattray Marsh since 2005. Some fish such as rainbow smelt, gizzard shad, alewife, emerald shiner that are typically considered lake resident can also be found in the marsh. It is likely that they enter the marsh to reproduce. However, no evidence of successful reproduction of these species has been found. Other species such as northern pike and largemouth bass, which should be the top predatory species in the marsh, have only been found as single individuals and do not appear to be present in numbers high enough to suggest they are self-sustaining.

Turtle Creek

Very little information on the aquatic habitat and fish community of Turtle Creek was found. A remnant coastal marsh is located adjacent to the lake and it is here that Brook Stickleback were observed in 2003. In 2009, one Lake Chub was collected at the culvert under Silver Birch Trail. Even though fish access from Lake Ontario into the creek is possible, Turtle Creek does not appear to get a run of White Sucker in the spring. Turtle Creek is piped for a section upstream of Lakeshore Road, where it then emerges and runs through a treed section before going under the rail-line.

Birchwood Creek

Birchwood Creek is one of the larger Lake Ontario tributaries in the Study Area and splits into two branches upstream of Lakeshore Road. An on-line pond with an impassible barrier on the east branch upstream of this confluence contains Goldfish and Common Carp. 2009 sampling upstream of the pond did not result in the capture of any fish species. Visual observations in the same year showed high numbers of scuds. Sampling in 1993 along the rail-line resulted in the collection of Common Carp, Blacknose Dace and Creek Chub. Downstream of Lakeshore Boulevard, the creek is piped for 400 m before emerging into a small wetland feature and then discharging into the lake. A single Three-spine Stickleback was collected during a site visit by CVC staff in 2009.

Riparian and instream habitat is fairly good and although the watershed is highly developed, there still remain some relatively natural sections.

Moore Creek

A 1993 report on Moore Creek appears to have confused this tributary with Birchwood Creek so there is no information on this tributary. Aerial photos and CVC mapping show it going north to Lakeshore Road and then disappearing.

Lornewood Creek
The 2006 URS report provides the most detailed discussion on this tributary. It is described as a relatively natural stream with permanent flow. A wetland feature resulting from an old roadway is found upstream of the rail-line. Instream habitat in this reach is dominated by cattails while riparian vegetation provides a mostly open canopy. Downstream of the rail-line, the canopy provides more shade and the cattails disappear as the channel becomes deeper. Some evidence of groundwater seepage was found.

Sampling in 1993 found White Sucker, Northern Hog Sucker, Common Shiner, Spotfin Shiner, Sand Shiner, Mimic Shiner, Bluntnose Minnow, Fathead Minnow, Blacknose Dace, Creek Chub, Brook Stickleback, Pumpkinseed and Slimy Sculpin. 2005 sampling near the rail-line found Fathead Minnow, Blacknose Dace, Creek Chub and Brook Stickleback. Sand Shiner, Mimic Shiner and Slimy Sculpin are uncommon species in CVC's jurisdiction and their historic presence is questionable.

Tecumseh Creek
The habitat information for Tecumseh Creek comes from URS (2006). This report states that Tecumseh Creek originates 1 km to the west of the CN corridor and is contained within a relatively naturalized greenspace. Flow is considered to be permanent. The reach upstream of the rail-line is fairly natural and does show signs of natural channel design. Riparian and instream vegetation consisted of cattails, willows, and some dogwoods. No fish were collected during the survey.

Credit River
CVC has an Integrated Watershed Monitoring Program station located in the Port Credit Marshes downstream of the QEW. This station was first sampled in 2000 using a boat electroshocker. Twenty six species were caught including the only record of troutperch in 2000. Carp and bullhead dominate the biomass that was suspected for this Lake Ontario associated marsh. White sucker, smallmouth and rock bass and northern pike are also present. The IBI scores range from poor to excellent in health having a fair average IBI over the 3 years sampled. The highest score was attained the last year sampled in 2005.

North of the QEW where the influence from Lake Ontario ends, the Credit River continues upstream to the limits of the Study Area (approximately 1 kilometre north of Dundas Street in Erindale Park). At the downstream end, the reach is highly managed on the two golf course properties and the amount of riparian vegetation is low. As the valley narrows and deepens upstream, the channel becomes less managed and riparian vegetation more common and dense.

The first barrier to fish movement on the Credit River is located upstream of the Study Area in Streetsville. Management of this structure is set out in the Credit River Fisheries Management Plan (MNR and CVC, 2002) and functions as a biological barrier to invasive species such as sea lamprey, Pacific salmon and round goby, as well as the many native species moving upstream in the spring. A fishway at the dam is managed to collect jumping species such as Atlantic Salmon and Rainbow and Brown Trout. Overall, the connection of the river to the lake is good. However, fish movement during low water periods may be reduced at some of the higher velocity riffles and some species such as smallmouth bass would benefit from additional passage upstream of the Streetsville dam.

Being at the downstream end of the Credit River, this reach is subject to the flows resulting from upstream precipitation and run-off and as such, flows can fluctuate greatly. High flows resulting from high run-off from impervious surfaces in urban settings regularly re-sort material in the reach and destabilize the streambed and banks. Low flows as a result of reduced infiltration upstream may limit fish habitat and production in the summer. Water quality impacts on aquatic life in this reach include bacteria, sedimentation, temperature, nutrients, metals, and other water quality parameters.

Substrates in this reach vary greatly and include shale outcrops and benches, gravels, sands, and silts. Excessive siltation can fill in spaces used by smaller fish or asphyxiate eggs laid on larger substrates.

Given the flowing conditions, flow changes and substrate, instream habitat in the form of aquatic vegetation is sparse. Filamentous algae is the most common form of vegetation, particularly during the summer. Some deep pools may support limited submergent vegetation and sporadic off-line or oxbows may also support floating vegetation.

CVC has two sampling stations in this reach. The most downstream is located at the south end of the Mississaugua Golf and Country Club just north of the Queen Elizabeth Way and the second is located north of Dundas Street in Erindale Park. At total of 27 fish species have been captured at the Erindale Park site and 34 at the Mississaugua Golf and Country Club site since 2001. The number of species captured at these sites reflects the important connection to the lake and their importance as source areas for lake fish. Species of note found at these sites includes Logperch, Greater Redhorse, American Eel and White Bass. An angler did report a Round Goby at Erindale Park in the late 2000s but they have not shown up in sampling at Erindale Park.

The site upstream of Dundas St at Erindale Park site is representative of the Lower Zone of the Credit River characterized by urban development of the Peel Clay Plain (although much of the upstream watershed remains more rural and groundwater rich). The average IBI for this site is 5.7. Specimens from three out of the four years sampled ranked in fair health and seem to be relatively stable over time.

The site at Mississauga Golf and Country Club is representative of the lower most reach of the river and is located at the first riffle upstream of the estuarine marshes influenced by Lake Ontario backwaters. Species diversity is greatest here at 32 species and is related to the downstream wetland and lake habitats in close proximity. Unique species include greater and shorthead redhorse sucker, logperch and rosyface shiner. The average IBI over four years of data collection is 27.0 indicating excellent health.

Associated with the Credit are the following subwatersheds:

Loyalist Creek
Two sampling events totalling four stations were found for Loyalist Creek. The most sampling event was in 2001 when no fish were collected upstream from Erin Mills Parkway. In 1984, Loyalist Creek near Mississauga Road was sampled three times, with Coho Salmon, Chinook Salmon, Rainbow Trout, White Sucker, Northern Hog Sucker, Common Shiner, Creek Chub, Blacknose Dace and an unidentified Stickleback being collected.

Sawmill Creek
Sawmill Creek is a highly urbanized system that has undergone significant modification to the channel over time. Fish access into Sawmill Creek is completely prevented by a massive drop structure downstream of Dundas Street so any hope of natural recolonization is not possible. A 1993 survey found no fish in a channel length of one kilometre. More recent surveys from 2004 to 2009 have found three species: fathead minnow, creek chub and brook stickleback. These are likely a result of stocking by CVC staff.

Wolfdale Creek
Wolfdale Creek is located west of Mavis Road and runs parallel to it from Burnhamthorpe Road to Dundas Street. It is then piped until it emerges downstream of the Queensway where it drops steeply through the golf course. There is a large armourstone drop structure upstream of confluence with the Credit River that limits fish passage during lower flows. No fish data was found for this tributary but fish would have access up to the armourstone drop structure.

Stavebank Creek
Stavebank Creek flows into the Credit River downstream of the Queen Elizabeth Way. A 1999 survey (EcoTec) found no fish in Stavebank Creek. The stream was described as permanent and the habitat was 50% riffles with 20% each of pools and runs and 10% flats. Substrates were muck, sand, silt, and minor gravel deposits. Cattails grew densely in the channel and the banks were stable. The downstream end had much more woody cover but bank undercutting and slumping was evident.

Kenollie Creek
This tributary is located between Stavebank Creek and Mary Fix Creek. The 1999 EcoTec survey indicated it is a permanent, low gradient stream composed of mostly riffles and flats. Substrates were mostly sands. Downstream of Pinetree Way, the banks were lined with gabion baskets and upstream, there was moderate bank instability. Upstream of the QEW, good instream cover was provided by emergent cattails and grasses but very little overhead bank cover was present. Downstream of the QEW, the reverse situation was found. The channel was highly altered and contains a drop structure at the downstream end of the natural section. No fish were found in the 1999 survey and three-spine stickleback were found in 2006.

Mary Fix Creek
The 1999 survey by EcoTec was the only set of detailed fish and habitat data found for this tributary. It reported that the stream was permanent, with riffle and runs dominating the morphology and substrates being equally distributed between rubble, gravel, sand and silt. Upstream and downstream of the QEW, instream cover was reported as pools and undercut banks and bank erosion was low. Upstream of the QEW, overhanging grasses provided some overhead cover. Bank cover was more common downstream. No fish were found in the three reaches sampled.

Cumberland Creek
Very litte data are available for Cumberland Creek, with much of it conveyed directly by stormsewer into the lake.

Cooksville Creek (including Cawthra Creek)
After the Credit River, Cooksville Creek is the next largest of the tributaries in the Study Area. A recent subwatershed study by CVC provides much more detail on the aquatic habitat and fish community in this watershed.

Cooksville Creek originates in an industrial area around Britannia Road west of Highway 10. It transitions to a naturalizing reach with an on-line stormwater pond and then becomes heavily impacted and modified around Eglinton Avenue until its junction with Lake Ontario. The historic coastal marsh has been replaced by a gabion lined channel. Riparian vegetation is poor to moderate, with numerous non-native species. Many instream barriers prevent recolonization by fish and the first barrier at the rail-line (less than 1 kilometre from Lake Ontario) prevents further access to many fish species. The next barrier is 400 metres upstream at Atwater Avenue and entirely limits further fish passage. Flashy flows in the watershed are uncontrolled by stormwater management.

