The Canal and Mitchell Lakes, Talbot River and Whites Creek Subwatershed Plan

2016

KAWARTHA CONSERVATION
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Lake Simcoe Region
conservation authority

The Canal and Mitchell Lakes, Talbot River, and Whites Creek Subwatershed Plan

2016

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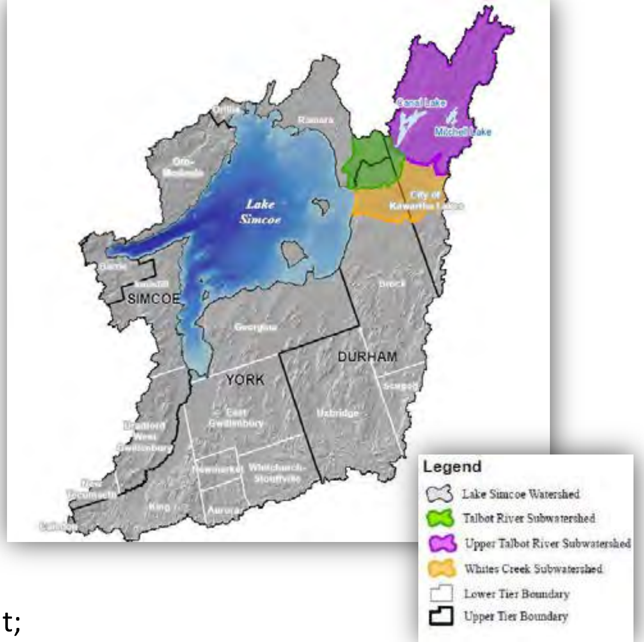
The Canal and Mitchell Lakes, Talbot River, and Whites Creek Subwatershed Plan (2016)
Executive Summary

WHAT IS A SUBWATERSHED PLAN?

Subwatershed planning is a process whereby the components of the environmental system are characterized, the stresses and demands on that system are identified, and actions are recommended to guide the management of the subwatershed. These demands can be from urban and agricultural land uses and recreation and also include the ecological needs of the system. Social and economic factors are also considered through the subwatershed planning process.



A subwatershed plan will normally include recommendations around:

- Maintenance or enhancement of fish habitat;
- Protection of the integrity of both hydrological and hydrogeological functions;
- Improvement of water quality;
- Conservation of wetlands and woodlands;
- Stormwater management;
- Conservation and restoration of ecologically functional natural features and corridors; and,
- Land-use planning.

Maintenance of the ecological processes of the subwatershed through the retention of key natural heritage features, sufficient supplies of ground and surface water, and the protection of water quality and aquatic habitat, while planning for urbanizing land uses and landscape restoration, are integral to the subwatershed planning process.

Subwatershed plans are often implemented through the incorporation of policies into municipal planning documents, including Official Plans; Secondary, District, or Community Plans; and subsequent development applications.

CONTEXT

This subwatershed plan looks at the lakes, rivers and tributaries that make up the Canal and Mitchell Lakes, Talbot River, and Whites Creek subwatersheds, located in the northeast of the Lake Simcoe watershed. The subwatersheds fall within the upper tier municipalities of Simcoe County, Durham Region, and the City of Kawartha Lakes, as well as the lower tier municipalities of the Township of Ramara and the Township of Brock. The Whites Creek and Talbot River subwatersheds are 10,540 ha and 36,908 ha in area, respectively. Canal and Mitchell Lakes are located completely within the Talbot River subwatershed and measure 846 ha and 275 ha in area, respectively.

The dominant land use in these subwatersheds is agriculture, which accounts for slightly more than half of the subwatershed area in Whites Creek (59%), and 20% of the area in Talbot River. Natural heritage cover, including wetlands, forests, and grasslands, accounts for 76% and 38% of the Talbot River and Whites Creek subwatersheds, respectively. The remaining land is comprised of urban areas, rural development, roads and railways, aggregate operations, and golf courses.

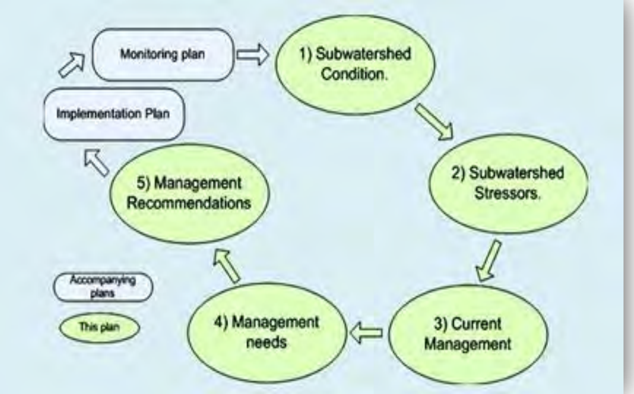
This subwatershed plan was prepared under the direction of the Lake Simcoe Protection Plan (LSPP), which was released by the province in 2009. The LSPP identifies the preparation of subwatershed evaluations/plans as a crucial stage in its implementation. The LSPP states that they “will be critical for prioritizing actions, developing focused action plans, monitoring and evaluating results…[and will] provide more detailed guidance for area-specific hydrologic and natural heritage resource planning and management.”

It should be noted that the Lake Simcoe Region Conservation Authority’s (LSRCA’s) Integrated Watershed Management Plan (IWMP) (2008) also influenced the development of this subwatershed plan. The IWMP is considered to be a road map that outlines the future direction of the protection and rehabilitation of the entire Lake Simcoe watershed. Its broad-scale recommendations provide the basis for a number of this plan’s recommended actions for the smaller scale Talbot River and Whites Creek subwatersheds; these two reports are meant to complement each other.

APPROACH

The initial focus of this subwatershed planning exercise used an ecosystem approach. This approach takes into consideration all of the components of the environment to assess the overall health of the environment in the subwatershed, including consideration of the movement of water through the system, land use, climate, geology, and local species. Everything is intricately related; changes in any one area can have significant effects on others.

This subwatershed plan includes an analysis of water quality, water quantity, aquatic habitat, lake health and terrestrial habitat (e.g. wetlands, forests, and grasslands). Each chapter follows an identical format loosely structured around a *state-pressure-response* framework. Each chapter begins with a description of the current condition (*state*), then describes the stressors likely leading to the current condition (*pressure*), and finally provides recommendations for improvement (*response)*.



State-pressure-response framework

Based on this analysis, a separate document, known as an "Implementation Plan", was developed to act upon the recommendations made in the subwatershed plan. The implementation plan was prepared by LSRCA and Kawartha Conservation staff, and reviewed by a subwatershed plan working group comprised of representatives from municipalities, provincial ministries, conservation authorities and community group representatives. The Implementation Plan will become the common work plan used in long term protection and rehabilitation efforts.

STATUS

Water Quality – The monitoring network for the subwatersheds can be separated into two areas – the Upper Talbot River, which is monitored by Kawartha Conservation and the Lower Talbot River / Whites Creek, which is monitored by LSRCA. Water quality sampling in the Upper Talbot River includes three water quality stations on major tributaries, two stations at the Canal Lake and Mitchell Lake outlets and three water quality stations on the lakes (two on Canal and one on Mitchell). Within the Lower Talbot River and Whites Creek, three long-term stations and nine spot check stations were used for water quality monitoring.

Water quality samples are generally tested for a number of substances, such as phosphorus, chloride and suspended sediments. Sampling in the Upper Talbot River occurred between 2013 and 2015, while the station located in the Lower Talbot River and Whites Creek have been regularly sampled since 1993/1994. In addition, a number of 'spot-check' samples were taken twice at seven locations in the Lower Talbot River and Whites Creek area in May 2013 to provide some indication of the spatial distribution of water quality.

The data from the water quality stations shows relatively few exceedances of relevant guidelines, with phosphorus being the main parameter of concern. For example, 31% of the samples taken at the Whites Creek station have exceeded the phosphorus guidelines, while 16% and 17% of the samples collected from the Lower Talbot and Upper Talbot River stations have exceeded this guideline. Though some trends for nitrates and TSS were increasing in the short-term period, very few of the samples collected at the Lower Talbot River and Whites Creek stations between 1993 and 2014 exceeded the Canadian Water Quality Guidelines for these parameters. Samples taken at the spot-check sites showed exceedances of phosphorus guidelines, with all of these seen in the samples taken during high flows. This indicates that rain events are likely causing the movement of phosphorus into the watercourses by causing soil to erode (particularly in areas that lack streamside vegetation), and washing fertilizers, manure and pet excrement, as well as other phosphorus-containing contaminants from lawns, fields, and streets and other hard surfaces into area streams. Chloride, the most common source of which is winter salt use for de-icing, has not been shown to be of concern at these stations except for one exceedance in the Talbot River. These low concentrations may be due to the rural nature of the surrounding land uses in this area, as chloride concentrations are typically higher in urban areas.

Water Quantity – Groundwater in the subwatershed generally flows in a westward to south-westward direction toward the eastern shores of Lake Simcoe. Many of the surface water features in the Whites Creek subwatershed are sustained by groundwater discharge that comes from recharge areas located in the Talbot River subwatershed. The silt-dominated surficial geology that characterizes the subwatershed reduces the recharge capacity of the landscape in this subwatershed. Under a drought scenario, the headwater tributaries in the study area would be the most significantly affected surface water features. Because of their strong reliance on groundwater discharge, these tributaries are sensitive to very small changes in groundwater levels.

Groundwater recharge is the process by which rain and melting snow percolate from the surface through the soil to replenish groundwater stores (which also ensures that there is a water source for streams and wetlands). In order to protect this process, areas referred to as Significant Groundwater Recharge Areas have been identified for the study area. This work has been further refined to identify Ecologically Significant Groundwater Recharge Areas, which are areas thought to contribute to ecologically important features such as streams and wetlands in the study area. The highest groundwater recharge rates in the study area are found across the Carden Plain alvar in the Upper Talbot River subwatershed.

Aquatic Natural Heritage – Fish communities in this subwatershed vary; of the twenty sites that were surveyed, seven sites exhibited 'Good' conditions according to the Index of Biotic Integrity used to evaluate fish community health, eleven exhibited 'Fair' conditions, one exhibited 'Poor' conditions, and at the remaining site no fish were caught.
Stream temperature data combined with fish community data, suggest that warmwater and coolwater conditions are dominant throughout the Talbot River and Whites Creek subwatersheds. However, cold water indicator species have been documented within the Whites Creek subwatershed. This is likely due to consistent cold water inputs from groundwater discharge areas. Overall, 43 fish species were found in the study area; some of the notable species caught at these sites include mottled sculpin (*Cottus bairdii*), Northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieu*), and largemouth bass (*Micropterus salmoides*). The healthiest sites were found within, and downstream, of large tracts of natural heritage areas with minimal disturbance. Communities of benthic invertebrates (organisms that live at the bottom of rivers and lakes) also vary within the subwatershed, with ratings ranging from 'Good' to 'Very Poor'. Warm water, barriers to migration, inputs of sediment and nutrients, and lack of riparian cover limit the aquatic communities that can be supported by the watercourses in this subwatershed. Conditions can be improved through stream rehabilitation, wetland protection, streambank planting, and treating stormwater run-off from both urban and agricultural areas.