During recent fish collections, seven fish species were found in the river up to the QEW but nothing upstream. The fish community is more diverse at the lake with 17 lake and stream species found in 2008 and 2009 sampling.

The White Sucker migration in the spring is limited by the drop structure at the rail-line. Some chub, shiners, suckers and Rainbow Trout are found between this barrier and the next one at Atwater Avenue. Only longnose dace are found in the section between Atwater Avenue and the QEW.

Serson Creek
No information was found for this tributary and, given the existing lack of access at Lake Ontario and the nature of this urban watercourse, there are likely no fish present. A site visit undertaken on May 6, 2010 suggests that there may have been a diversion of this tributary just north of the Ontario Power Generation site to the north for several hundred metres, after which it follows a southern path and presumably links back up with the original watercourse located on the eastern side of the OPG site and to west of the Lakeview WWTP. This reach appears to be well vegetated although access was not possible due to fencing.

Applewood Creek
A 2004 report by Dillon Consulting provides some information on the habitat and fish community in this tributary downstream of South Service Road. This report indicates that upstream of South Service Road, the stream is piped. Runs made up just over half of the habitat, with riffles and pools making up the remainder. Channel substrates contained a mix of rubble, cobble, gravel, sand, and clay, with some sporadic boulders. Undercut banks, boulders, large woody debris, and terrestrial plants provided instream cover. Portions of the banks were considered unstable and there had been attempts to stabilize the banks using a variety of techniques. Riparian vegetation shaded about 70% of the reach. A potential instream barrier was identified at Lakeshore Road and no fish were found in the reach. The confluence with Lake Ontario remains natural and fish passage is unimpeded.

3.8.4 Conclusions

Data from numerous surveys of the lower Credit River in the 1980s were reviewed; however, only a few historic sampling events in Lake Ontario and the tributaries were located. Some older data collected by other agencies or anecdotal information from other sources was also reviewed. While the majority of this information documented species that would be expected or were also found by CVC in 2008 and/or 2009, a few uncommon species have been recorded. In total, 55 fish species have been recorded recently in the Study Area of which 12 are introduced. Since 2008, 29 species have been recorded in the nearshore Lake Ontario environment. There are only limited data within the Study Area related to benthic invertebrates, and this has been identified as a knowledge gap.

A full list of data gaps identified during this phase of the study are summarized in Table 4.7.

3.9 Stewardship, Education, and Communications

3.9.1 Introduction

The Lake Ontario Integrated Shoreline Strategy encompasses a Study Area that is highly urbanized and includes a diverse mix of publicly- and privately-owned properties. Planning and implementation will need to involve the general public and specific stakeholders at various stages of the process.

Stewardship (the fostering of an environmental ethic and promotion of sustainable practices), Education (the process of teaching and learning) and Communication (the interchange or transmission of ideas, opinions or information) are all critical components of the LOISS study in order to assist in:

- identifying key stakeholders;
- gaining an understanding of how different individuals and organizations use the shoreline area and the lake;
- gathering information about stakeholder values and concerns regarding the shoreline area and the lake;

- designing a comprehensive public consultation process;
- promoting an understanding of and appreciation for the shoreline, the lake and related issues and opportunities;
- encouraging participation in protection and restoration actions;
- promoting ecological and social sustainability as key principles in any future development of the shoreline;
- participating in broader lake restoration and protection efforts, and;
- helping people make connections between the northern parts of the watershed and the lake, as well as adjacent coastal areas and the LOISS shoreline.

Understanding and appreciating the human dimensions of the LOISS study is a critical component of the short- and long- term success of this initiative.

3.9.2 Background Information

CVC's SEC staff, other agencies and many citizens are already active in stewardship, education, and communications efforts within CVC's jurisdiction. At this time, few CVC projects or programs are specific to the lakeshore, but several can be readily adapted to working with shoreline stakeholders. Some limited shoreline work has already been undertaken, and some CVC programs are in the process of further developing shoreline materials and targeting sites.

External agencies and organizations were also consulted and reports were reviewed, in order to gain a better understanding of completed and planned initiatives within the Study Area to facilitate the identification of additional outreach and education needs and opportunities.

Communication within CVC, the City of Mississauga and various other organizations is on-going; the lists of CVC and external programs will be updated as new information becomes available. A Communications Strategy has been developed by CVC's communications staff with input from outreach and education staff. This Strategy will be refined as the study process unfolds. Communications plans and tools will work with and supplement existing programs and resources. In addition, some resources related to the lake can easily be added to existing tools for stakeholders in other areas of the watershed.

A draft list of possible stakeholders was also created as part of the SEC, and a more comprehensive list of interested individuals and organizations is currently being developed and is anticipated to evolve throughout the Study process. Some of these contacts will be invited to participate more actively as representatives of the proposed LOISS Advisory Committee.

Finally, Stewardship personnel gathered data on the settlement history of the lakeshore, in part to identify restoration opportunities, and in part for use in educational materials. A summary of historical information can also assist in:

- assessing impacts of various human settlement patterns and activities, and needed changes;
- inspiring change if individuals can understand and appreciate historical natural and cultural information; and,
- identifying key stakeholders.

See the Conservation Lands section (**Appendix I**) for additional information and a chronology of key historical information related to the LOISS Study Area.

Existing CVC Stewardship and Education Activities

CVC Stewardship and Education programs that complement the LOISS are:
- *Urban Outreach*
- *Conservation Youth Corps (CYC)*
- *Community Outreach*
- *Education*
- *Low Impact Development and Pollution Prevention*

For a complete list of programs, targets, themes and tools, see Table 3.15

The Aquatics Restoration team is also involved in Stewardship projects with community groups, such as*:*
- *Lakefront Promenade Park Aquatic Plant Planting*
- *Lakefront Promenade Park Spawning Bed Project*

Table 3.15: Existing CVC Stewardship and Education Activities

Target(s)	**Program Area (consult with others as need)**	**Main Theme(s)**	**Tools**
Residential landowners/tenants	Urban Outreach	• green cities • ecological landscaping and restoration • tailored to their watershed and site(s)	• workshops • presentations • print/web resources • select site advice • demonstration sites/signs
Residential landowners/tenants	Low Impact Development and Pollution Prevention	• innovative stormwater practices • reduce risk of contaminants entering local waterways • education of best management practices	• Guidance • Peer review of engineering designs and tender documents • On-site construction assistance • Performance monitoring • print/web resources
Business landowners/tenants	Urban Outreach	• green cities • ecological landscaping and restoration • broad audience and/or tailored to their watershed and site	• site plans • aid with site implementation • workshops • presentations • displays

Target(s)	Program Area (consult with others as need)	Main Theme(s)	Tools
		• other partnership/funding opportunities	• print/web resources • signs
Business landowners/tenants	Low Impact Development	• innovative stormwater management practices	• workshops • conferences • presentations • print/web resources • guidance documents • professional training
Commercial/Industrial/ Institutional	Low Impact Development	• innovative stormwater practices • reduce risk of contaminants entering local waterways • education of best management practices • ecological landscaping and restoration	• guidance • peer review of engineering designs and tender documents • support for grant applications • on-site construction assistance • assist with performance monitoring • develop signage
Public landowners (Mississauga/CVC)	Urban Outreach	• green cities • ecological landscaping and restoration • broad audience and/or tailored to their watershed and site • other partnership/funding opportunities	• site plans • aid with site implementation • presentations • signs • partnership activities • aid various City initiatives, laws, policies (eg. Living Green Plan)
Public landowners (Mississauga/CVC)	Low Impact Development and Pollution Prevention	• innovative stormwater practices • reduce risk of contaminants entering local waterways • education of best management practices	• Guidance • Peer review of engineering designs and tender documents • On-site construction assistance • Performance monitoring • print/web resources
Public landowners (Mississauga/CVC)	Community Outreach, CYC	• ecological landscaping and restoration	• site plans (by Forestry staff) • planting events

Target(s)	Program Area (consult with others as need)	Main Theme(s)	Tools
Rattray Marsh (CVC)	CYC, Aquatics, Forestry, NHP, Education	• ecological landscaping and restoration • interpretive programs	• site plans • aid with site implementation • print/web resources • signs
Landscape Industry/Land Managers/Developers	Urban Outreach	• green cities • ecological landscaping and restoration • other partnership/funding opportunities	• workshops • presentations • print/web resources • select site advice • partnership activities
Landscape Industry/Land Managers/Developers	Low Impact Development	• innovative stormwater practices	• workshops • conferences • presentations • print/web resources • guidance documents • professional training
General Public	Urban Outreach	• green cities • ecological landscaping and restoration • other CVC materials • broad or tailored to their watershed and neighbourhood	• displays • presentations • planting events • other hands-on activities • print/web resources
General Public	Community Outreach, CYC	• general env. stewardship • other CVC materials	• displays • planting events • Stewardship Forum • Conservation Awards
General Public	Education	• interpretive programs • multicultural outreach • other CVC materials • via Speakers Bureau - any topic available and of interest (all depts contribute)	• displays • community events • hands-on activities • print/web resources • presentations
Students/Teachers	Education	• interpretive programs • general env. stewardship • Stream of Dreams program • Save the Leopard Frog program • teacher training	• community tours • hands-on activities • print/web resources • presentations • mural (SoD)
Students/Teachers	Urban Outreach (limited basis due to limited staff	• schoolyard/public lands ecological landscaping and	• site plans • planting events

Target(s)	**Program Area (consult with others as need)**	**Main Theme(s)**	**Tools**
	availability)	restoration • teacher training in process	
High School Students/Teachers	CYC	• general env. stewardship	• on-the-ground projects • presentations
NGOs	Urban Outreach	• ecological landscaping and restoration	• partnership activities
NGOs	Community Outreach	• general env. stewardship	• partnership activities
NGOs	Education	• interpretive programs • general env. stewardship	• partnership activities

Existing External Initiatives Related to Stewardship, Education and Communications

External programs and projects that directly or indirectly complement the LOISS are:

City of Mississauga

- *Strategic Plan: Our Future Mississauga*
- *Living Green Master Plan*
- *Library, Recreation, Parks and Natural Areas Master Plan*
- *Parks Naturalization Program*
- *Litternot Program*
- *Credit River Parks Strategy*
- *Credit River Sedimentation Strategy*
- *Waterfront Parks Strategy*
- *Harbour West Plan: JC Saddington; Memorial; and, JJ Plaus Park*
- *Briarwood site planning*
- *Inspiration Lakeview*
- *Lakeview and Port Credit District Policy Review*
- *Mississauga Summit (section devoted to the shoreline)*

Local NGOS

- *Mississauga Bassmasters*
- *Credit River Anglers Association (CRAA)*
- *Riverwood Conservancy*
- *EcoSource Mississauga*
- *Evergreen Mississauga Stewardship Program*

Toronto Region Conservation Authority

- *Watershed on Wheels*
- *Mississauga/Toronto Waterfront Connection (CVC/TRCA)*

Region of Peel

- *Climate Change Strategy*
- *Peel Region Official Plan and Significant Wildlife Habitat Study*
- *Children's Water Festival*
- *Peel Water Story*
- *Water Treatment Plant Tours*
- *Waste Water Treatment Plant Expansions*
- *Sourcewater Protection Program*
- *Phosphorus Mitigation Campaign*

Provincial/National Government and NGO

- *Ontario Stewardship*
- *Conservation Ontario*
- *Great Lakes Beach Association*
- *Lake Ontario Biodiversity Strategy (Canada-Ontario Agreement)*
- *Blue Flag Program*
- *Ontario Water Research Consortium*
- *Great Lakes and St. Lawrence Cities Initiative*
- *Environment Canada - various Great Lakes resources including Remedial Action Plan and others*
- *State of the Lakes Ecosystem Conference (International Joint commissions US-Canada)*
- *Waterlife (a film on the Great Lakes)*
- *Waterfront Regeneration Trust (waterfronttrail.org)*
- *Great Canadian Shoreline Cleanup*

.

US-based

- *Biodiversity Project - Great Lakes Communications research*
- *Great Lakes Restoration Initiative Action Plan 2010 (multi-agency initiative)*

3.9.3 Conclusions

There are currently few resources and programs *specific* to the Lakeshore within CVC; however, there are many programs engaged in shoreline-*related* Stewardship, Education, and Communications activities. Those shown in Table 3.19 vary in their relevance to the lakeshore. For example, Urban Outreach is poised to reach out to shoreline landowners, tenants and others, while other existing programs could be modified to meet the objectives of LOISS as needed.

Community involvement will be enhanced by incorporating many concurrent methods and tools, while attempting to ensure that stakeholders are not overwhelmed with too many messages, initiatives and/or personnel. As far as possible, CVC will coordinate in-house initiatives and liaise with external stakeholders, including but not limited to the City of Mississauga and the Region of Peel.

Critical to LOISS is to gain an understanding of how the shoreline is being used, values and concerns, and interest in protection and restoration, by the general public, landowners, and other individuals and organizations. This information can then help inform study recommendations, as well as key messages and methods for encouraging involvement in implementation. Much of this information will be compiled as part of the Ecological Goods and Services component of the LOISS and will be used to help inform the tactics outlined in the Communications Strategy.

3.10 Ecological Goods and Services

3.10.1 Introduction

Ecological Goods and Services refer to the benefits arising from the ecological features and functions of healthy ecosystems. Shoreline and nearshore environments are where most people interact with the Great Lakes. These interactions include direct uses such as recreation (e.g. boating, fishing, and swimming) or municipal drinking water supply and indirect uses such as the role the shoreline can play in mitigating property damages by buffering the effects of storms. While the nearshore is used directly and indirectly and provides a wide array of benefits, it is simultaneously used as a repository for our wastewater discharge and storm water.

From an economic perspective these uses translate into (a) benefits (uses that improve peoples' well-being), or (b) costs (uses that reduce peoples' well-being). In economics, well-being provided by environmental resources can be expressed using the total economic value (TEV) framework. This framework (shown in Figure 3.) suggests that economic values can be subdivided into direct use, indirect use, option, and non-use values.

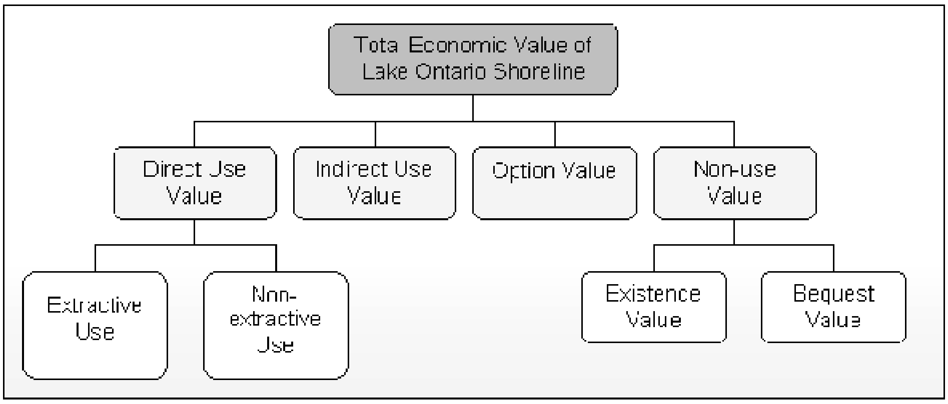


Figure 3.33: Total Economic Value

Direct Use Value **–** the values resulting from the direct use of a resource (i.e. output is directly consumed), which can be extractive (e.g. fish or timber harvest) or non-extractive (e.g. recreation).

Indirect Use Value **–** the values of a resource that support and protect economic activity and well-being (e.g. ecosystem services)

Option Value **–** when there is uncertainty over future demand and availability of a resource, maintaining the option for future use may be considered valuable.

Non-use Values **–** the values of knowing a resource exists (existence value) and that it will be available for future generations to enjoy (bequest value).

If the objective of land use policy is to improve the well-being of those who use the resource, then proposed changes to the Lake Ontario shoreline should examine all the values associated with the shoreline. Table 3.15 provides a list of potential values that should be examined when considering policy changes that influence the Lake Ontario shoreline and nearshore environment.

Table 3.15: Potential Ecosystem Goods and Services Provided by Lake Ontario Shoreline

<table>
<tr><th colspan="3">Use Values</th><th>Non-use Values</th></tr>
<tr><th colspan="2">Direct</th><th rowspan="2">Indirect</th><th rowspan="2">Existence / Bequest</th></tr>
<tr><th>Extractive</th><th>Non-extractive</th></tr>
<tr><td>Drinking water
Industrial water use
Water for heating and cooling
Commercial Fishing
Recreational Fishing</td><td>Recreation
- Sailing
- Canoeing
- Rowing
- Waterskiing
- Wakeboarding
- Wildlife watching
- Walking
- Beach and lakefront
- Swimming
Transportation
- Commercial
- Tourism operators
Amenity</td><td>Gas regulation
Local climate regulation
Water filtration
Water supply
Nutrient cycling
Shoreline protection
Groundwater recharge
Flood control
Erosion control
Waste treatment</td><td>Biodiversity
Cultural heritage
Habitat</td></tr>
</table>

3.10.2 Background Information

A literature review was undertaken to provide background information related to the valuation of goods and services provided by shoreline environments, with most focused on coastal shorelines, and a list of these documents is provided in **Appendix H**.

3.10.3 Technical Assessments

The EGS component of this study involved summarizing information obtained from the documents listed in **Appendix H**, with any missing information highlighted as data gaps.

The valuation literature on goods and services provided by shoreline environments is focused predominantly on coastal shorelines (e.g. Silberman et al., 1992; Gren, 1993; Le Goffe, 1995; Pompe and Rinehart, 1995; Brystrom, 2000; Taylor and Smith, 2000; Leggett and Bockstael, 2000; Parsons and Powell, 2001; Hanley et al., 2003). Studies examining values in the Great Lakes region tend to focus on commercial and trade implications (Krantzberg and de Boer, 2006) and if non-market values are considered at all, coastal shoreline values are relied on to infer freshwater shoreline values (Troy and Bagstad, 2009). Despite the vast number of studies exploring the economic contribution and value of the Great Lakes, particularly the commercial and recreational values, only a handful have focused specifically on the nearshore environment (Kreutzwiser, 1982; Bishop et al., 2000; Institute for Research and Innovation in Sustainability, 2006; Braden et al. 2008a; Braden et al. 2008b).

Most of the direct use resources, such as commercial fishing or water use, have a market value that can be conventionally measured, e.g. total landed value of fish. Table 3.16 provides an example of such market values for some direct uses of ecological goods and services.

Table 3.16: Summary of Select Market Values Provided by Great Lakes Resources to Ontario (Adapted from Krantzberg and de Boer, 2006)

Economic Sector	Value (per year)	Notes
Commercial Fishing	$35 million	Landed value of fish only (before processing)
Aquaculture	$23-24 million	Landed value of fish
	$65 million	Total value added to the economy
Transportation	$2.2 to 3 billion	Value added to provincial GDP through activities generated by transport activity
Sport Fishing	$500 million	Direct spending on trips only

In the process of generating market values, humans use near shore resources and land as raw materials as well as waste repositories. This use of land and resources lead to external costs, namely environmental degradation that affects human well-being. In order to fully understand the role shoreline environments play in influencing human well-being, we must be aware of and account for these external costs. Krantzberg and de Boer (2006), identify key threats to the value of the Great Lakes as a whole. Some of the threats that are relevant to the Credit Valley Conservation's portion of the shoreline are summarized in Table 3.17.

Table 3.17: Summary of Economic Threats to the Market Value of Great Lakes Resources (Adapted from Krantzberg and de Boer, 2006)

Threat	Potential Loss	Notes	Geographic Area
Sprawl	$700 million to $1 billion	Excess costs for infrastructure, operating, maintenance, emissions, health care, traffic policing, etc.	Greater Toronto Area
	$18 billion	Infrastructure needed over next 15 years to provide drinking water to Great Lakes population due to inefficient pricing of water use in the past	Ontario, Canada
Invasive Species	$500 million	Control costs spent by Canada every year on current invasive species	Ontario, Canada
	$4 million	Monitoring, reporting, and public dissemination of all ballasting activities	Canada and U.S.
Toxic Chemicals	$93-$250 million	Reduced productivity and increased social costs due to mercury exposure	Ontario, Canada

	$5 billion +	Increased mortality rates due to pollution carried in the Great Lakes	Ontario, Canada

The idea of incorporating non-market values into policy making is one that has been slowly gaining increasing support over the last few decades. As a result, analysts have been increasingly reliant on existing literature. A recent government report attempted to incorporate the role of shorelines and near shore environments in the process of examining the ecosystem services provided by the southern Ontario landscape (Troy and Bagstad, 2009). Specifically, they produced estimates for the near shore, embayments and coves, coastal wetlands, and beach (summarized in Table 3.18).

Table 3.18: Summary of Great Lake Shoreline and Nearshore Ecosystem Services from Troy and Bagstad (2009)

Cover type	Description	Services Considered	Estimated Value (per ha per year)
Open water - great lakes near shore margin	Nearshore zones, defined as surface waters where depth is less than 10 meters for Lake Erie, 20 meters for Huron, and 30 meters for Ontario.	- Recreation - Aesthetic and amenity	$795
Open water – embayments and coves	Areas of the Great Lakes forming significant embayment, estuaries or coves	- Nutrient regulation - Water supply - Recreation - Aesthetic and amenity - Habitat refugium	$1,852
Wetlands - Great Lakes coastal	Wetlands, bogs, marshes, and fens designated as coastal but not located in urban / suburban areas	- Gas regulation - Nutrient regulation - Recreation - Aesthetic and amenity - Other Cultural	$14,761
Beach	Open and treed sand barrens / dunes located within 1 km of the coast	- Disturbance regulation - Recreation - Aesthetic and amenity	$89,608

One remarkable gap in the literature is related to drinking water. While nearly every document and publication highlighting the importance of protecting the Great Lakes makes reference to the provision of drinking water. In fact, only one study was found that attempted to estimate welfare implications of drinking water consumption (Renzetti, 1999). Simply recognizing the importance of a resource for something as essential as drinking water is not enough. Everyday decisions impact the quantity and quality of drinking water and until we understand its value relative to others, we will continue to make poor trade-off decisions.