Lake Health - Canal and Mitchell Lakes are a part of a chain of lakes known as the Kawartha Lakes, and are part of the navigable route of the Trent-Severn Waterway system. The waters from these lakes flow through the Talbot River, discharging into Lake Simcoe. The total length of lake shoreline in the subwatersheds is over 70km, and while much of it remains naturalized, over 25% has been developed to some extent.
Both Canal and Mitchell Lakes, as well as the nearshore area of Lake Simcoe, have extensive amounts of aquatic vegetation, resulting from water conditions that are clearer, warmer and more sediment and nutrient rich. Based on studies conducted in 2013, Mitchell Lake has relatively biodiverse community of native pondweeds, while Canal Lake is almost entirely

dominated by the invasive Eurasian water milfoil (*Myriophyllum spicatum*). There was a decrease in aquatic plant biodiversity in Lake Simcoe between 2008 and 2013, and several invasive species are also present. Water quality in Canal and Mitchell Lakes is relatively good, with average phosphorous concentrations below guidelines. However, in Lake Simcoe, the area near the outlet of the Talbot River has one of the highest sediment phosphorus concentrations in the entire lake.

The Terrestrial Natural Environment – These features include woodlands, wetlands, grasslands, and riparian (streambank) habitat, and account for approximately 76% of the land area in the Talbot River subwatershed, and 38% of the Whites Creek subwatershed. Woodlands cover 35% and 22% of these subwatersheds, respectively, close Environment Canada's guideline of 30%, as outlined in its '*How much habitat is enough*' document. The Environment Canada guideline is seen as a minimum forest cover threshold (considered to be a 'high risk' approach that will not support the healthiest systems).

With respect to wetland cover, the subwatersheds have very healthy levels, at 22% (Talbot River) and 24% (Whites Creek); this is well above Environment Canada's recommended wetland cover level of 10%. There are fairly high levels of natural cover along the watercourses of the Talbot River subwatershed, with over 80% of this area being in natural cover. In Whites Creek, this value is lower, with only 53% natural riparian cover. Environment Canada recommends that at least 75% of the 30 metre riparian buffer be in natural vegetation. Agriculture, recreation, increases in urban area, and climate change are the concerns for the natural environment features in these subwatersheds.

RECOMMENDATIONS

Recommendations based on analysis of the current conditions and stressors are provided in each chapter of this subwatershed plan. There are approximately 105 recommendations in total, with some pertaining to all of the partners involved in the development of the plan, including the LSRCA, Kawartha Conservation, municipalities, and the provincial ministries of Natural Resources and Forestry, Environment and Climate Change, and Agriculture, Food, and Rural Affairs. Through policies in the Lake Simcoe Protection Plan, it is expected that municipal Official Plans will be made consistent with these recommendations.

These recommendations include:

- Develop an adaptive stewardship strategy to identify, implement and track stewardship projects in the study area subwatersheds, in order to improve aquatic habitat and water

quality, promote infiltration of precipitation, reduce invasive species, and broaden the extent of natural features;
- Adopting policies that protect the recharge of groundwater;
- Educating members of the public and targeted industries on topics including the dangers of using invasive species in horticulture, the importance of maintaining groundwater recharge areas, good practices for the use of road salt to minimize environmental impacts, and the ecology of aquatic plants, and how to properly manage them on their property;
- Developing an environmental monitoring strategy for Canal Lake, Mitchell Lake and the Talbot River subwatershed, addressing limitations and gaps in existing data, parameters to be studied, agencies involved, and potential funding sources;
- Studying the potential impacts of climate change and developing plans to limit its impacts;
- Researching and using new and innovative solutions, such as Low Impact Development practices, to address uncontrolled stormwater in urban areas; and,
- Working to make information about the health of the subwatershed readily available to all stakeholders.

NEXT STEPS

These recommendations form the basis of the Implementation Plan, which is the framework and process for acting on the recommendations. The Implementation Plan prioritizes the recommendations, identifying activities to be carried out to achieve each of the priority recommendations. It also identifies the milestones to be met, specific deliverables, and partners' responsibilities. The implementation process will also include regular tracking of activities to ensure that milestones are being met.

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1 Approach and Management Setting

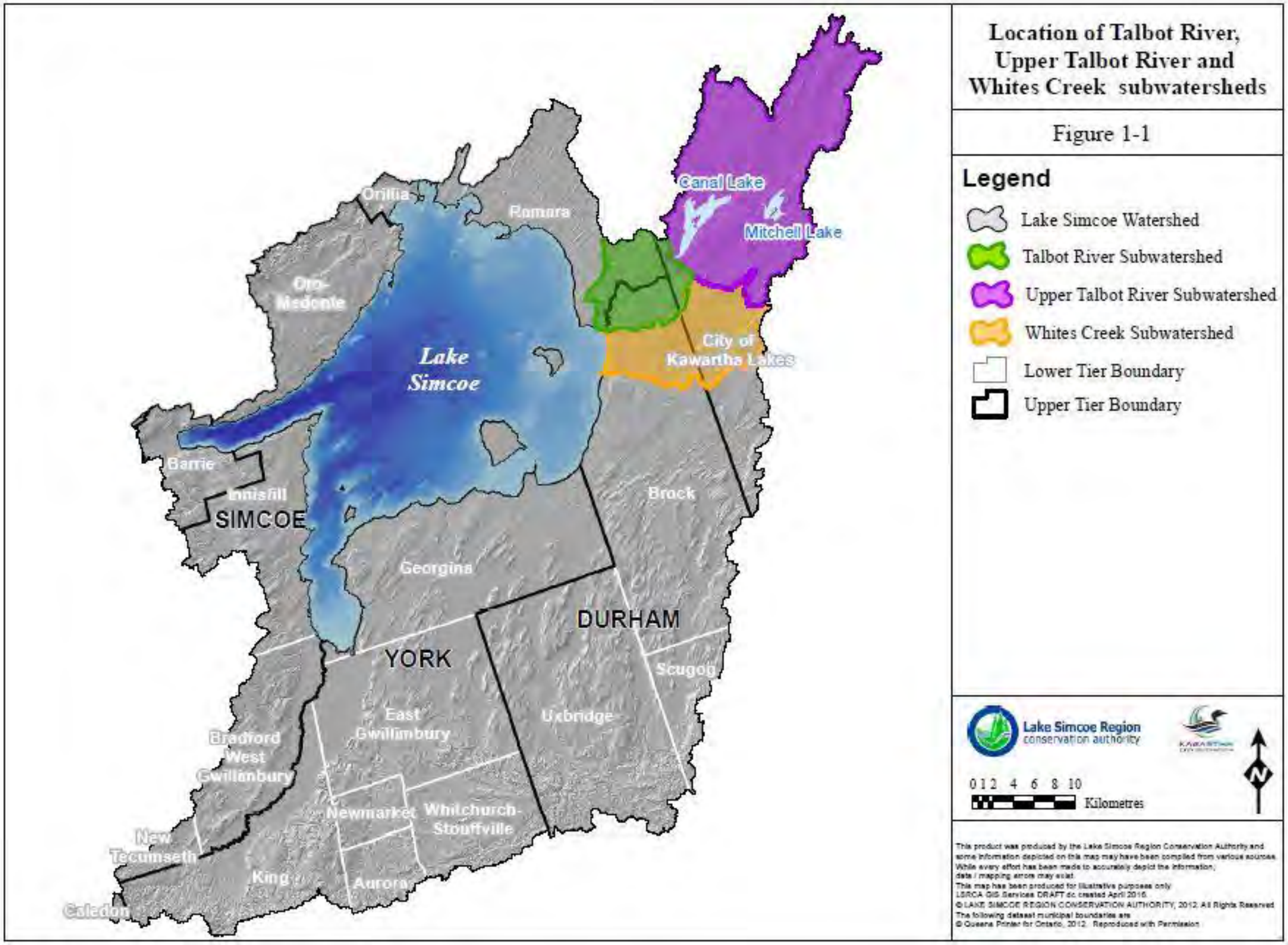
1.1 Introduction

The Whites Creek (WC) and Talbot River (TR) subwatersheds, located in the northeast section of the Lake Simcoe watershed, are comprised of a series of lakes, rivers, creeks and drains that flow directly into Lake Simcoe. The subwatersheds are 10,540 ha and 36,908 ha in area, respectively, comprising a total of 34% of the Lake Simcoe watershed. The subwatersheds fall within the upper tier municipalities of Simcoe County and Durham Region as well as the lower tier municipalities of the City of Kawartha Lakes, the Township of Ramara and the Township of Brock (Figure 1-1). Canal and Mitchell Lakes are located completely within the Talbot River subwatershed and measure 846 ha and 275 ha in area, respectively.

Agriculture is the dominant land use in the Whites Creek and Talbot River subwatersheds, occupying 58.9% of the area in Whites Creek and 20.0% of the area in the Talbot River. The majority of land use in this area is for hay and pasture, while the remainder is in crop land. Natural areas such as wetlands (24.0% [WC]; 22.3% [TR]), upland forest (7.1% [WC]; 18.9% [TR]) and grassland (6.2% [WC]; 28.2% [TR]) also comprise a significant portion of the subwatersheds' land area. Other land uses include urban areas (1.1% [WC]; 1.4% [TR]) and rural development (0.8% each) of the subwatershed area. As mentioned above, the subwatershed consists of a series of creeks and rivers that flow into the lake. These systems include the Alsops Beach Creek, Whites Creek and the Talbot River. Most of these watercourses originate in agricultural areas, or in the wetland (treed swamp) areas in the extreme northern section of the subwatershed. Most of the subwatershed's urban areas fall near the shorelines of Lake Simcoe, Talbot River, Canal Lake and Mitchell Lake.

In the Lake Simcoe watershed, the various land uses have had considerable impacts on water quality and quantity, as well as aquatic and terrestrial habitats. In order to mitigate the impacts of land use changes in each of the subwatersheds, and to prevent future impacts, subwatershed plans are developed. This plan provides a framework for the implementation of remedial activities and a focus for community action. More importantly, it helps to prevent further serious degradation to the existing environment and can reduce the need for expensive rehabilitation efforts. Subwatershed plans provide a framework within which sustainable development can occur.

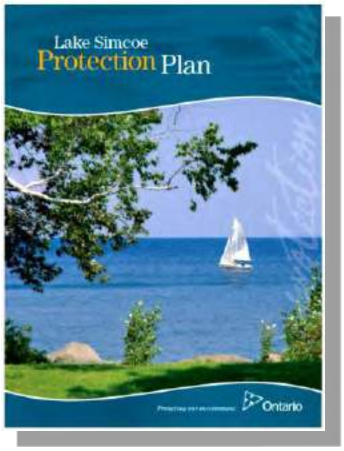
As part of the requirements through the Lake Simcoe Protection Plan (LSPP), subwatershed evaluations need to be developed and completed for priority subwatersheds within five years of the Plan coming into effect. Subwatershed plans for York Region (includes the East and West Holland Rivers, Maskinonge River and Black River subwatersheds) were completed in 2010 and Durham Region (includes the Beaver River and Pefferlaw Brook subwatersheds) in 2012. Subwatershed plans for the City of Barrie (includes Barrie Creeks, Lovers Creek and Hewitts Creek subwatersheds) and the Town of Innisfil (includes Innisfil Creek subwatershed) were completed in late 2012. A subwatershed plan for the Oro and Hawkestone Creeks subwatersheds was completed in 2013, and a subwatershed plan for Ramara Creeks was completed in 2015. The evaluation of the Whites Creek and Talbot River subwatersheds, as well as Canal and Mitchell Lakes will reflect the goals, objectives, and targets of the Lake Simcoe Protection Plan and will be tailored to the needs and local issues of the area.



This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only
LSRCA GIS Services DRAFT dc created April 2016.