Aesthetic and amenity values are relatively well documented and can be divided into two broad categories of literature: those that focus on valuing an environmental amenity (Earnhart, 2001; Johnston et al., 2002; Pompe, 2008) and those that focus on the dis-amenity of living near a polluted site (Zegarac and Muir, 1998; Patunru et al., 2007; Austin et al., 2008; Braden et al., 2008a; Braden et al., 2008b). For example, it is intuitive that properties in proximity to environmental amenities and scenic vista command a price premium; however, quantifying the dis-amenity of properties in proximity to polluted sites is much more useful since it is ultimately tied to human actions that can invoke change. In other words, the value of a dis-amenity highlights the cost of environmental damages and represents a benefit of restoration (highlighted in Table 3.19). It should be noted that restoring degraded shoreline areas not only recovers the property values losses, it has also been shown to produce increased property taxes revenues for local municipalities (Zegarac and Muir, 1998; Braden et al. 2008a; Braden et al. 2008b).

Table 3.19: Summary of Studies Valuing Dis-amenities of Shoreline Environments

Study	Description	Geographic Area	Benefit Estimate	Units
Zegarac and Muir (1998)	Increase in property value after restoration of Hamilton Harbour	Hamilton, Ontario	$12,065 per waterfront property	1996 CAD
Leggett and Bockstael (2000)	Increase in property value from improving fecal coliform counts from 240/100mL to 100/100mL	Chesapeake Bay, Anne Arundel County, Maryland	$230,000 or 2% of assessed value	
Austin et al. (2008)	Projected increase in property value from restoration of water quality in Great Lakes	Buffalo, New York	$0.6 to $1.1 billion	2006 USD
		Chicago, Illinois	$7.4 to $13.3 billion	
		Cleveland, Ohio	$2.1 to $3.7 billion	
		Detroit, Michigan	$3.7 to $7 billion	
		Duluth, Minnesota	$0.2 to $0.3 billion	
		Erie, Pennsylvania	$0.4 to $0.5 billion	
		Gary, Indiana	$0.2 to $0.3 billion	
		Milwaukee, Wisconsin	$1.5 to 2.3 billion	
Braden et al. (2008a)	Depressed property value from proximity to Area of Concern	Buffalo River, New York	$118 million	
Braden et al. (2008b)	Depressed property value from proximity to Area of Concern	Sheboygan River, Wisconsin	$158 million	

Another well-document benefit of shoreline environments is that of recreational values, particularly those related to beach recreation. Again, most of the research has been done for coastal environments (Whitehead et al., 1997; Kline and Swallow, 1998; Johnston et al., 2002; Hanley et al., 2003; Whitehead et al., 2009). However, some work has been on the Great Lakes shoreline examining the benefits of cleaning up the Hamilton Harbour area of concern (Dupont, 2003) as well as some beach recreation values estimated for some regional conservation areas (Ecologistics, 1990).

There are a number of other non-market values aside from amenity and recreation values, as highlighted in Table 3.15. However, the literature examining those services within the context of shoreline or even coastal environments is rather scarce.

The benefit of nutrient regulation in coastal regions has been studied using two different economic valuation methods: replacement cost (Gren, 1993; Brystrom, 2000), and contingent valuation (Le Goffe, 1995). Both studies demonstrate the important economic role of coastal ecosystems in terms of nutrient regulation. Disturbance regulation is another essential service provided by coastal and shoreline environments. However, literature relevant to the Great Lakes shoreline environment is in short supply.

Finally, non-use values have been shown to comprise a considerable portion of the total economic value of resources. Silberman et al. (1992) estimated the value of restoring New Jersey beaches to both users and non-users, finding non-use value to be $9.26 (a one-time contribution in 1985 USD) compared to $6.40 for recreational use. Examining the restoration of coastal wetlands, Whitehead et al. (1997) found that non-users of the Albemarle-Pamlico estuarine system were willing to pay between $19.83 to $41.31 per household per year (1991 USD). When compared to values estimated for users, Whitehead et al. (1997) suggested that the non-use portion of value held by users comprised a large portion of their overall willingness to pay for estuarine quality improvement.

Most studies that examine the economic benefits of ecosystems are less interested in estimating the total value and more concerned with the change in economic value resulting from (i) restoring the shoreline environment (Ecologistics, 1990; Zegarac and Muir, 1998; Whitehead et al., 1997; Leggett and Bockstael, 2000; Dupont, 2003; Hanely et al., 2003), or (ii) damages caused by human activity (Bishop et al., 2000; Braden et al., 2008a; Braden et al., 2008b).

Changes to shoreline environments, whether restoring natural conditions or further development, have significant implications for the well-being of local and regional citizens. Understanding the implication to well-being requires economic tools, of which three are most relevant:

- Economic Impact Analysis
  - Method for determining how a change in policy or other action affects regional income, revenues, expenditures, and jobs.
- Cost-effectiveness Analysis
  - Method used when it is unnecessary or impractical to consider the dollar value of the benefits.
  - Method identifies which option has the lowest cost to achieve a given benefit.
- Benefit-cost analysis
  - Method comparing the present value of all socio-economic benefits with the opportunity cost of a change in policy or action.
  - Method requires the quantification of benefits.

Economic impact assessments track the impact that economic activity (e.g. spending on recreation) in a particular location has on the rest of the local economy. In the US, Austin et al. (2007a) used such an impact analysis to measure the multiplier effects from a $26 billion investment in Great Lakes restoration. The study estimated that this investment would increase short-term economic activity between $30 and $50 billion. It should be noted that these estimates do not represent economic value; rather it is a measure of economic activity generated by spending in the local economy. While studies such as these do not measure value, they do have an important place in policy development.

Another example of particular relevance to the Lake Ontario shoreline demonstrated that economic significance of recreational spending generated by public marshes at Long Point and Point Pelee (Kreutzwiser, 1981). In pursuit of nature viewing, photography, fishing, waterfowl hunting, and canoeing, users had a direct impact on the economy by spending more than $250,000 of which approximately $120,000 was spent in the local community. Considering the impact on the local economy only, Kreutzwiser (1981) suggests that this spending generated additional (or indirect) economic activity of $105,000 for a total economic impact of $225,000.

There are a few examples of benefit-cost analysis conducted within the context of the Great Lakes, the most impressive being the work Austin et al. (2007a). This analysis examined the United States' Great Lakes Regional Collaboration Strategy which articulates a restoration plan designed to enhance coastal health, treat areas of concern, reduce non-point contamination sources, eliminate toxic pollutants, preserve habitats, address invasive species, and develop a system of indicators. The collaboration strategy is a massive undertaking proposed by US federal, state, and local governments. Taking into account initial capital costs and continuing operating costs, the strategy is estimated to cost $26 billion in present value terms. A detailed analysis of restoration benefits resulted in their estimation in excess of $50 billion (summarized in Table 3.20), for a benefit-cost ratio of 2:1.

Table 3.20: Economic Benefits from Great Lakes Restoration in the United States (from Austin et al., 2007)

Benefit Description	Benefit Estimate
Direct use economic benefits from tourism, fishing and other recreation	$6.5 to $11.8 billion
Rise in coastal property values by areas of concern remediation	$12 to $ 19 billion
Reduction in costs to municipalities from reduced water treatment costs	$50 to $125 million
Total quantifiable benefits	$18 to $31 billion
Expected total benefits (including unquantifiable benefits)	> $50 billion

While Austin et al. (2007a) provide a comprehensive analysis of the benefits and costs of Great Lakes restoration south of the boarder, the scope of such an analysis provides little guidance for Credit Valley's assessment of the Lake Ontario shoreline. However, two other studies focused on coastal areas provide some insight to conducting a benefit-cost analysis to a small portion of a shoreline using an ecosystem services approach (Whitehead et al., 1997; Luisetti et al., 2008).

Recognizing the increasing threats and vulnerability to shoreline environments from climate change, the UK government is reorienting its coastal strategy to increase flexibility and adaptability (Luisetti et al., 2008). This policy switch has led to managed realignment projects resulting in the restoration of salt marshes, which under the new policy are considered a more sustainable form of flood defence. In addition to flood defence benefits, the restored salt marshes have resulted in a number of other benefits including increased biodiversity and carbon storage. Luisetti et al. (2008) used an ecosystem services approach to assess the costs and benefits of various managed realignments of the shoreline finding that restoring the natural shoreline had significant net benefits.

3.10.4 Conclusions

Addressing the question of human values from the Lake Ontario shoreline and near shore environment will require a variety of information and data ranging from psychological and behavioural to biological and physical. Ultimately, this analysis will be concerned with how people use the shoreline and near shore environment and how changes to biological and physical components result in perceived and experienced changes in human well-being.

In terms of placing a monetary value on benefits from the provision of ecosystem services or on environmental damages, there are a number of potential techniques that could be used. The method that involves the smallest investment in time and resource is value transfer, which relies on the results from previous valuation studies. Given the significant gaps in the peer-reviewed literature, it is unclear whether there is enough relevant information on shoreline services and related environmental issues to effectively rely on value transfer.

It is clear from the review of literature that natural coastal and shoreline environments provide significant economic benefits which must be considered in order to properly inform policy and management decisions. However, it would be prudent to offer a cautionary note when interpreting non-market benefits. As the LOISS moves forward there will need to be continued communication between the ecologic and economic components in order to achieve the desired integration.

4 KEY FINDINGS AND DATA GAPS

4.1 General

The objective of this chapter is to summarize the key findings for each discipline and identify data gaps. An overview as to the type of program, timing and approximate cost to collect the required information is also provided. Collectively, this information will be used to direct additional data collection and analysis for the proposed Shoreline Characterization and Shoreline Restoration Plan. The last section of this chapter will prioritize the data gaps.

4.2 Hydrology and Hydraulics

The key findings of the hydrology and hydraulics component of the study were the return period flows, the structure and building flooding lists, the watershed characteristics, and the availability of hydrologic and hydraulic modelling on a watershed basis. A summary of these findings is provided in section 3.2.4.

After reviewing the available floodline studies for the subject area, the data gaps were identified. These data gaps are summarized in Table 4.1 and Table 4.2 below.