Figure 1-1: Location of the Whites Creek and Talbot River subwatersheds

1.2 Subwatershed Evaluation Requirements within the Lake Simcoe Protection Plan



The Lake Simcoe Protection Plan (LSPP), released by the Province in 2009, aims to be a comprehensive plan to protect and restore the ecological health of the lake and its watershed. Its priorities include restoring the health of aquatic life, improving water quality, maintaining water quantity, and improving ecosystem health by protecting and rehabilitating important areas, as well as addressing the impacts of invasive species, climate change, and recreational activities.

Preparation of subwatershed evaluations/plans is identified as a crucial stage in implementation of the LSPP. The LSPP states that subwatershed plans “will be critical in prioritizing actions, developing focused action plans, monitoring and evaluating results… The plans will provide more detailed guidance for area-specific hydrologic and natural heritage resource planning and management”

Policies within the LSPP guiding the preparation of this subwatershed plan are:

8.1-SA Within one year of the date the Plan comes into effect, the MOE and LSRCA in collaboration with other ministries, the First Nations and Métis communities, watershed municipalities, the *Lake Simcoe Coordinating Committee* and the *Lake Simcoe Science Committee* will develop guidelines to provide direction on:

a. identifying sub-lake areas and subwatersheds of the *Lake Simcoe watershed* and determining which sub-lake areas and subwatersheds are of priority;

b. preparing subwatershed evaluations including, where appropriate, developing subwatershed-specific targets and recommending actions that need to be taken within subwatersheds in relation to:

    i. the phosphorus reduction strategy (Chapter 4),

    ii. stormwater management master plans, including consideration of the amount of impervious surfaces within subwatersheds (Chapter 4),

    iii. water budgets (Chapter 5),

    iv. instream flow regime targets (Chapter 5),

    v. preventing *invasive species* and mitigating the impacts of existing *invasive species* (Chapter 7),

    vi. natural heritage restoration and enhancement (Chapter 6),

    vii. increasing public access (Chapter 7), and

    viii. climate change impacts and adaptation (Chapter 7);

c. monitoring and reporting in relation to subwatershed targets that may be established; and

d. consultation to be undertaken during the preparation of the subwatershed evaluations.

8.2-SA In developing the guidance outlined in 8.1, the partners identified above will develop approaches to undertake the subwatershed evaluations in a way that builds upon and integrates with source protection plans required under the Clean Water Act, 2006, as well as relevant work of the LSRCA and watershed municipalities.

8.3-SA Within five years of the date the Plan comes into effect, the LSRCA in partnership with municipalities and in collaboration with the MOE, MNR, and MAFRA will develop and complete subwatershed evaluations for priority subwatersheds.

8.4-DP Municipal official plans shall be amended to ensure that they are consistent with the recommendations of the subwatershed evaluations.

This plan is being developed to meet requirements of policy 8.3-SA, while also following requirements of policies 8.1-SA and 8.2-SA. Ensuring municipal Official Plans are updated in accordance with policy 8.4-DP is identified as an activity within the associate implementation plan.

This subwatershed plan aims to be consistent with the themes and policies of the Lake Simcoe Protection Plan to ensure a consistent approach is being taken by all of the partners toward improving watershed health.

The ecosystem approach to environmental management takes into consideration all of the components of the environment. These components include the movement of water through the system, the land use, climate, geology, human communities, and all of the species that comprise the community living in the system. These ecosystem components are all intricately related, and changes in any can have significant effects on the others.

To manage natural resources using an ecosystem approach it is essential to establish biophysical boundaries. In the Lake Simcoe watershed, the subwatersheds or river systems that drain into the lake have been identified as the best “fit” for the implementation of an ecosystem study because they are virtually self-contained water-based ecosystems (OMOE and OMNR, 1993). Watersheds are defined as the area of land drained by a watercourse and, subsequently, the land draining to a tributary of the main watercourse (Lake Simcoe is the “main watercourse” in this case) is called a subwatershed. Watershed processes are controlled by the hydrologic cycle (Figure 1-2). The movement of water influences topography, climate, and life cycles. It is due to this connectivity that any change within the watershed will impact other parts of the subwatershed.

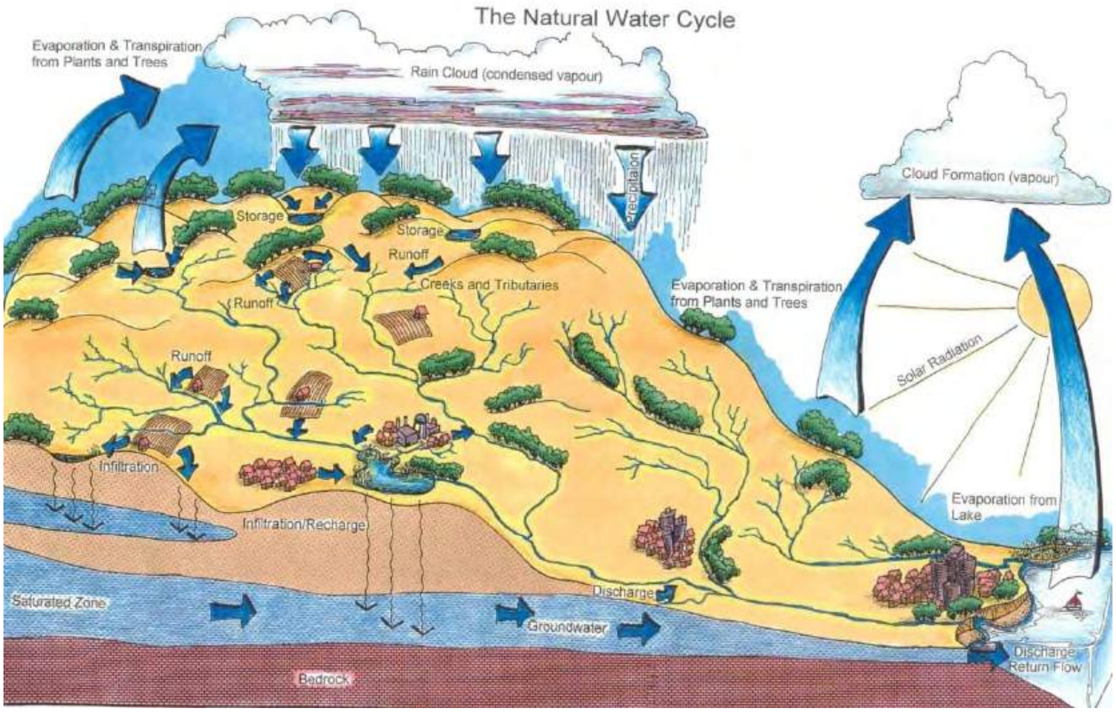


Figure 1-2: The hydrological cycle (image courtesy of Conservation Ontario).

1.2.1 Subwatershed Planning Context

This subwatershed plan has been written firstly to comply with the requirements under the province's Lake Simcoe Protection Plan. However there are other documents that have influenced and fed into the development of this plan and its recommendations. The LSRCA's Integrated Watershed Management Plan (LSRCA, 2008) and the Lake Simcoe Phosphorus Reduction Strategy (OMOE, 2010) are the two main documents aside from the LSPP that have guided this plan's development. These are discussed in Section 1.3 below.

1.2.2 Subwatershed Planning Process

<u>Preliminary Consultation</u>

A start up meeting was held with Kawartha Conservation to review over the intended direction and scope of the subwatershed plan, the projected timeline and how it would incorporate any new information coming from studies currently underway.

<u>Characterization</u>

The initial focus of the subwatershed planning exercise has involved the completion and summarization of subwatershed characterization work. It also involved the development of water quality, quantity, aquatic, and terrestrial habitat models to assess the environmental impacts associated with potential changes in the landscape. Based on this important information, recommendations are developed to address the stressors as well as the gaps and limitations for each parameter. They are also intended to be consistent with the policies of the LSPP.

Subwatershed Working Group – Review Committee

The Subwatershed Working Group (SWG) consists of representatives from the City of Kawartha Lakes, the Township of Brock, Ministry of Environment and Climate Change, Ministry of Natural Resources and Forestry, Ministry of Agriculture, Food, and Rural Affairs, the Simcoe County Federation of Agriculture, Couchiching Conservancy, Trent Matters, the Trent-Severn Waterway, as well as local residents. This is a voluntary committee that is essential to confirming that material presented in the subwatershed plans is tailored to the specific conditions within each municipality. The SWG met twice in 2015 and once in 2016 to discuss plan chapters. Before each meeting, committee members are presented with characterization chapters and their associated recommendations. Comments received on the characterization material were documented and addressed, while comments received on recommendations were discussed, incorporated and re-distributed for further discussion/approval at the next meeting. This was done to ensure that all parties are fully aware of, and agree with, final recommendations that will be the basis of the Subwatershed Implementation Plans. The SWG, along with some additional representatives met a final time in June of 2016 to review and provide comment on the subwatershed implementation plan.

Public Consultation

Public consultation occurred in August of 2016 and was intended to educate residents within the subwatersheds about the area they live in, what the current conditions are in their subwatershed, what the immediate stressors are and how the recommendations will be carried out, in addition to receiving public comments.

1.2.3 Subwatershed Implementation Process

Implementation Plan

Once the subwatershed plan is approved by the LSRCA and Kawartha Conservation Boards of Directors and endorsed by the municipalities, the recommendations are used to form the basis of the development of the Implementation Plan for the subwatersheds. The Implementation Plan is a framework and process for acting on the recommendations put forth in the Subwatershed Plans. It prioritizes the recommendations, identifying available options, the associated funding/ costing estimates, and partner’s responsibilities.

Implementation Working Group

A significant part of the Implementation Plan involves the development of a long term work plan with the various partners. Through the initiation of the Implementation Working Group (IWG), efforts that are undertaken to implement the related recommendations will be documented and recognized. Project updates, integrating and linking the numerous efforts, and monitoring and reporting on success will be the ongoing business of the IWG.

It is recognized that many of these undertakings will be dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed through the development of the Implementation Plan.

Implementation

To ensure that this subwatershed plan remains current and relevant, it has been developed using an adaptive management framework. As such, the subwatershed plan is scheduled to be updated every five years to ensure that it contains the best available science and monitoring data reflecting the health of the subwatershed. Between reviews, ongoing monitoring, assessing and evaluation of the subwatersheds as well as the extent and effectiveness of implementation of the recommendations of this subwatershed plan will be occurring, with new reports and studies being produced. Communications will need to be updated to coincide with these studies and implementation approaches will need to adapt to reflect the most current information available.

Figure 1-3 depicts the relationship between this subwatershed plan and the materials that have guided and contributed to its development. It also depicts the implementation plan, which will provide details of a plan to undertake the recommended actions.

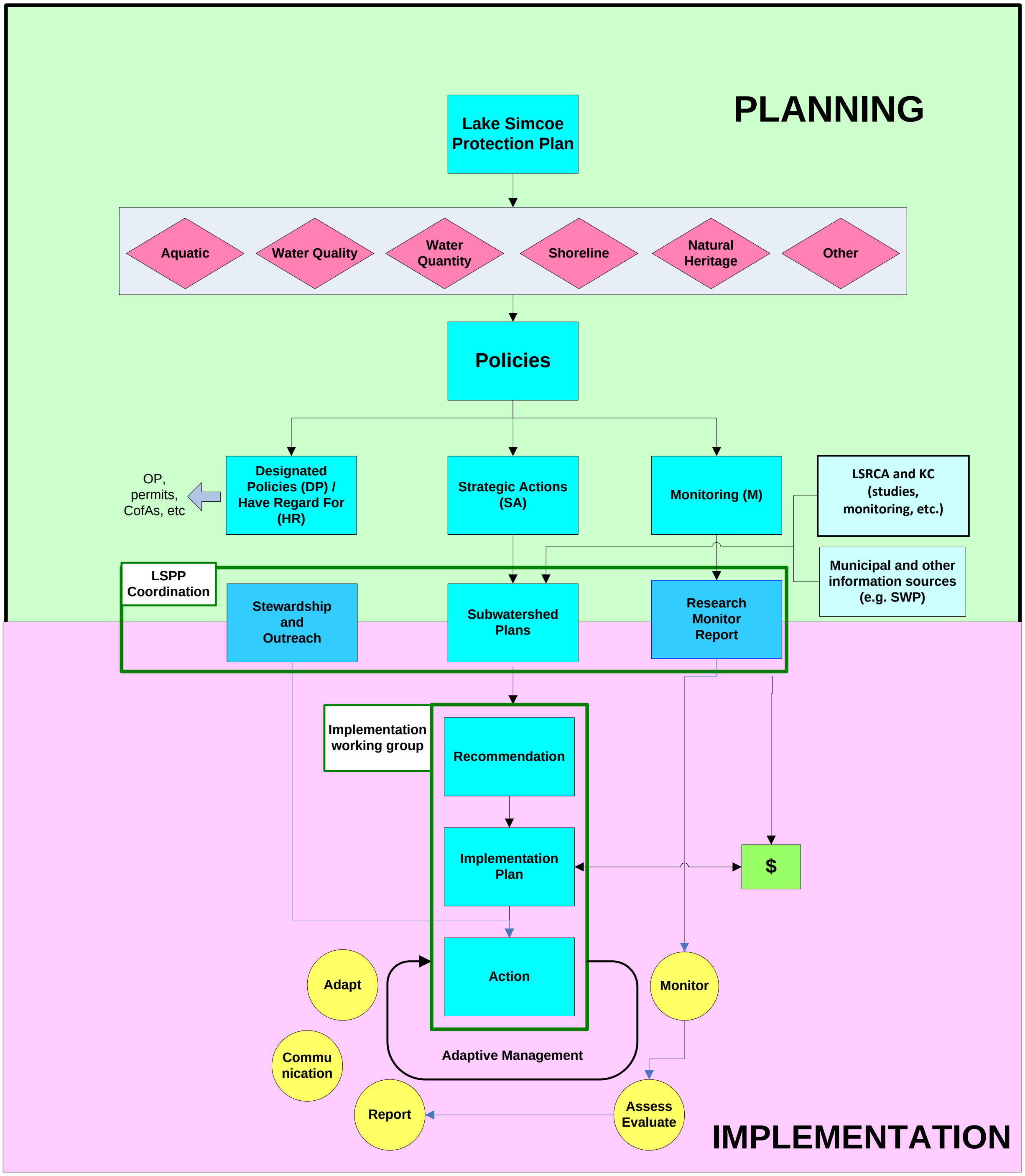


Figure 1-3: Subwatershed planning context

1.3 Current Management Framework

This subwatershed plan has been written firstly to comply with the requirements under the province’s Lake Simcoe Protection Plan. However, there are other documents that have influenced and fed into the development of this plan and its recommendations. The LSRCA’s

Integrated Watershed Management Plan (LSRCA, 2008) and the Lake Simcoe Phosphorus Reduction Strategy (OMOE, 2010) are the two main documents aside from the LSPP that have guided this plan's development.

The Integrated Watershed Management Plan, released by the Lake Simcoe Region Conservation Authority in 2008, was intended to be a roadmap to provide future direction for the protection and rehabilitation of the Lake Simcoe watershed ecosystem. Its broad-scale recommendations for the Lake Simcoe watershed provided the basis for a number of this plan's recommended actions.

The Lake Simcoe Phosphorus Reduction Strategy, released by the Province in 2010, was a requirement of the Lake Simcoe Protection Plan. The Phosphorus Reduction Strategy is a long term, phased approach that focuses on a constant reduction of phosphorus in Lake Simcoe through shared responsibility. The actions that come out of the Strategy are providing a foundation and early planning tool for the reduction of phosphorus. As this is a living document, it will be reassessed and updated a minimum of every five years to ensure that it includes the most up to date information and is following the best approach to reduce phosphorus within the watershed.

There are a number of other technical documents that have been or are being developed to meet the 'strategic action' policy requirements of the Lake Simcoe Protection Plan; the documents completed to date have been incorporated into this plan. In cases where the documents are not available when a subwatershed plan is being written, they will be incorporated into the five year review and update of the subwatershed plan, as well as be addressed in the implementation plan where feasible.

This subwatershed plan also aims to complement and be supportive of the policies of the applicable upper and lower tier municipal official plans and the related municipal programs that strive to achieve similar outcomes related to subwatershed health.

1.4 Guiding Documents

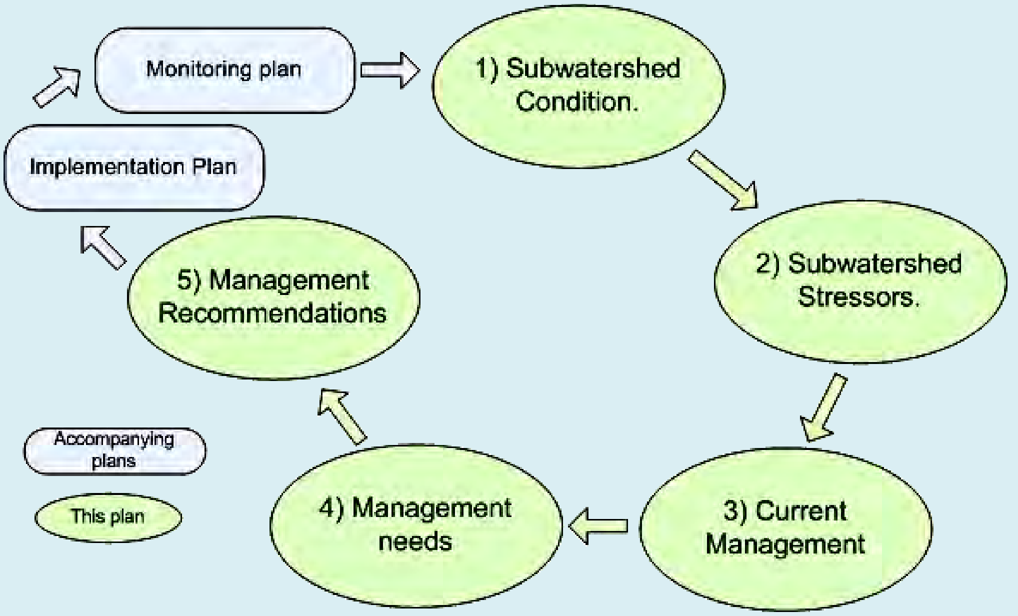
A number of documents and studies have been prepared with information and recommendations pertinent to the Whites Creek and Talbot River subwatersheds and how to ensure its environmental health into the future. These documents cover a wide range of issues, and have influenced the formation of this subwatershed plan. They include:

- Natural Heritage System for the Lake Simcoe Watershed (Beacon Environmental and LSRCA, 2007)
- Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services (Wilson, 2007)
- Assimilative Capacity: Pollutant Target Load Study for the Lake Simcoe and Nottawasaga River Watersheds (Louis Berger Group, 2006)
- Estimation of the Phosphorus Loadings to Lake Simcoe (Louis Berger Group, 2010)
- Lake Simcoe Watershed Environmental Monitoring Report (LSRCA, 2013)

- South Georgian Bay-Lake Simcoe Watershed Preliminary Conceptual Water Budget Report (2007)
- Lake Simcoe Watershed Tier one Water Budget and Water Quantity Stress Assessment Report (LSRCA, 2009)
- Water Balance Analysis of the Lake Simcoe Basin using the Precipitation-Runoff Modelling System (PRMS) (Earthfx, 2010)
- Tier 2 Water Budget, Climate Change, and Ecologically Significant Groundwater Recharge Area Assessment for the Ramara Creeks, Whites Creek, and Talbot River Subawatersheds (Earthfx, 2014)
- Lake Simcoe Basin Wide Report (2008)
- Lake Simcoe Integrated Watershed Management Plan (2008)
- Lake Simcoe Protection Plan (2009)
- Lake Simcoe Phosphorus Reduction Strategy (2010)
- State of the Lake Simcoe Watershed (2003)
- Lake Simcoe Climate Change Adaptation Strategy (2011)

1.4.1 How this plan is organized

This plan includes a chapter dedicated to each of the five subwatershed features identified previously, these being water quality, water quantity, tributary health, lake health, and terrestrial natural heritage. Each of these chapters follows an identical format, loosely structured around a pressure-state-response framework, in that each chapter firstly describes the current condition (state), secondly describes the stressors likely leading to the current condition (pressure), and finally recommends management responses in the context of the current management framework (response) (See the following text box).



Plan section:

1) ***Subwatershed Condition:*** Describes and analyzes the current state or condition of the subwatershed feature based on the best available data and information. This assessment is based on monitoring data, model output, surveys etc.
2) ***Subwatershed Stressors:*** Uses the best available information to identify and quantify the factors affecting the current condition of the watershed. For example, describing phosphorus loads from different land use activities.
3) ***Current Management:*** Establishes the relationship of the subwatershed plan to other legislation and planning documents;
4) ***Management needs:*** Identifies areas within the current management framework where improvements within this plan may be able to have greatest impact i.e. gaps or opportunities for the subwatershed plan to act upon.
5) ***Management recommendations:*** outlines resource management goals and objectives; as well as options for protection, rehabilitation, and enhancement of conditions in the subwatershed.

The resulting plan will protect the existing natural resources, facilitate informed planning decisions, and improve the efficiency of the development review process. An over-arching concept to keep in mind throughout the subwatershed planning process is that it is far more beneficial, both financially and ecologically, to protect resources from degradation than to rehabilitate them once they have been damaged.

2 Study Area

2.1 Summary of Observations

The Canal and Mitchell Lakes, Talbot River, and Whites Creek subwatersheds occupy the northeastern area of the Lake Simcoe subwatershed, and together cover an area of 470 km^2. The total population within the study area is 5,296 and the population has decreased between 2006 and 2011. The study area contains portions of the City of Kawartha Lakes as well as the Townships of Brock and Ramara. The largest industry in the subwatershed municipalities is retail trade.

There are a large number of recreational opportunities within the subwatersheds, including boating, kayaking, fishing, camping, swimming, snowmobiling and hiking, which contribute to a high quality of life.

The predominant land uses in the study area are natural heritage, agriculture and rural/urban development. These land uses affect the quality of natural areas (eg. forests for recreation vs. impervious surfaces impacting water quality), and more natural heritage features lead to higher economic values for non-market ecosystem services.

2.2 Study Area Location

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary subwatersheds. The Talbot River and Whites Creek are two of the 18 subwatersheds that make up the Lake Simcoe watershed; with the outlets of its many tributary catchments discharging into the northeast portion of Lake Simcoe (Figure 2-1). The Talbot River consists of two portions, the Upper and Lower Talbot River, at 294.6 and 70.1 km^2, respectively (364.7 km^2 combined); Whites Creek is 105.4 km^2 in area. There are a number of important features to note in these subwatersheds; these include the Trent-Severn waterway, which connects Lake Ontario and Lake Huron via a series of locks, and two recreationally important lakes which are found in the upper section of the Talbot River subwatershed, Canal and Mitchell Lakes. These lakes are also connected to the Trent-Severn waterway.