Table 4.1: Summary of Missing Flow Data

Watercourse	Location	Missing Flows
Avonhead Creek	North of Lakeshore Road – Existing	2- to 25-year
	Western portion of watershed – Post-development	2- to 25-year
Credit River	Upstream of Highway 5	Regional
	Upstream of QEW	Regional
	CNR	Regional
Cumberland Creek	All	All
Moore Creek	All	All

Table 4.2: Summary of Additional Missing Data

List of overtopped structures and flooded buildings	• Avonhead Creek • Clearview Creek • Cumberland Creek • Moore Creek • Sheridan Creek
Fraction developed	• Clearview Creek • Credit River • Cumberland Creek • Moore Creek • Sheridan Creek
Drainage area	• Cumberland Creek • Moore Creek
Hydrologic model	• Cumberland Creek • Moore Creek
Hydraulic model	• Cumberland Creek • Moore Creek
Flood hazard mapping	• Cumberland Creek • Moore Creek

One other shortcoming within the Hydrology and Hydraulic portion of the LOISS is the precipitation record. The record is less than 15 years in length and contains many gaps. Additionally, of the two gauges within the Study Area, Station 1 and Station 2, only Station 2 is a heated gauge. The Station 1 data set was too full of data gaps and errors to be of use. To remedy the issues associated with the precipitation record, it is recommended that monitoring of precipitation be continued to increase the length of the record and that the gauges be maintained regularly to prevent data gaps. As well, it may be beneficial to replace the gauge at Station 1 with a heated gauge.

4.3 Fluvial Geomorphology

The following list provides the key findings from the Fluvial Geomorphology component of the LOISS.

- The majority of the reaches within the Study Area were categorized as “moderately stable” by the RGA results and their condition was classified as “fair” by the RSAT results.
- Aggradation and widening are the dominant processes in the downstream-most reach of most watercourses in the Study Area.
- An opportunity may exist to daylight reach 1 of Lornewood Creek and reach 2 of Birchwood Creek through Richard’s Memorial Park and Jack Darling Memorial Park respectively.
- The possibility of replacing the concrete-lined trapezoidal channel in reach 1 of Clearview Creek with a natural channel could be explored.
- Applewood Creek, Lakeside Creek, and Turtle Creek are most sensitive to backwater effects from Lake Ontario.
- Interaction between tributaries and Lake Ontario is minimal for Cawthra, Lornewood, Serson, and Clearview Creeks as these creeks are conveyed to the lake via stormsewers or concrete channels.
- For the remaining watercourses, there is an interaction between the beach form and the creek mouths.
- The Credit River is the primary source of sediment to Lake Ontario from the Study Area, supplying more than 174,000 tonnes of sediment per year. This sediment is primarily composed of medium sand sized particles.

Data gaps for the Fluvial Geomorphology component of the study include the following:

- RSAT evaluations for reaches on the Credit River.
- Documentation on the mouth of Serson Creek. (Creek mouth was inaccessible during field walk.)
- Geomorphological data for Moore Creek. (Watercourse is located within a privately-owned development.)
- Sediment loads to Lake Ontario for all watercourses within the Study Area except the Credit River.

4.4 Coastal Processes

At this stage in the study, what does or does not constitute a gap in the Coastal Processes portion is somewhat speculative due to the nature of the coastal processes at this site. There is sufficient wind and water level data available to allow long-term simulations of nearshore wave and sediment transport conditions. It is reasonable to assume that nearshore wave conditions will need to be generated for any location subject to further analysis as those analyses tend to be site specific, but within the context of this report we cannot speculate where such analyses may be required.

If sub-littoral sediment movement needs to be modeled, that will have to be done with a nearshore circulation model. The extent to which wave-driven currents and/or general lake hydrodynamics affect the critical circulation patterns will define both the physical extent of the area to be modeled and the type of model that is required. Again, that assessment is expected to be part of the shoreline characterization of the LOISS.

Nearshore sediment samples will be required for any thorough assessment of nearshore sediment transport rates. Samples should be collected for the area of interest as well as updrift and downdrift of the site. Sediment sampling is typically carried out as part of the sediment transport analysis so, although a data gap exists here, it need not be resolved until any actual modeling is planned.

If the water quality modeling finds areas of concern in water depths of less than approximately 5 metres, the influence of breaking waves on the nearshore currents may need to be examined. Wave-induced mean currents can be up to an order of magnitude greater than wind, temperature, and density driven currents.

Section 3.4.4 presents the initial outline of a coastal processes descriptive model that is based on a sediment budget approach. Not all of the reach-attribute data listed in Table 3.11 currently exist and therefore, these could constitute a data gap. There is a benefit to establishing erosion monitoring stations now, as described below, but it is our opinion that clarification of what other data needs to be collected will be found during the shoreline characterization phase of the LOISS.

The most significant data gap related to coastal processes within the CVC watershed is the lack of shoreline recession rate data. Due to the nature of the unprotected shoreline within the Study Area and the relatively low recession rates, recession rate data is best determined through surveyed profiles. Erosion monitoring stations were established in 1971 and 1972 as part of the Canada/Ontario Shore Damage Survey, but the re-surveying of those profiles was terminated some time ago. New erosion monitoring stations should be established at selected sites on publically owned shoreline within the Study Area. The frequency with which the profiles should be re-surveyed will depend upon the physical characteristics of the site. Dynamic shorelines such as the Rattray barrier beach should be surveyed twice a year for a few years to determine what sort of annual profile shifts take place. Profiles on cohesive shores should be surveyed annually for a few years and then less frequently if little erosion is taking place.

A data gap also exists for the exact extent and existing condition of shoreline protection structures within the LOISS Study Area. An inventory and assessment of publically owned shoreline structures could be carried out using the approach recently employed in Oakville (Shoreplan, 2009). Ranking the condition of those structures could help develop priorities for the potential decommissioning of the hardened shoreline. Privately owned shoreline protection structures could also be assessed but the implications of having a public agency assess the condition of privately owned structures would have to be carefully considered.

Recommended actions and timelines to address the data gaps in Costal Processes have been considered and are summarized in Table 4.3 and Table 4.4. The items in Table 4.3 are actions that we recommend be carried out to fill the data gaps. The items in Table 4.4 show the actions that will be required if other disciplines show a need to fill those data gaps or if future development plans may alter the nearshore regime.

Table 4.3: Coastal Processes Data Gaps – Recommended Actions

Data Gap	Recommended Action	Time Frame	Estimated Cost
shoreline recession rates	establish new erosion monitoring stations and initial surveys	2010 - 2011	$30,000
	future monitoring	2012 +	$15,000 per year with surveys
Condition and extent of shoreline protection structures	inventory and assessment of publically owned structures	2010	$60,000

Table 4.4: Coastal Processes Data Gaps – Potential Actions

Data Gap	Recommended Action	Estimated Cost
Effects of waves on nearshore currents at a specific location	Local bathymetric survey, if required	$10,000
	Numerical modeling of key storm events	$50,000
Influence of proposed shoreline modifications on littoral sediment regime	Local bathymetric survey, if required	$10,000
	Nearshore bottom sediment sampling and analysis	$10,000
	Profile based modeling of average annual transport conditions	$30,000
Influence of proposed shoreline modifications on sub-littoral sediment regime	Local bathymetric survey, if required	$10,000
	Nearshore bottom sediment sampling and analysis	$10,000
	Sediment sampling and circulation driven 2-D modeling on selected storm events	$60,000
Condition and extent of shoreline protection structures	inventory and possible assessment of privately owned structures	TBD

4.5 Water Quality

Work carried out for the Water Quality component showed that there is ample information relating to the concentrations of water quality parameters from storm sewer outfalls and within each of the streams. This information, in turn, can be used to predict pollutant loadings to the Lake for a variety of parameters including phosphorus, solids, metals, and bacteria.

This information was also compared to loadings from the Wastewater Treatment Plants (WWTP) located along the waterfront. A comparison of the results showed that the stormwater runoff loadings exceed (by a factor of 2-4) the loadings from the WWTPs. Some of the key data gaps include:

- Sediment loadings from the streams
- Concentrations for pollutants along the waterfront
- Relative importance of loadings from streams within CVC's jurisdiction vs. in-lake concentrations/loadings from adjacent municipalities (Oakville and Toronto)
- An assessment as to how flows, sediment, and pollutants move along the waterfront

The following items should be undertaken to fill the data gaps. Estimated costs and timing are also provided.

1. Sediment assessments, which will be used to define the quantity of sediments discharging to the Lake, should be taken at two or three key stream outlets to the lake. This work could be undertaken in 2011 at an approximate cost of $50,000

2. Water quality sampling at key locations (typically where historic problems have been identified) should be undertaken to confirm in-lake levels of key water quality parameters. This work can be undertaken in 2010 at an approximate cost of $50,000.

3. The City of Toronto has set up a MIKE 3 model to define how pollutants move along the waterfront. To properly identify how pollutants from the CVC streams or adjacent municipalities move along the waterfront a MIKE 3 model (or equivalent) would need to be set up for the Mississauga waterfront. It will also be necessary to determine the contribution of loadings from Oakville. This exercise could be undertaken at an approximate cost of $75,000.

The main data gaps identified and directions forward are as follows:

1. There are data gaps and discrepancies in the calculations of loads of key pollutants between various studies. Loadings have been calculated for the Credit River using HSP-F. It would be appropriate to use a simplified HSP-F model to calculate loads for the other 13 tributaries, and existing MIKE 3 models can assist with calculating loadings to the waterfront. Such Loadings are essential to delineate and to refine Intake Protection Zones (IPZ). For example, the IPZ for the water treatment plants in the LOISS Study Area identified WWTP effluent as being responsible for an ammonia plume, which has been confirmed by the loading calculation (79% of ammonia loads to the LOISS area are from WWTP), whereas phosphorus loads from WWTP are significantly lower (at 31%).

2. Although there is a general picture of large-scale hydrodynamic circulation of Lake Ontario (see Table 4.1), there is insufficient detail as to how pollutants are dispersed, transported, and mixed with deeper waters. The hydrodynamics variables include the role of winds, storms, seasonal stratification, the thermal bar, and the associated upwelling and downwelling events, will have profound local effects on water quality in the nearshore.