There are three lower or single tier municipalities found within the study area. In the Whites Creek subwatershed, there are portions of the Township of Brock and the City of Kawartha Lakes, and the Talbot River subwatershed falls within the boundaries of the Township of Brock, the Township of Ramara, and the City of Kawartha Lakes. The Townships of Brock and Ramara fall within the upper tier municipalities of Durham Region and the County of Simcoe, respectively. The area includes the smaller communities of Bolsover, Gamebridge, Kirkfield, Rohallion, Corsons, Bexley and Talbot. There are substantial cottage developments around Canal and Mitchell Lakes, which both fall within the subwatershed, as well as along the Lake Simcoe shoreline.

There are a number of tributaries that comprise these two subwatersheds. Aside from the main branches of the Whites Creek and Talbot River, and the Trent-Severn waterway, some of the main tributaries include: Grass Creek which occupies the south –eastern corner of the Talbot

River watershed and the Mitchell Lake watershed and; a non named tributary referred to as "Northern Tributary" located to the north of Canal Lake was included. The total watercourse length in the Talbot River subwatershed is 549km (including both the Upper & Lower Talbot River), which comprises 13% of the combined length of the Lake Simcoe watershed's watercourses. The watercourse length in Whites Creek is 171.25km, or 4% of the the watershed's watercourses.

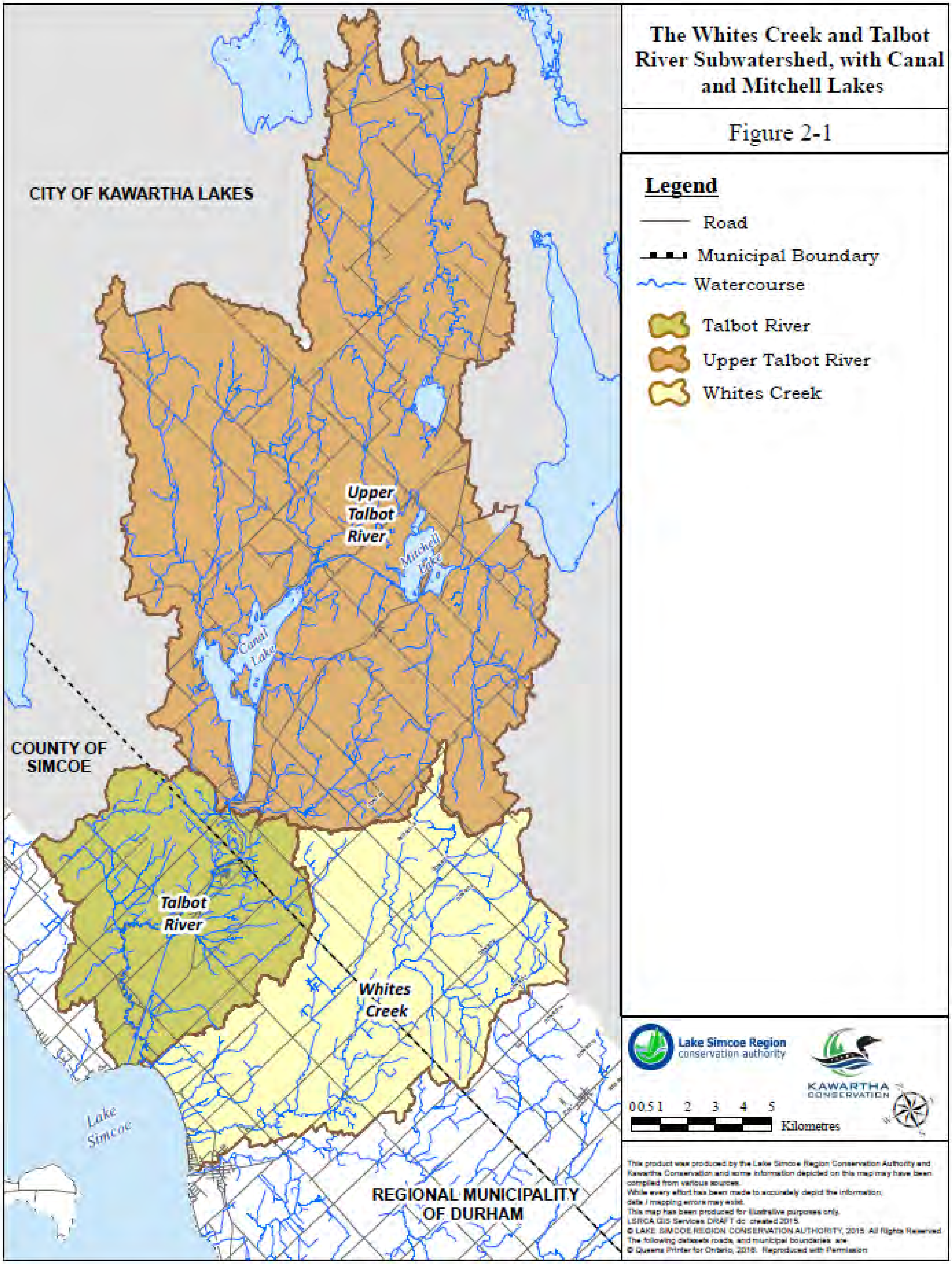


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Figure 2-1: The Whites Creek and Talbot River subwatershed, with Canal and Mitchell Lakes

2.3 Human Geography

2.3.1 Population and Municipal Boundaries

As discussed earlier, the study area contains portions of the City of Kawartha Lakes and the Townships of Brock and Ramara. The populations of all three municipalities decreased between the 2006 and 2011 censuses; the City of Kawartha Lakes, Township of Brock, and Township of Ramara experienced decreases of 1.8%, 5.3%, and 1.6%, respectively. The national average growth rate is 5.9%; with the negative growth rate these municipalities are lagging behind in this regard, although some growth is anticipated in the coming years.

The following demographic calculations were based on the portions of the townships that fall within the actual study area. The median age of of City of Kawartha Lakes residents in 2011 was 52.42, an increase from 45.1 in 2006. This is much higher than both the national and provincial median ages, 40.6 and 40.4, respectively. The median age for the Township of Ramara is even higher than that of the City of Kawartha Lakes, at 49 in 2011, while the Township of Brock is very similar, at 49.89. These higher median ages could be reflective of the draw of the numerous lakeside communities in the study area as retirement residences. The distance to major employment centres may also prevent some people from settling here, as the length of commute would be prohibitive for many, particularly those with younger families. The median before-tax income for all census families in 2010 for the City of Kawartha Lakes, the Township of Ramara, and the Township of Brock were $57,319, $47,500, and $73,924, respectively; with only Brock falling above the provincial median income of $66,358 (Statistics Canada, 2015).

The municipal population for the municipality and estimated population density for the subwatershed is presented below in Table 2-1.

Table 2-1: Population and population density within the Talbot River and Whites Creek subwatersheds (Data Source: ESRI, 2015 Community Profiles)

Subwatershed	Subwatershed Area (km^2)	Estimated Total subwatershed population (2015)	Municipality	Total Municipal Population	% Municipality in Subwatershed	Municipal Population (2015) within subwatershed*	Estimated Population Density (persons/km^2)
Talbot River (including Upper & Lower)	364.73	3351	City Kawartha Lakes	73,214	83.40	2584	9.19
			Township of Brock	11,341	7.27	395	
			Township of Ramara	9,275	9.32	372	
Whites Creek	105.39	1945	City of Kawartha Lakes	73,214	57.17	511	18.46
			Township of Brock	11,341	42.82	1434	

* Based on proportion of municipality within subwatershed

2.3.1.1 Settlement Areas

As noted above, the Townships of Brock and Ramara and City of Kawartha Lakes are the municipalities found within the study area. Within these municipalities, the communities of Gamebridge, Bolsover, and Bexley fall in the study area. There are also number of developments along the shores of Lake Simcoe, Canal Lake, and Mitchell Lake. Population growth within the study area is not as significant as in areas such as York Region, the City of Barrie, and the Town of Innisfil, but the populations of all three municipalities are anticipated to experience some growth, particularly the City of Kawartha Lakes; whose population is expected to increase from its current 73,214 to 100,000 by 2031 (Watson & Associates, 2009; Ontario Ministry of Finance, 2016). While much of this growth will be concentrated in the urban centres outside of the study area, some growth can likely be anticipated.

A large number of residents of the study area municipalities work outside their municipality, county, and even province and Canada; this is particularly evident in the Township of Ramara, where the majority of the residents work outside of the municipality or have no fixed workplace address (~80%). Many of the people who work in large cities cannot afford to live within them, so they commute from smaller towns that have a more affordable cost of living. These small towns/communities are known as ‘bedroom communities’. Typically bedroom communities are located in rural or semi-rural areas, surrounded by green space, and are in close proximity to a major highway that leads to the larger cities. The Township of Ramara is a good example of this, with only 11% of the total employed labour force working within the municipality (Table 2-2). A higher proportion of residents of the City of Kawartha Lakes works within the municipality, with over half either working from home or within the City. Close to half of Brock residents work outside of the Township, either at another municipality within the Region of Durham (15%), or outside of the region altogether.

Table 2-2: Place of work status in the study area municipalities (Data Source: Statistics Canada, 2006).

Place of Work Status	City of Kawartha Lakes		Township of Brock		Township of Ramara	
	Population	Pop. Percentage (%)	Population	Pop. Percentage (%)	Population	Pop. Percentage (%)
Worked at home	3,950	11	760	12	415	9
Worked outside Canada	115	<1	15	<1	20	<1
No fixed workplace address	4,300	12	870	14	725	16
Worked in census (municipality) of residence	14,895	42	1,445	24	530	11
Worked in different census subdivision (municipality) within the census division (county) of residence	0	0	920	15	2235	48
Worked in different census division (county)	12,110	34	2,085	34	690	15
Worked in different province	55	<1	10	<1	10	<1
Total employed labour force	**35,420**	**100**	**6,105**	**100**	**4,625**	**100**

2.3.2 Demographics

2.3.2.1 Education

The level of education attained by a person can influence both their career choice and income level. Table 2-3 lists the percentage of the populations in the study area municipalities, 15 years and over, and their educational attainment compared to provincial standings.

Table 2-3: Educational attainment for the study area municipalities (Statistics Canada, 2011)*

	City of Kawartha Lakes	Township of Brock	Township of Ramara	Province of Ontario
No certificate; diploma or degree	22%	21%	20%	19%
High school certificate or equivalent	31%	33%	31%	27%
Apprenticeship or trades certificate or diploma	10%	10%	15%	7%
College; CEGEP or other non-university certificate or diploma	23%	22%	20%	20%
University certificate or diploma below the bachelor level	2%	4%	2%	4%
University certificate; diploma or degree	11%	10%	12%	23%

* Numbers subject to rounding error

2.3.2.2 Industry

The economies of the three municipalities in the study area are quite varied, with employment across a number of sectors (Table 2-4). The largest employment sector in the City of Kawartha Lakes is retail trade, constituting 25 % of jobs within the study area Trades, Transport and Equipment Operators accounted for 21% followed by Business, Finance and Administration at 11%. Retail trade is the largest employment sector in the Township of Brock, accounting for 13% of jobs, followed by construction (11%) and health care and social assistance (9%). The Township of Ramara's largest employment sectors are construction (11%) and professional, scientific, and technical services (11%), while service jobs also constitute a large percentage of the employment, with close to 9% in retail trade, 8% in educational services, and 7% in Accomodation and Food Services. The values reported in this section were calculated according to the geographical area of this study.

Table 2-4: Occupations in the City of Kawartha Lakes and the Townships of Brock and Ramara Overall (Data Source: Statistics Canada, 2011)

Industry	Kawartha Lakes	Brock	Ramara	Industry	Kawartha Lakes	Brock	Ramara
Agriculture, forestry, fishing and hunting	1,460	310	140	Industry – not applicable	880	70	125
Mining, quarrying, and oil and gas extraction	115	20	35	Real estate and rental and leasing	405	55	170
Utilities	480	75	55	Professional, scientific, and technical services	1,490	290	320
Construction	3,330	665	490	Administrative and support, waste management and remediation services	1,295	290	170
Manufacturing	3,080	500	285	Educational services	2,800	420	385
Wholesale trade	1,600	275	215	Health care and social assistance	4,005	540	255
Retail trade	4,885	785	450	Arts, entertainment and recreation	910	155	325
Transportation and warehousing	1,445	275	240	Accommodation and food services	1,895	225	295
Information and cultural industries	385	150	55	Other services (except public administration)	1,905	190	205
Finance and insurance	1,100	255	115	Public administration	2,655	430	290
Total labour force	**36,130**	**5960**	**4,625**				

2.4 Human Health and Well-being

One of the major reasons for understanding and managing watersheds and their function is to protect the health and well-being of watershed residents. Figure 2-2 illustrates the watershed governance prism (Parkes *et al.,* 2010) and the four different aspects of watershed governance including “watersheds”, “ecosystems”, “health and well-being”, and “social systems”. The combination of all of the aspects of watershed management gives a comprehensive view of the way watershed governance can link the determinants of health and well-being to watershed management.

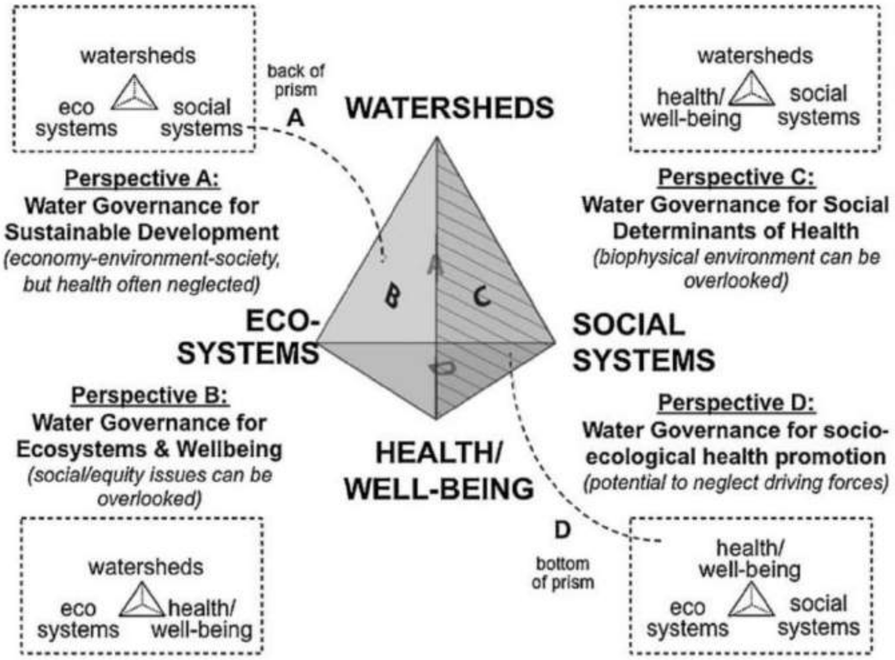

Figure 2-2: Watershed Governance Prism (Parkes *et al*. 2010).

The management of the Lake Simcoe watershed and its contributing area, including the Whites Creek and Talbot River subwatersheds and Canal and Mitchell Lakes, includes a number of these perspectives, incorporating issues related to human health and well-being, protection of wildlife habitats, and ensuring the preservation of water quality and water quantity.

2.4.1 Outdoor Recreation and Human Health

The Talbot River and Whites Creek subwatersheds support summer and winter recreation via boating, kayaking, fishing, camping, swimming, snowmobiling and hiking. The Carden Alvar is in close proximity to this area and is considered a national treasure for birdwatchers and nature lovers (NCC 2016a). There are kilometres of adjoining trails providing hikers, All Terrain Vehicles (ATV) and mountain bikers with ample opportunities to enjoy a variety of all season outdoor experiences (Ontario Trail Maps, 2016).

There are two City of Kawartha Lakes RV Campgrounds on Canal Lake. These are seasonal campgrounds with beach and park areas. These parks are maintained by the City of Kawartha Lakes (CKL, 2016).

Both Mitchell and Canal Lakes assist in the passage of many vessels traversing the Trent Severn Waterway and provide enterance to the Kirkfield lift lock and the remaining 4 locks to gain access to Lake Simcoe, including Bolsover- Lock 37, Talbot- Lock 38, Portage –Lock 39 and Thorah-Lock 40, respectively. Smaller vessels such as kayaks and fishing boats use the lakes for recreation.

These subwatersheds are increasing in recreation value as more people are beginning to understand the importance of the positive benefits that nature can offer to our physical and mental health. Within an urban setting, green spaces (including parks, conservation areas, forests, wetlands, streams and lake shore) are at a premium. Even within a more rural setting, these features are sometimes taken for granted when, in fact, they are an essential part of a healthy community.

Physical

Whether it's an open soccer field, running/walking trails through forests or sandy beaches along the lake front, the green spaces within these subwatersheds provide a number of outdoor recreational opportunities for residents and visiting tourists. The different types of areas available offer a variety of physical activities that would not be available at a local gym and come at little to no cost. Parks and sports field provide areas for recreational or pick up games of soccer, football or frisbee. Trails are areas to walk, run, or bike. Parks and conservation areas with forest and wetlands provide a range of recreational and aesthetic opportunities and the nearby lake shore and waterways offer residents a place to swim, canoe, kayak and fish. It is these types of areas that encourage the physical stimulation of individuals and families, creating a healthier lifestyle for people of all ages.

By encouraging children to be active outdoors at a young age, a number of health-related issues can be minimized or avoided all together. These include:

- Childhood Obesity: In Canada, over 30% of children ages 2-17 are currently overweight or obese (Childhood Obesity Foundation, 2016). Obesity can also lead to a number of other diseases including Type-2 diabetes, hypertension, asthma and cardiovascular disease (National Environmental Education Foundation (NEEF, 2015)).
- Vitamin D Deficiency: Most common diseases resulting from a lack of Vitamin D include rickets (children) and osteoporosis later in life (NEEF, 2015).
- Myopia: One study found that 12 year olds who spent less time doing near-work activities (reading, drawing, etc.) and more time doing outdoor activities were two to three times less likely to develop myopia than those who spent the majority of their time doing near-work activities (Rose *et al.,* 2008).

Mental

In addition to physical health benefits, there are a number of mental health benefits associated with natural areas. These areas, free of technology and the “jolts per minute” of contemporary life, allow people to take in their surroundings, and benefit from the serene and calming environment. Those who like to explore natural areas are mentally engaged to interact with the surrounding flora and fauna and associate these visual ‘pictures’ with other senses, such as touch, smell, and sound. Studies have also shown the benefits of nature on the social interactions, emotional status, and cognitive growth of children. Many young children have grown up watching television and playing on computers or with video games, with very little ‘play-time’ (unstructured, spontaneous activity) in their daily routine. Burdette and Whitaker (2005) suggest that through playing outdoors, a child’s social interactions, emotional status, and their cognitive growth are improved. In an unstructured, non-monotonous environment they will come across different situations that encourage them to problem solve, interact, and communicate with others and learn from the different experiences they are exposed to. Studies also show interactions with nature have positive impacts on those with attention-deficit/hyperactivity disorder (ADHD). Something as simple as a 20 minute walk through a park was found to increase concentration and elicit a positive emotional response (Faber and Kuo, 2008).

Recent studies have also linked walks in a natural environment with improvments in memory and mood in subjects suffereing from depression; and exercise is often touted as one of the ‘natural cures’ for depression and other mood disorders.

It should also be noted that many individuals also have an important spiritual connection to the environment.

2.4.1.1 Community Engagement and Cohesiveness

The more people recognize the benefits that the green spaces in their city or town have on their well being, the more they will work to maintain and protect these areas. Green spaces can bring a community together to perform maintenance and restoration work, create fun and interactive environments, boost tourism (and in turn the local economy), and are places for community events, camps, or public forums. By putting effort into caring for the green spaces and enjoying the benefits they gain from them, people form an attachment to these areas, as well as their community as a whole.

2.4.1.2 Economic Benefits

While the previous section highlighted the social and health benefits of urban natural areas, studies have also shown the monetary benefits of having tree-lined streets and urban natural areas.

For example, the presence of mature trees in residential areas can increase the sale prices of neighbouring properties by 2-15% (Wolf, 2007; Donovan and Butry, 2010), and decrease the amount of time such properties are on the market (Donovan and Butry, 2010). The presence of larger natural areas nearby can increase property values by up to 32% (Wolf, 2007). Even during the initial development process, retaining mature trees on residential lots can increase their sale value by up to 7% (Theriault *et al*., 2002).

As a result, the preservation of urban green space can attract new businesses with highly paid staff, and strengthen the local economy (Florida, 2002). Commercial sectors can also benefit from an increase in urban tree cover. Studies have shown that shoppers tend to spend more time, and make more purchases, in downtown commercial and retail districts that have more trees, creating income both for the city and for store owners (Wolf, 2005).

2.4.2 Drinking Water Source Protection

A threat to human health is the degradation and depletion of freshwater resources. Degradation of water quality can either be anthropogenic or natural in nature. Humans can impact their water through:

- Poor sanitation habits (crude solid waste disposal methods, improper filtration methods of waste water and drinking water);
- Removal of riparian buffers, allowing unfiltered run off from streets, lawns and agricultural fields to go directly into waterways;
- Improper storage of chemicals that can spill in to surface water or leach into the ground to reach the deeper groundwater resources;
- Warming of water temperatures (creates ideal temperatures for growth of bacteria) by connecting runoff systems to watercourses or creation of standing bodies of water that link to the watercourse.

Climate change can also impact water quality through changes in air temperature, precipitation and extreme events by:

- Releasing contaminants: extreme events and increases in precipitation may damage buildings/containers holding contaminants, cause the overflow of retention areas holding contaminants, and/or wash surface contaminants into watercourses;
- Transporting contaminants: extreme events can transport contaminants greater distances, potentially increasing the exposure to them;
- Creating warmer environments: surface waters become more hospitable to pathogens and other waterborne disease.

Poor water quality, either because of anthropogenic or natural conditions, can lead to an increase in water-borne diseases, loss of fisheries, contaminated food sources, and closures of beaches due to high levels of *Escherichia coli*. Residents can be directly impacted through sickness, increases in food costs (uncontaminated) or loss/decrease in income (loss of fisheries, farms with unusable, contaminated produce).

Depletion of available water is another major health concern. Low water quantity can result in water restrictions that lead to lower agricultural produce yields, increasing the cost of food. Less water available to residents also means that there is less water available to natural environments, leading to a loss of habitat through drying of wetlands and an increase in forest fires.