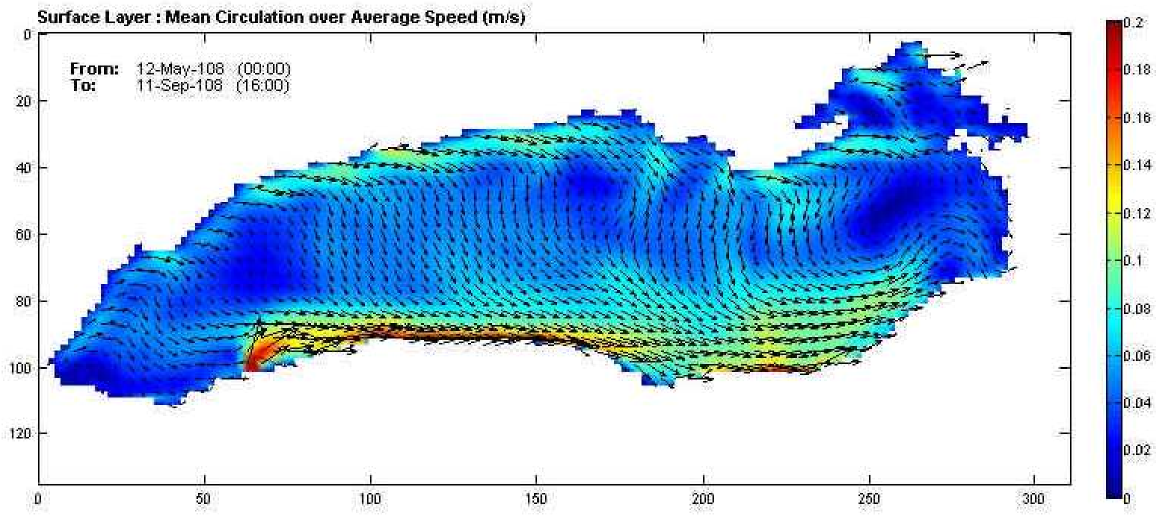


Figure 4.1: Mean Circulation Patterns and Average Velocities (metres/second) in Lake Ontario from May to September 2008 (from University of Waterloo (2009)

3. There are data gaps in the distribution of pathogens in the nearshore, and much of the information sought is gleaned from summaries of work-in-progress presented at workshops and conferences. Pathogens in lake water have significant implications for recreation. A review of beach postings in Mississauga points to some improvement in recent years (Table 4.5). The status and results of continuing studies of pathogens, algal toxins and watershed loadings (as part of the Lake Ontario Collaborative) will be a welcome addition. In the LOISS Study Area, the Lake Ontario and Credit River Pilot Study (MOE 2007 – 2008) entailed biweekly water sampling for bacteria and virus at 3 water treatment plants, one WWTP, and reference sites 10 km offshore of the Credit River and the Humber River. Work proposed for 2009 onwards includes tributary monitoring and modelling to evaluate delivery of nutrients, particulate materials, and fecal indicators to the shoreline; surveys of the shoreline and nearshore to identify characteristics of water quality across the gradient from watershed to offshore lake; deployment of remote instrument-based collection of physical information in the nearshore; and biological surveys of the lakebed to assess distribution of dreissenid mussels, benthic algae (e.g. *Cladophora*), and benthic invertebrates.

Table 4.5: Beach Postings (2006-2009) in Mississauga

Beach Name	Dates of Posting 2006 (E.coli Geo. Mean)	Dates of Posting 2007 (E.coli Geo. Mean)	Dates of Posting 2008 (E.coli Geo. Mean)	Postings June – July 2009
Jack Darling, Mississauga	June 27 (1,084) July 11 July 13	August 21	July 22	0
Richard's Memorial, Mississauga	July 11 July 14 (1,070)	August 14 August 21	July 22 August 26	0
Lakefront Promenade, Mississauga	August 9 August 15 August 22 (2,762) August 29	August 14 August 21	July 22	0

4. The phosphorus cycle has been disrupted since the proliferation of zebra and quagga mussel, whose feeding habits and excretions have effectively short-circuited the natural processes of sedimentation and burial of organic forms of phosphorus (Figure 4.2). Recent studies by the University of Waterloo in Halton (for LOSAAC) and in Durham (for Ontario Power Generation) indicate that phosphorus analysis should include total phosphorus (TP) and soluble reactive phosphorus (SRP) as the biologically-available form of phosphorus. The phosphorus cycle may have to be redefined, since the lake reservoir (even at concentrations below the Provincial Water Quality Objectives) is a virtually inexhaustible reservoir for mussels and algae.

5. A significant data gap concerns the data themselves. Firstly, there is a lack of coherence in Lake Ontario research in that it involves federal, provincial, and state governments in two countries, municipalities, conservation authorities, utilities, and universities, whether singly or as consortia. How much data represent duplication of effort is unknown. Secondly, many researchers have commented that a centralized database of water quality information (e.g. a web portal) would be useful and worthy of funding.

6. There are few water quality analyses of lakes and streams during winter months (December through March). This is significant as it has been demonstrated (for the Duffins Creek watershed) that the greatest loadings occur between January and April.

7. There are sparse sediment sampling data in the nearshore environment in the LOISS area, apart from a reconnaissance study conducted by Environment Canada in 2003. Further work is needed on the role of sediments as reservoirs, sinks, or sources of contaminants, notably with regard to the phosphorus cycle.

Recommended actions and timelines to address the data gaps in water quality have been considered and are summarized in Table 4.6.

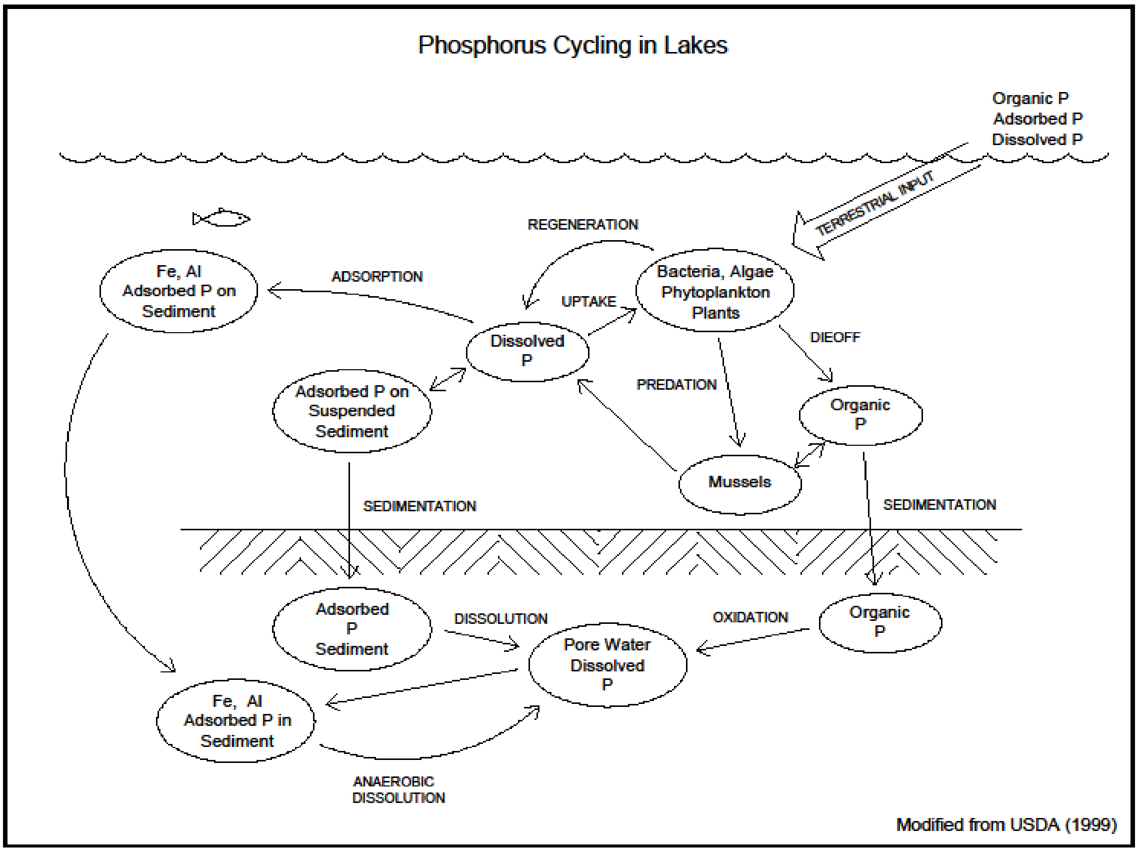


Figure 4.2: The phosphorus cycle in lakes, emphasizing the role of invasive mussels feeding in the transformation of organic phosphorus (from the life-cycle of phytoplankton) and subsequent excretion of bioavailable forms (orthophosphate or soluble reactive phosphorus)

Table 4.6: Approach to Address Water Quality Data Gaps

Recommended Action	Approach	Time Frame	Estimated Cost
Tributary Loading	Simplified HSP-F for 13 tributaries	2010 – 2011	$50,000
Loading and mixing along LOISS waterfront	Existing MIKE-3 model	2010 - 2011	$75,000
Centralized database of water quality data	Agreement to share data (MOE. EC, CA, Region of Peel, OPG, LaMP	2010 - 2011	$50,000
Sediment sampling at mouths of tributaries (except Credit River)	Sinks and reservoirs and role in cycling of pollutants (esp. phosphorus cycle)	2011	$75,000

4.6 Terrestrial Natural Heritage

A number of data gaps or opportunities for future work were identified through the background study for the Terrestrial Natural Heritage portion of the LOISS. Specifically, these gaps and opportunities were as follows:

- A landscape scale analysis will be conducted for the Study Area that will involve the identification and description of potential core areas, supporting areas, and corridors. Micro and macro corridors will be mapped and assessed.

- Landuse mapping will continue throughout the watershed based on Ecological Land Classification definitions and CVC's urban landuse classification system to accurately characterize the landuse of this highly urbanized Study Area. Small natural features that could potentially serve as habitat or corridors within the urban matrix should be identified.

- Detailed mapping of shoreline/nearshore vegetation is not complete. This would be beneficial to identify areas of wildlife habitat and to inform future development of shoreline and riverine areas.

- Any unevaluated wetlands identified through surveys or mapping should be evaluated.

- Terrestrial and wetland communities will be assessed to determine their relative significance in the watershed with regard to several standard parameters (for example: significant wildlife habitat, community rarity or presence of rare species, old-growth forests, etc.)

- Species abundance and species of concern locations should be mapped and documented. Currently information provided by the Mississauga NAS and other incidental reports do not have this level of information or accuracy. This information will, in many cases, be necessary to evaluate against thresholds for Significant Wildlife Habitat criteria.

- Data to accurately and consistently identify Significant Wildlife Habitat across the Study Area is limited. Studies documenting the following parameters should be undertaken:

    - Migratory Waterfowl staging/stopover areas,
    - Migratory Shorebird stopover monitoring,
    - Migrant landbird stopover monitoring,
    - Migratory bat stopover monitoring, and
    - Butterfly and odonate monitoring should be continued over the long-term.

- Turtle surveys should be undertaken on the Credit River, creek mouths, and Rattray Marsh to update species at risk records and verify the presence of turtle species in the lakeshore area.

- Amphibian monitoring should continue in order to assess population changes over time.

- Surveying and monitoring for invasive species along the shoreline and Credit River should be undertaken to control pioneer populations of priority species.

- Restoration opportunities on-the-ground should be identified through field visits and site walks along the shoreline and the various riparian areas. Invasive species locations should be mapped for potential removal and monitoring, pollution or disturbance hot-spots identified, and actions prioritized.

4.7 Hydrogeology

The following data gaps were identified within the Hydrogeology component of the study:

- Groundwater-surface water interactions are not well understood at a local scale. Additional rounds of baseflow measurements should be collected, with more locations to allow for better identifications of discharge locations.
- Properties of the buried bedrock valley are not well understood, and this increases the uncertainty of the characterization of groundwater system. A further review of available geological information, and a scoped field investigation, would be required to significantly improve our understanding of the buried valley properties.
- It would be difficult to quantify groundwater discharge to the lake solely through a hydrogeological field investigation. It may be possible to confirm the presence of groundwater discharge to the lake that was predicted by other indicators (e.g., habitat type). Remote sensing may be an option.
- Groundwater quality does not appear to be negatively affected by urbanization based on the available groundwater quality data from the Cooksville and Sheridan subwatershed studies. There may be unidentified impacts at a more local scale, and these may be identifiable through a review of environmental assessment reports. If there are localized groundwater quality impacts, what is the significance to the natural environment?

4.8 Aquatic Natural Heritage

A number of data gaps were identified within the Aquatic Natural Heritage component of the LOISS and are presented in Table 4.7.

Table 4.7: Aquatic Natural Heritage Data Gaps

Data Gap	Issue	Action
Recreational fishing surveys (MNR)	No data on the use of the area by shore or boat anglers	Conduct seasonal user surveys at various access points in the Study Area. Coordinate with EGS Knowledge Gaps.
Partial/full Barrier inventories including beach deposits	Fish access into smaller tributaries in the study is not well understood	Perform a spring survey to assess seasonal fish access into tributaries
Atlantic salmon research (MNR)	What happens to Atlantic Salmon after returning to the lake is not known	Conduct creel surveys of boat anglers; check stomach contents of

Data Gap	Issue	Action
		retained fish; track angling information (e.g. location, depth, date, etc) from captures
Pacific salmonid competition (MNR)	Scale and effects of competition with Pacific salmonids with native species is not known	
Coaster brook trout (MNR)	Historic reports of brook trout and one recent capture	Continue monitoring of the Streetsville fishway in the fall; genetic analysis of any future brook trout from the lower river
Nearshore fish sampling (abundance/Index of Biotic Integrity)	Only two years of electrofishing data from Lake Ontario sites; hoop netting data has not been fully analysed	Continue Lake Ontario electrofishing; possibly expand to spring and/or fall sampling; finalize hoop netting IBI analysis Investigate opportunity to incorporate key stations into IWMP program
Beach/offshore spawning and locations	Spawning areas for some species like bass, lake trout and forage species has not been identified	Conduct surveys to identify spawning locations
Rearing/nursery habitats	These habitats have not been defined	Determine locations within the Study Area
Species At Risk status	Status of Lake Sturgeon, American Eel in the Study Area is unknown	Conduct surveys to determine use of the Study Area by these species
Wetland evaluations and potential wetland creation areas	Only Rattray Marsh and Turtle Creek have been evaluated. Potential wetland creation sites have not been evaluated	Evaluate other potential wetland and wetland creation sites. Coordinate with Terrestrial Natural Heritage knowledge gaps
Benthic invertebrates	No data on mussel surveys was found	Conduct benthic invertebrate surveys Coordinate with MOE surveys (5 year cycle with next one in 2013)
Nearshore and tributary water temperatures	No data found	Use data from NOAA Great Lakes CoastWatch Program and associated proprietary software (cwsample.exe) to link

Data Gap	Issue	Action
		temperature data with sampling stations Conduct surveys to assess thermal characteristics of the nearshore area. Coordinate with Water Quality Knowledge Gaps.
Areas of aquatic vegetation	Informal vegetation surveys completed (NRSI 2009)	Complete detailed aquatic vegetation surveys to assess species, density and distribution.

4.9 Stewardship, Education and Communications

Although the primary geographic focus will be municipal, Peel, CVC watershed and GTA initiatives, there will be on-going additions to the inventory of shoreline-specific programs/resources from other Great Lakes Basin jurisdictions (eg. other CAs and municipalities, Federal/Provincial, joint US-Canada, US State/Federal, other). A strategic approach responding to the specific needs of the LOISS has been developed as part of the related Communications Strategy.

4.10 Ecological Goods and Services

The following is a summary of knowledge gaps identified as part of the EGS background review:

- The first step to understanding the human dimensions of shoreline management will be characterizing the existing shoreline and nearshore use as far as how the shoreline is being used, values and concerns, and interest in protection and restoration, by the general public, landowners, and other individuals and organizations.

- Since an economic analysis is based on understanding changes, examining the human dimensions of shoreline management with economic tools will require at least an approximate understanding of how things are going to change. Therefore, in addition to characterizing existing uses of the shoreline resource, we will also need to explore the impacts from potential future land, shoreline, and nearshore use scenarios.

- Environmental damages are directly or indirectly linked in some way to the human use of a resource. The Characterization and Impact Analysis phase of the LOISS should also detail existing environmental issues along the shoreline and nearshore environment.

4.11 Prioritization of Data gaps

The previous sections have outlined data gaps for each of the disciplines. The findings have been reviewed with the Technical Steering Committees. Based on these discussions, a timeline has been developed for the studies. A summary of the work plan is presented below by discipline. The work plan is periodically updated based on new information and identification of data gaps.

Action	Lead Agency/ Organization	Partner Agency/ Organization	Location	Study	Status
Conservation Lands/Stewardship, Education, and Communication/Planning					
Current legal opinion on lakebed ownership and riparian rights	CVC		All	Conservation Lands Shoreline Policy	Initiated
Policy review of applicable legislation to identify barriers/needs of Authority for carrying out works (shoreline/lakebed)	CVC		All	Conservation Lands Shoreline Policy	Initiated
Review CVC conservation land agreements with Mississauga – recommendations for integrating LOISS priorities into new lease agreements	CVC	Mississauga DFO MOE	8 CVC-owned properties	All	Initiated
Communications Strategy: Planning and Implementation	CVC	Mississauga Region of Peel	All	Stewardship, Educ and Comm	Ongoing
Workshops: Ratepayer Reps and Corporate	CVC	Mississauga Region of Peel	All	Stewardship, Educ and Comm	Completed
Living by the Lake : Factsheet	CVC		All	Stewardship, Educ and Comm	Completed
LOISS webpage: CVC website	CVC		All	Stewardship, Educ and Comm	Completed
Historic Shoreline Mapping	CVC	University of Toronto at Mississauga	Shoreline	Stewardship, Educ and Comm Coastal Processes	Ongoing
Video	CVC		All	Stewardship, Educ and Comm	Completed (Draft)
Terrestrial Natural Heritage					
Determine current land use in LOISS study area (TEEM LSA)	CVC		All	Terrestrial Natural Heritage	Completed (Draft)
TEEM Landscape scale analysis to identify potential core areas and supporting areas/corridors.	CVC	Mississauga	All	Terrestrial Natural Heritage Conservation Lands	Completed (Draft)
Field truthing/prioritization of restoration opportunities	CVC		All	Terrestrial Natural Heritage Planning	2013++
Integrate TEEM into Greenlands Securement Strategy to guide priority acquisitions in LOISS	CVC	Mississauga	All	Terrestrial Natural Heritage Aquatic Natural Heritage Conservation Lands	2013++

Spring surveys: stopover landbird	CVC	CWS	All Point Count/area searches	Terrestrial Natural Heritage	Ongoing
Spring surveys: staging/stopover areas; shorebird / waterfowl	CVC	CWS MNR	Rattray Port Credit marshes	Terrestrial Natural Heritage	Ongoing
Fall surveys: stopover landbird	CVC		All	Terrestrial Natural Heritage	Ongoing
Fall surveys: staging/stopover areas - waterfowl	CVC		Rattray Port Credit Marshes	Terrestrial Natural Heritage	Ongoing
Radar Interpretation	CVC		All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Surveys: butterfly / odonate monitoring	CVC		All	Terrestrial Natural Heritage	Ongoing
Bat acoustic surveys	CVC		All	Terrestrial Natural Heritage	Ongoing
Amphibian surveys: Breeding	CVC		Rattray Port Credit marshes Turtle Creek	Terrestrial Natural Heritage	Ongoing
Turtle Surveys : Presence/Absence Credit	CVC	MNR	Rattray Port Credit marshes	Terrestrial Natural Heritage	Ongoing
Georeference Species of Conservation Concern	CVC	Mississauga	All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated Miss NAS by North-South but need more detail
Invasive species surveys	CVC		All: shoreline	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Aquatic Natural Heritage					
Shoreline Treatment – NRSI 2009 and Shoreplan	CVC		Aquatic Natural Heritage	Aquatic Natural Heritage	Completed
Broadscale surveys of nearshore vegetation (NRSI 2009)	CVC		Shoreline	Aquatic Natural Heritage	Completed
Detailed Nearshore Vegetation Surveys	CVC		All	Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Habitat: video (JC Saddington)	CVC	C. Chu – Trent U GLIN		Aquatic Natural Heritage Coastal Processes	Completed

Tributaries water temperatures (temp loggers)	CVC	Region of Peel Env Canada	Clearview Avonhead Tecumseh Turtle Applewood	Aquatic Natural Heritage Water Quality	Ongoing
Seasonal fish use (complete) and access into tributaries (2009-2011) Sampling in tributaries where data lacking	CVC	MNR	Shoreline 3 IWMP (Sheridan, Cooksville, Port Credit)	Aquatic Natural Heritage	Completed
Nearshore fish sampling Species at Risk status (e.g. Lake Sturgeon; American Eel) Sample gobies/abundance	CVC	MNR DFO	Shoreline (18-19 stns) 1 IWMP Finalize hoop netting IBI analysis Electrofishin g Seining	Aquatic Natural Heritage	Ongoing
Beach/offshore spawning and locations. Identify rearing/nursery habitatsSpawning areas for some species (e.g. bass; lake trout; forage species) not identified	CVC	MNR	Shoreline	Aquatic Natural HeritageMNR Lake Unit	Planning Initiated
Pike survey	CVC		Rattray Marsh	Aquatic Natural Heritage	Planning Initiated
Airlift Sampling: MOE Divers	CVC	MOE	Transects mouth of tributaries (2m-10m) Shoreline (control)	Aquatic Natural Heritage Water Quality	Planning Initiated
Invertebrate Surveys: benthic insects; dreissenid mussel	CVC	MOE Env Can / CWS	Shoreline (6 stns) (1) Kick and Sweep (nearshore) (2) Ponar (offshore)	Terrestrial Natural Heritage Aquatic Natural Heritage Water Quality	Completed (2011)
Gill Netting	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	Planning Initiated
MNR recreational fishing: conduct seasonal user surveys at various access	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority

points in the study area.					
Atlantic salmon research: conduct creel surveys of boat anglers; check stomach contents of retained fish; track angling information (e.g. location, depth, date, etc) from capture	MNR	CVC	Shoreline/Offshore	MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority
Pacific salmonid competition: scale and effects of competition with Pacific salmonids with native species not known	MNR	CVC		MNR Lake Unit Aquatic Natural Heritage	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		MNR Lake Unit Aquatic Natural Heritage	Not CVC Priority
Hydrology and Hydraulics					
Map Ice Cover using existing data from NOAA	CVC		Shoreline	Hydrology and Hydraulics Coastal Processes	2013++
Precipitation data collection and maintenance of stations Replacement of Station 1 gauge with heated gauge	City of Mississauga	CVC		Hydrology and Hydraulics	Ongoing
Sediment loading to Lake Ontario from Cooksville Creek (suspended? bedload?)	CVC	Mississauga	Cooksville	Hydrology and Hydraulics Fluvial Geomorphology Aquatic Natural Heritage	2013++
Sediment loading to Lake Ontario for Serson, Applewood, Lornewood, and Birchwood Creeks	CVC	Mississauga	All	Hydrology and Hydraulics Fluvial Geomorphology	Planning Initiated Lakeview Waterfront Connection Inspiration Lakeview
Sediment loading to Lake Ontario from Sheridan Creek (suspended? bedload?)	CVC	Mississauga	Sheridan	Fluvial Geomorphology Aquatic Natural Heritage	2013++