In 2006, the provincial government made a commitment to the citizens of Ontario by passing the *Clean Water Act* (CWA). The CWA introduced a new level of protection – Source Water Protection - for the Province's drinking water resources that will help communities across Ontario enjoy a safe and plentiful supply of clean drinking water for generations to come. Drinking Water Source Protection is the first step in a multi-barrier approach to protecting our sources of drinking water. It identifies possible threats to drinking water, assesses the risks of those threats, mitigates them and plans ahead to prevent contamination before it gets into the water supply. It is a responsible and effective way of ensuring safe, clean drinking water and avoiding serious health issues.

Drinking Water Systems and their Vulnerable Areas

The South Georgian Bay-Lake Simcoe (SGBLS) Source Protection Region (SPR) is one of 19 in Ontario. It contains three Source Protection Areas (Lakes Simcoe and Couchiching-Black River, Nottawasaga Valley, and Severn Sound) that are composed of four watersheds: Lake Simcoe[1], Black-Severn River, Nottawasaga Valley, and Severn Sound.

One of the key documents of the Source Protection program that has been completed for each of the Source Protection Areas (and the watersheds within their borders) is the Assessment Report. The SGBLS Source Protection Committee released three Assessment Reports in November 2011 that provide the following information for each area (an update to these reports were submitted in July of 2014):

- Characterization of the Source Protection Area watershed: This includes descriptions of the natural and human geography;
- A conceptual water budget for the entire Source Protection Area and a Tier 1 water budget for each subwatershed: Those systems identified as having water quantity stress in the Tier 1 water budget progress to a more detailed Tier 2 water budget and Tier 3 if needed;
- Broad scale assessment of Regional Groundwater Vulnerability: This aspect of the Assessment Report requires that both Highly Vulnerable Aquifers (HVA) and Significant Groundwater Recharge Areas (SGRAs) be identified; and
- Drinking water system assessment: For each drinking water system within the Terms of Reference, the Vulnerability of the supply wells or surface water intakes is assessed and any potentially Significant Threats to the water quality are identified.

Within the whole SGBLS SPR there are 108 drinking water systems, with 31 in the Lake Simcoe Source Protection Area and 10 in the Black-Severn Source Protection Area, a portion of which falls within the Upper Talbot River subwatershed. There is one drinking water system identified

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[1] Information for the drinking water systems within the study area subwatersheds can be found in the Approved Lakes Simcoe and Couchiching-Black River Source Protection Area Assessment Report, Part 2: Black Severn River Watershed. Chapter 6 of this Assessment Report is specific to the City of Kawartha Lakes.

in the study area, in the Upper Talbot River subwatershed; the Western Trent/Palmina system, which is a groundwater system.

All drinking water systems within the watershed have had their vulnerable areas delineated. These vulnerable areas that are directly associated with drinking water systems are referred to as Wellhead Protection Areas (WHPAs) for groundwater systems and Intake Protection Zones (IPZs) for surface water intakes:

- A WHPA is the area around a wellhead where land use activities have the greatest potential to affect the quality of water that flows into the well. Each WHPA is subdivided into four time-of-travel zones that estimate the amount of time it would take a contaminant to reach the municipal well
    - WHPA-A: 100 m radius.
    - WHPA-B: 2 year time of travel (tot) capture zone
    - WHPA-C: 5 year tot capture zone
    - WHPA-C1: 10 year tot capture zone (for WHPAs delineated before April 2005).
    - WHPA-D: 25-year tot capture zone
- Similarly, an IPZ is the area around a surface water intake and includes three time-of-travel zones.
    - IPZ-1: 1000 m radius
    - IPZ-2: 2 hour time of travel
    - IPZ-3: Area within the surface water body through which contaminants released during an extreme event could be transported to the intake. For the intakes associated with this subwatershed, this includes the entire Lake Simcoe watershed, as well as the Lake Couchiching catchment area, as some flow back into Lake Simcoe has been noted.

Two additional vulnerable areas that were also delineated in the Assessment Reports are SGRAs and HVAs. These vulnerable areas do not pertain directly to any particular drinking water system, but instead are on a regional (landscape) scale:

- SGRAs are areas where water enters an aquifer (underground reservoirs from which we draw our water) through the ground. Recharge areas are significant when they supply more water to an aquifer than the land around it. SGRAs are important on the landscape for ensuring a sufficient amount of water enters an aquifer. For example, paving over an SGRA would prevent water from getting into the ground to recharge an aquifer, potentially decreasing the amount of water available.
- HVAs are those areas where an aquifer may be more prone to contamination. These areas have been identified where there is little or no protection from an overlying aquitard (a protective layer of low permeability materials). Generally, the faster water is able to flow through the ground to an aquifer, the more vulnerable the area is to

contamination. For example, a fuel spill would get into an aquifer much more quickly where an HVA has been identified than where one has not.

Further information on these two regional scale Vulnerable Areas can be found in the South Georgian Bay Lake Simcoe Source Protection Region Assessment Reports.

Western Trent/Palmina, the only drinking water system within the Upper Talbot subwatershed is located within the community of Bolsover in the City of Kawartha Lakes. The people of the Western Trent and Palmina rely on this water supply as a source of safe drinking water; highlighting the importance of maintaining and/or improving the quality (and quantity) of these supplies. Working to maintain the function and quality of groundwater recharge areas around this drinking water supply, and elsewhere, will help to ensure a safe source of drinking water for residents, and will also benefit local wildlife and natural habitats of the lakes and rivers of the study area.

For the Assessment Report, studies were undertaken to assess the vulnerability, issues, and threats for each of the Wellhead Protection Areas.

The Western Trent/Palmina Well Supply consists of two water supply wells, located at the outlet of Canal Lake, in the community of Bolsover, servicing the residents of the Western Trent and Palmina subdivisions. A total of 172 significant drinking water threats were identified in association with 172 land parcels. The majority of these threats were associated with individual sewage systems (168), with others related to the handling and storage of fuel (1 threat, associated with 167 parcels of land); and the use of land as livestock grazing or pasturing land (3).

The final document the Source Protection Committee (SPC) is responsible for is creating a Source Protection Plan that will be effective in mitigating all existing significant threats and preventing new ones from arising on the landscape. The process of creating this plan included the SPC developing policies to protect drinking water supplies. The revised proposed plan was submitted to the Minister in July, 2014 and was approved in 2015.

Full results of these studies, showing the vulnerability scores and the enumeration of threats to drinking water, can be found in the Approved Lakes Simcoe and Couchiching-Black River Assessment Report, Part 2: Black-Severn River Watershed. The local vulnerable areas (Wellhead Protection Areas) for the drinking water systems located in the study area are shown in Figure 2-3.

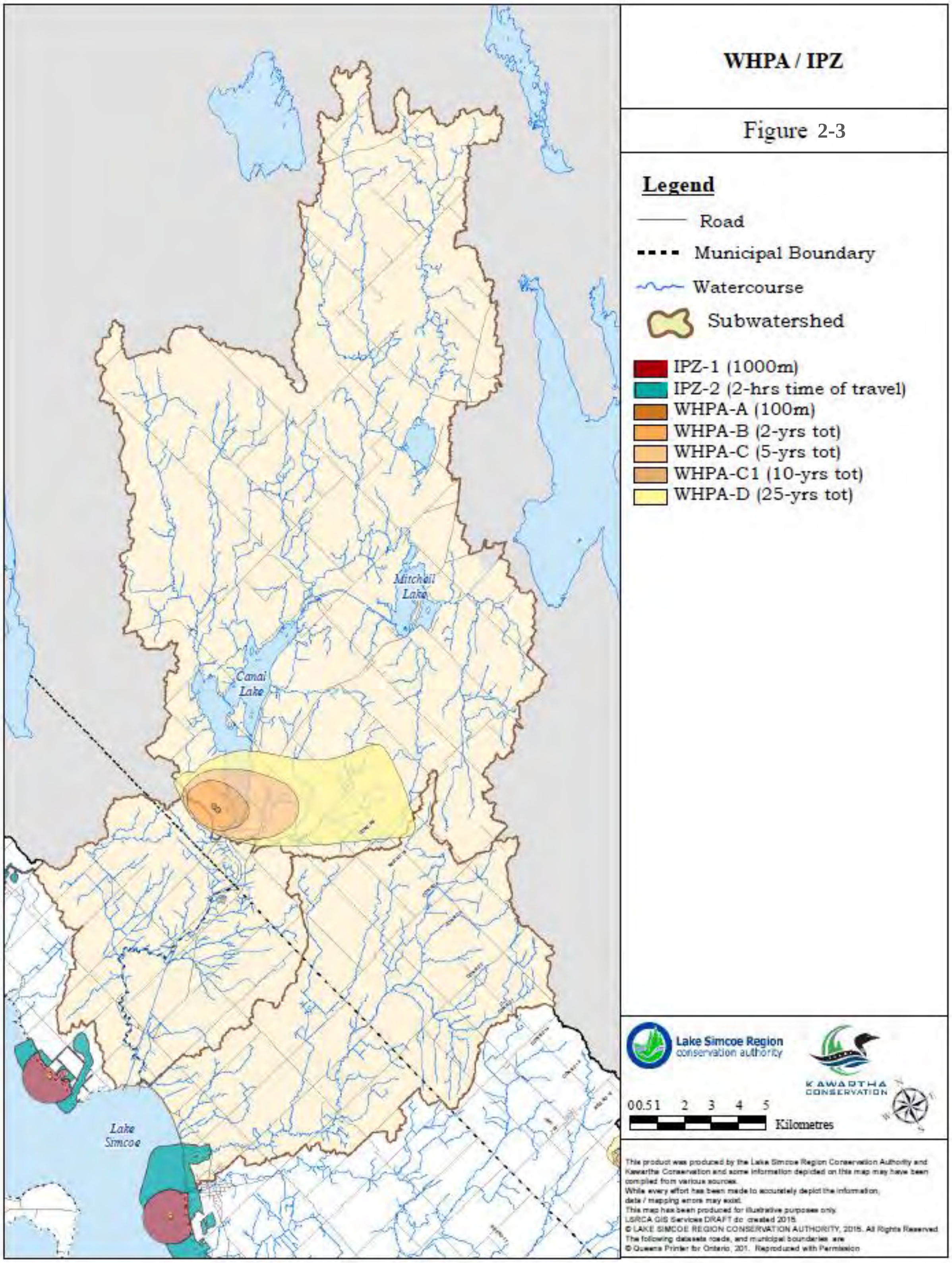

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Figure 2-3: Vulnerable Areas (WHPA/IPZ) located within the Whites Creek and Talbot River subwatersheds, including Canal and Mitchell Lakes.

2.4.3 Ecological Goods and Services.

In addition to the direct benefits to human health provided by publicly accessible natural areas and clean drinking water, the environment also provides a range of other, less tangible, benefits, often termed 'ecological goods and services'. These benefits include the storage of floodwaters by wetlands, water capture and filtration by forests, the absorption of air pollution by trees, and climate regulation.

The forests, wetlands, and rivers that make up watersheds are essentially giant utilities providing ecosystem services for local communities as well as the regional and global processes that we all benefit from. Ecosystems provide many services including carbon storage and sequestration, water storage, rainfall generation, climate buffering, biodiversity, soil stabilization, and more (Global Canopy Programme, 2015).

These benefits are dependent on ecosystem functions, which are the processes, or attributes, that maintain the ecosystems and the species that live within them. Humans are reliant on the capacity of natural processes and systems to provide for human and wildlife needs (De Groot, 2002). These include products received from ecosystems (e.g. food, fibre, clean air, and water), benefits derived from processes (e.g. nutrient cycling, water purification, climate regulation), and non-material benefits (e.g. recreation and aesthetic benefits) (Millennium Ecosystem Assessment, 2003).