Geomorphic Solutions (2007) Sedimentological Study of Rattray Marsh					
Real-time flood forecast and climate vulnerability	CVC	Mississauga		Hydrology and Hydraulics	2013++
Real-time rainfall and streamflow data	CVC	Mississauga		Hydrology and Hydraulics	2013++
Imperviousness	CVC	Mississauga	Clearview Creek Credit River Cumberland Creek Moore Creek Sheridan Creek	Hydrology and Hydraulics Aquatic Natural Heritage	2013++
Drainage Area	CVC	Mississauga	Cumberland Creek Moore Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Cumberland Creek including floodplain mapping[1]	CVC	Mississauga	Cumberland Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Moore Creek including floodplain mapping[1]	CVC	Mississauga	Moore Creek	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling of Cooksville including floodplain mapping	Mississauga	City	Cooksville Creek	Hydrology and Hydraulics	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	Credit River	Hydrology and Hydraulics	2013++
Hydrological and hydraulic modeling (2 to 25 yr) Avonhead Creek including floodplain mapping: n of Lakeshore; western portion of watershed (post dev)	CVC	Mississauga	Avonhead Creek	Hydrology and Hydraulics	2013++
List of overtopped structures and flooded buildings - Avonhead; Cumberland; Moore Creeks	CVC	Mississauga	Avonhead Creek Cumberland Creek Moore Creek	Hydrology and Hydraulics	2013++

Hydrogeology					
Geological Cross-Sections	CVC			Hydrogeology	Completed
Quantification of groundwater contributions in baseflows to tributaries of L. Ontario, and other groundwater-surface water interactions	CVC	MOE	28 stations (2 per tributary) Public access	Hydrogeology	Ongoing GW or lake upwellings? Piezometers? Temp probes?
Integrate baseflow measurements with Aquatic Natural Heritage and Water Quality	CVC			Hydrogeology ANH Water Quality	Planning Initiated
Orientation, size, and infill material for the buried bedrock valley	CVC	MOE	All	Hydrogeology	2013++
Groundwater Quality: local scale impacts?	CVC	MOE	All	Hydrogeology Water quality	2013++
Groundwater Discharge: Scope	CVC	MOE	All	Hydrogeology Terrestrial Natural Heritage Aquatic Natural Heritage	2013++
Water Quality					
Centralized database of water quality data: agreement to share data	MOE	CVC	All	Water Quality	Not CVC Priority
Upgrade existing MIKE3 model to define how pollutants move along waterfront. 270 m grids (basin); 90 m grids (local) Flow Monitors?? (MOE - In-Kind)	CVC Ray Dewey Ram Yerubandi Gary Bowen	Environment Canada Region of Peel MOE Mississauga	Shoreline and Tributaries	Water Quality Coastal Processes	Completed (Draft)
Phosphorus EMC values	CVC	Region	All	Water Quality	Completed
HSP-F model for remaining tributaries	CVC	Environment Canada and/or MOE, Mississauga	Shoreline and Tributaries	Water Quality Ecological Goods and Services	Planning Initiated
Integrate WQ data City of Mississauga Goose Mgmt Program	City	CVC	Shoreline and Tributaries	Water Quality Terrestrial Natural heritage	Planning Initiated

Water quality sampling at key locations of key parameters	CVC	EC and MOE	4 stations @ mouths Cooksville Sheridan Clearview Serson	Water Quality Fluvial Geomorphology Aquatic Natural Heriage	Ongoing
Sampling Credit River at Mississaugua Golf Course · Event Sampling (6-8 samples over season) · Winter Sampling · Install Stream Gauge (ice - bridge)	CVC	MOE	Credit River	Water Quality	Ongoing
Divers Algae, phosphorus / nitrates transects	CVC	MOE	2 stations	Water Quality Aquatic Natural Heritage	Planning Initiated
Key pollution sources and impact on environmental quality/health		Environment Canada MOE Mississauga	Shoreline and Tributaries	Water Quality Ecological Goods and Services	Planning Initiated
Thermal Monitoring: Nearshore and Offshore transects	Environment Canada	CVC	4 stations @ mouths CooksvilleSheridan ClearviewSerson	Water QualityFluvial GeomorphologyAquatic Natural Heritage	Ongoing (monitor installed)2011 -2013
Coastal Processes					
Develop Coastal Shoreline Monitoring Protocol: IWMP	CVC	Region of Peel MOE Env Can TRCA	Shoreline	All	Planning Initiated
Document detailed historic shoreline events, changes since 1988	CVC		All	All	Completed.
Inventory and assess public protection structures Effects of Piers	CVC	Mississauga	Shoreline	Coastal Processes	Planning Initiated
Inventory and assess private protection structures Effects of Piers	CVC	Mississauga	Shoreline	Coastal Processes	2013++
Assess effect of waves on nearshore currents	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific
1-D littoral sediment transport analysis	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific
2-D littoral or sub-littoral sediment transport analysis	CVC	Mississauga	Shoreline	Coastal Processes	Site-specific

Collection of baseline cross shore bathymetric data, sediment composition and underwater video	CVC		All	All	Completed
Bathymetry (JC Saddington)	City of Mississauga	CVC	Shoreline	Coastal Processes Aquatic Natural Heritage	Completed
Establish erosion monitoring stations and initial surveys Aerial photos: 35 year review	CVC	Mississauga	Shoreline	Coastal Processes	Ongoing
Aerial photos: Annual	CVC		Shoreline	Coastal Processes Aquatic Natural Heritage	Planning Initiated
LiDAR Survey: water penetrating	CVC	Cons Halton TRCA	Shoreline	Coastal Processes Terrestrial Natural Heritage Aquatic Natural Heritage	Planning Initiated
Seasonal fluctuations as station surveys spring/summer/storm events	CVC		Shoreline	Coastal Processes Aquatic Natural Heritage	2013
Resuspension of sediments	CVC	MOE	Nearshore	Coastal Processes Water Quality	Planning initiated
Ecological Goods and Services					
Public perception survey (and literature review)	CVC		All	Ecological Goods and Services Conservation Lands Stewardship, Education and Communications	Completed
Cost - Benefit Analysis of Restoration Options	CVC	Mississauga Region of Peel	All	Economics	Planning Initiated
Fluvial Geomorphology					
Cross-section/ longitudinal/planform data collected but not analysed	CVC		All	Fluvial Geomorphology	Planning Initiated
Seasonal backwater impact on biological elements (suspended sediment data collection - coastal process inetegration - FG detailed substrate analysis)	CVC	CVC	Applewood Lakeside Turtle	Fluvial Geomorpholoy Aquatic Natural Heritage Terrestrial Natural Heritage	2012 -

Assessment to determine feasibility of replacement of concrete channel with naturalized channel for Reach 1 of Clearview Creek (455 m)	Mississauga	CVC	Clearview	Fluvial Geomorphology Aquatic Natural Heritage Terrestrial Natural Heritage	Waterfront Parks Management Strategy
Assessment to determine feasibility of restoration of Serson Creek	Mississauga: Inspiration Lakeview	CVC	Serson	Fluvial Geomorphology Aquatic Natural Heritage Terrestrial Natural Heritage	Planning Initiated Lakeview Waterfront Connection Inspiration Lakeview
Assessment to determine feasibility of daylighting of Lornewood Creek Reach 1 (340 m)	CVC	Mississauga	Lornewood	Fluvial Geomorphology	2013++
Assessment to determine feasibility of daylighting of Birchwood Creek Reach 2 (450 m)	CVC	Mississauga	Birchwood	Fluvial Geomorphology	2013++

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Through the review of documents and data sources and completion of field assessments, the available information on the LOISS Study Area has been compiled. Technical assessments have been completed to outline the undertakings required to address the identified data gaps. The most important product from this Background Review and Data Gap Analysis report is the timeline of projects resulting from the prioritization of the data gaps. This timeline identifies the lead agency/organization as well as any partner agencies/organizations.

The Background Review and Data Gap Analysis Report will be beneficial to Credit Valley Conservation as well as the City of Mississauga, the Region of Peel, the Ministry of Natural Resources, and the Ontario Ministry of the Environment in terms of coordination of planning and programming within the Study Area.

5.2 Recommendations

Numerous studies have been identified to address the data gaps identified in this phase of the LOISS. Of these studies, the majority will be undertaken by CVC as part of their mandate. Those studies to be emphasized are the ones which involve CVC as well as partner organizations such as the City of Mississauga, The Region of Peel, and the provincial and federal governments. These key studies are as follows:

- Communications strategy,
- Water quality modeling program for phosphorus,

- Centralized database for water quality,
- Water quality loadings from tributaries,
- Sediment program examining loads and transport,
- Inventory of public shoreline treatments, and
- Establishment of shoreline erosion monitoring stations.

The Mississauga Waterfront Parks Strategy (MWPS) should be referenced during the inventory of public shoreline treatments as it contains an inventory completed by Baird and Associates as part of the MWPS.

The proposed timeline provides a prioritization of the studies and surveys designed to address the data gaps. Adherence to the schedule will ensure that the required data are collected and that initiatives and planning associated with the LOISS Study Area are carried out in a timely manner. The summary of background information and the timeline to address knowledge gaps will form the basis for the next two phases of the LOISS, the Shoreline Characterization and Impact Analysis and the Shoreline Restoration Plan.

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APPENDIX A – HYDROLOGY AND HYDRAULICS

APPENDIX B – FLUVIAL GEOMORPHOLOGY

APPENDIX C – COASTAL PROCESSES

APPENDIX D – WATER QUALITY

APPENDIX E – TERRESTRIAL NATURAL HERITAGE

APPENDIX F – HYDROGEOLOGY

APPENDIX G – AQUATIC NATURAL HERITAGE

APPENDIX H - ECOLOGIC GOODS AND SERVICES

APPENDIX I – CONSERVATION LANDS