In 2008, the Lake Simcoe Region Conservation Authority partnered with the David Suzuki Foundation and the Greenbelt Foundation to determine the value (natural capital) of the ecosystem goods and services provided by the natural heritage features in the watershed in the report: *Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services* (Wilson, 2008). By identifying and quantifying ecosystem services within a watershed, environmental resources can be directed towards areas that are currently of high value or areas that have the potential to be of high value.

2.4.3.1 Valuing Ecosystems

There have been several techniques developed to estimate economic values for non-market ecosystem services. The method used for the 2008 study uses avoided cost (i.e. damages avoided) and replacement cost (cost to replace that service) for ecosystem service valuation, as well as contingent valuations or willingness-to-pay studies for cultural values. Some of the values were derived using direct analysis and some values were adapted from other studies. Table 2-5 summarizes the value of the various ecosystem services by land cover type in the Talbot River and Whites Creek subwatersheds, as well as for the whole Lake Simcoe watershed. All ecosystem service values have been updated to 2014 Canadian dollars.

The estimated values provided are likely a conservative estimate because our knowledge of all the benefits provided by nature is incomplete, and because these values are likely non-linear in nature (i.e. the value of natural capital and its services will increase over time, as natural areas become more scarce, and demands for services such as clean water or mitigation of climate change become greater). It is also important to note that without the earth's ecosystems and resources, life would not be possible, so essentially the true value of nature is priceless. The valuations of ecosystem services, however, provide an opportunity to quantitatively assess the current benefits and the potential costs of human impact.

Table 2-5: Summary of non-market ecosystem service values by land cover type (2014 values).

Land Cover Type	Total Talbot River subwatershed value ($ million/yr)***	Total Whites Creek subwatershed value ($ million/yr)	Total Lake Simcoe basin value ($ million/yr)
Cropland	0.9	1.9	49.41
Forest	33.1	3.6	201.86
Forest/ Wetlands*	75.4	24.3	546.98
Wetlands	37.9	11.3	216.71
Grasslands	11.1	1.0	31.85
Hedgerows/ Cultural Woodland	1.6	0.12	8.62
Pasture	3.5	3.7	37.15
Urban Parks	0.06	0.01	2.93
Water**	1.9	0.01	104.50
Total	**165.5**	**45.8**	**1,200.01**

* This includes treed swamps.
** This does not include the value of Lake Simcoe
***Includes the value of Canal and Mitchell Lakes

As has been demonstrated, the natural systems of the Whites Creek and Talbot River subwatersheds provide a number of goods and services. These so-called “free” ecosystem services have, in fact, significant value. The analysis in the 2008 report provided a first approximation of the value of the non-market services provided – totalling annually (in 2014 values) $1.2 billion for the Lake Simcoe watershed and approximately $165 and $46 million for the Talbot River and Whites Creeks subwatersheds. The most highly valued natural assets for the services they provide are the forests and treed swamps. For the Lake Simcoe watershed these were calculated to be worth $202 and $546 million per year, respectively. Forested areas in the Talbot River and Whites Creek were valued at $33 and $4 million per year, respectively, and treed swamps were valued at $75 and $24 million, respectively.

The high value for forests reflects the many important services they provide, such as water filtration, carbon storage, habitat for pollinators, and recreation. Treed swamps and wetlands provide high value because of their importance for water filtration, flood control, waste treatment, recreation, and wildlife habitat.

It is important to note the value of Lake Simcoe, which was calculated to be approximately $102 million. This demonstrates its considerable value to all surrounding natural and human communities within the Lake Simcoe watershed. The value of Canal and Mitchell Lakes is also reflected in the relatively high value for 'Water' in the Talbot River, at $1.9 million. These lakes are the focal point of many waterfront communities, provide a vast number of recreational opportunities for locals and tourists alike, support substantial fisheries and, as well as being significant natural heritage features, provide people with beautiful scenery. Lake Simcoe is also a source of drinking water for seven municipal surface water intakes, and Canal and Mitchell Lakes provide drinking water for private landowners. Given the substantial benefits provided by these natural areas, the preservation of these lakes and the rest of the natural heritage features within the watershed results in a significant cost savings in municipal infrastructure that would otherwise be needed to watershed residents and users.

2.5 Historical Overview

The Trent Severn Waterway (TSW) is an important national historic site located in Ontario. It consists of 44 locks, including the first and second highest lift locks in the world, two flight locks and one marine railway. The waterway took 87 years to complete, beginning in 1833 when the first lock in Bobcaygeon was constructed until the Severn section was completed in 1920. Currently, it is managed and operated by Parks Canada (a division of the Environment Canada).

The TSW was designed as a route for trade and commerce and in timber more specifically. However, as a result of long delays in construction a decline in the timber industry occurred and in combination of the rapid development of roads and railways the TSW was never utilized as a commercial corridor. Instead, recreational users and tourists have steadily increased and they are now the primary users of the Trent Severn Waterway system (TSW Panel, 2007).

In order to form a navigable route through two neighbouring watersheds, the Trent and the Severn, natural rivers and lakes was connected by man-made canals, dams and locks. The Trent River watershed is included in the Lake Ontario drainage area, while the Severn River watershed belongs to the Lake Huron basin. The highest waterbody on the waterway is Balsam Lake. Boats transiting from Lake Ontario are raised 182 m to the summit at Balsam Lake and then descend 80 m down to Georgian Bay.

Two of these manmade lakes include Canal and Mitchell. Canal and Mitchell lakes was created as a result of water level manipulation via flooding of Grass Creek which occurred as a result of the dam creation at the west end of Canal Lake. The Kirkfield Lock which is part of the water course regime was completed and officially opened in 1907. The lock was one of the key pieces for successful access to Lake Simcoe in addition to the creation of 4 other locks to accommodate the 80m descent in elevation to Lake Simcoe (Parks Canada, 2013)

Kirkfield is one of the most significant towns within the Talbot and Whites Creeks subwatersheds. It was first settled in 1836 by Alexander Munro. It is now known as the birthplace of Sir William MacKenzie born in 1849, who later became an iconic railway contracter and entrepreneur. Bolsover was part of the Eldon township with a heavy Scottish influence which was common in this area. The Eldon township also incorporated the above mentioned Kirkfield, Woodville, Glenarm and Hartley. It was the rise and fall of the railway system which influenced the historical economics of these towns greatly (Ontario Genealogical Society, 2016). A large part of Eldon township was settled into many acres of agriculture in areas where topsoil was abundant (towards Mariposa) which is still part of the landscape today (Ontario Genealogical Society, 2016).

2.6 Land Use

Land use within the Whites Creek and Talbot River subwatersheds has been categorized into eight classes including intensive and non-intensive agriculture, rural development, urban (which includes residential, industrial, commercial, and institutional land uses), and natural heritage features.

The predominant land use in the Talbot River subwatershed by far is natural heritage, which occupies over 75% of the landscape. Agriculture occupies approximately 20% of the land, with the majority of this being non-intensive agriculture (16%) vs. intensive agriculture (4%). The remaining land is occupied by low levels of rural development, aggregate operations, and transportation such as road and rail (Figure 2-4).

In the Whites Creek subwatershed, agriculture is the predominant land use, with intensive agriculture (20%) and non-intensive agriculture (39%) occupying close to 60% of the subwatershed area. Natural heritage features occupy 38% of the subwatershed. The majority of the remaining area is occupied by urban area, rural development, and transportation (Figure 2-5). The distribution of land uses within the subwatersheds can be seen in Figure 2-6.

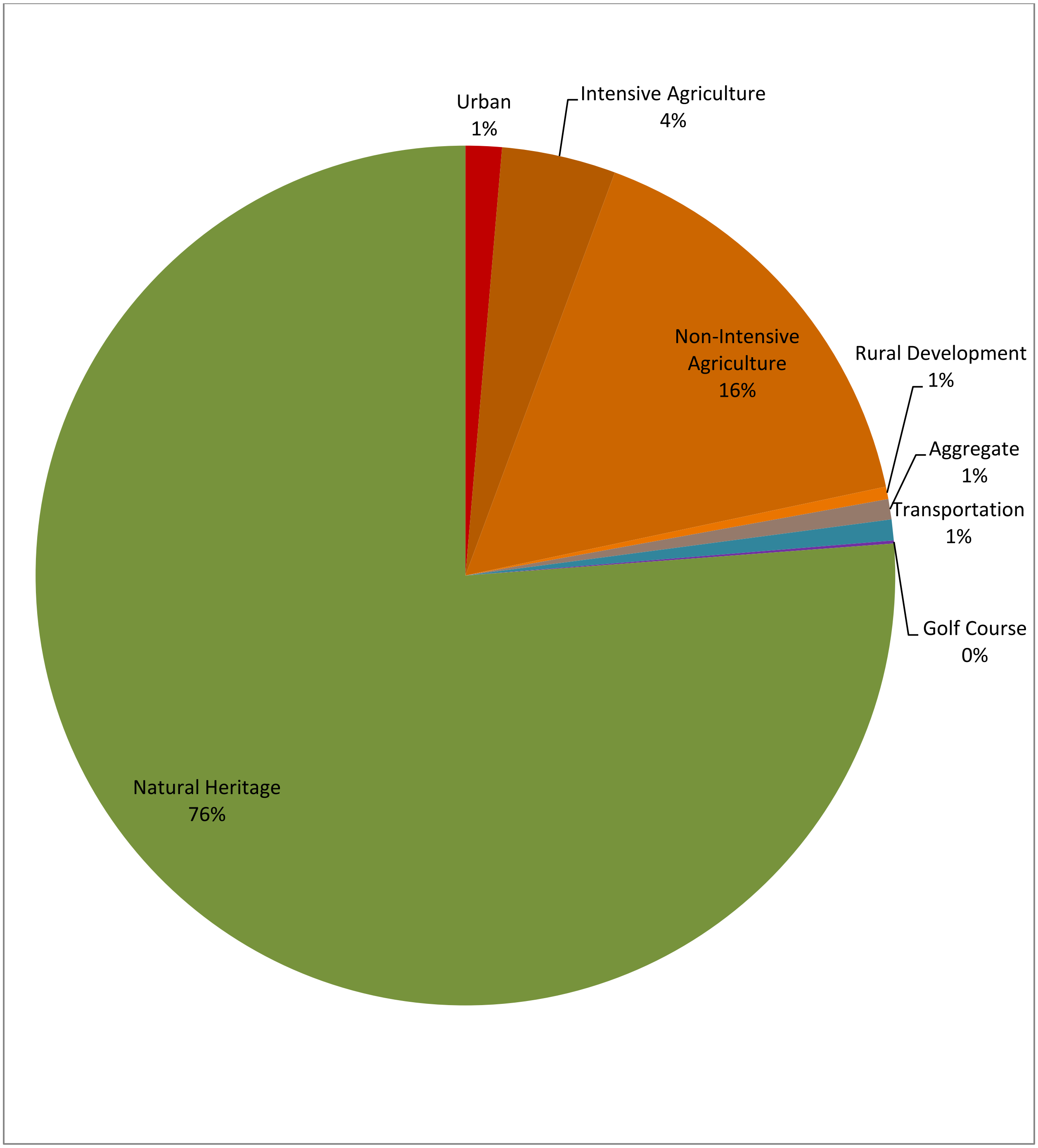

Figure 2-4: Land use distribution within the Talbot River subwatershed.

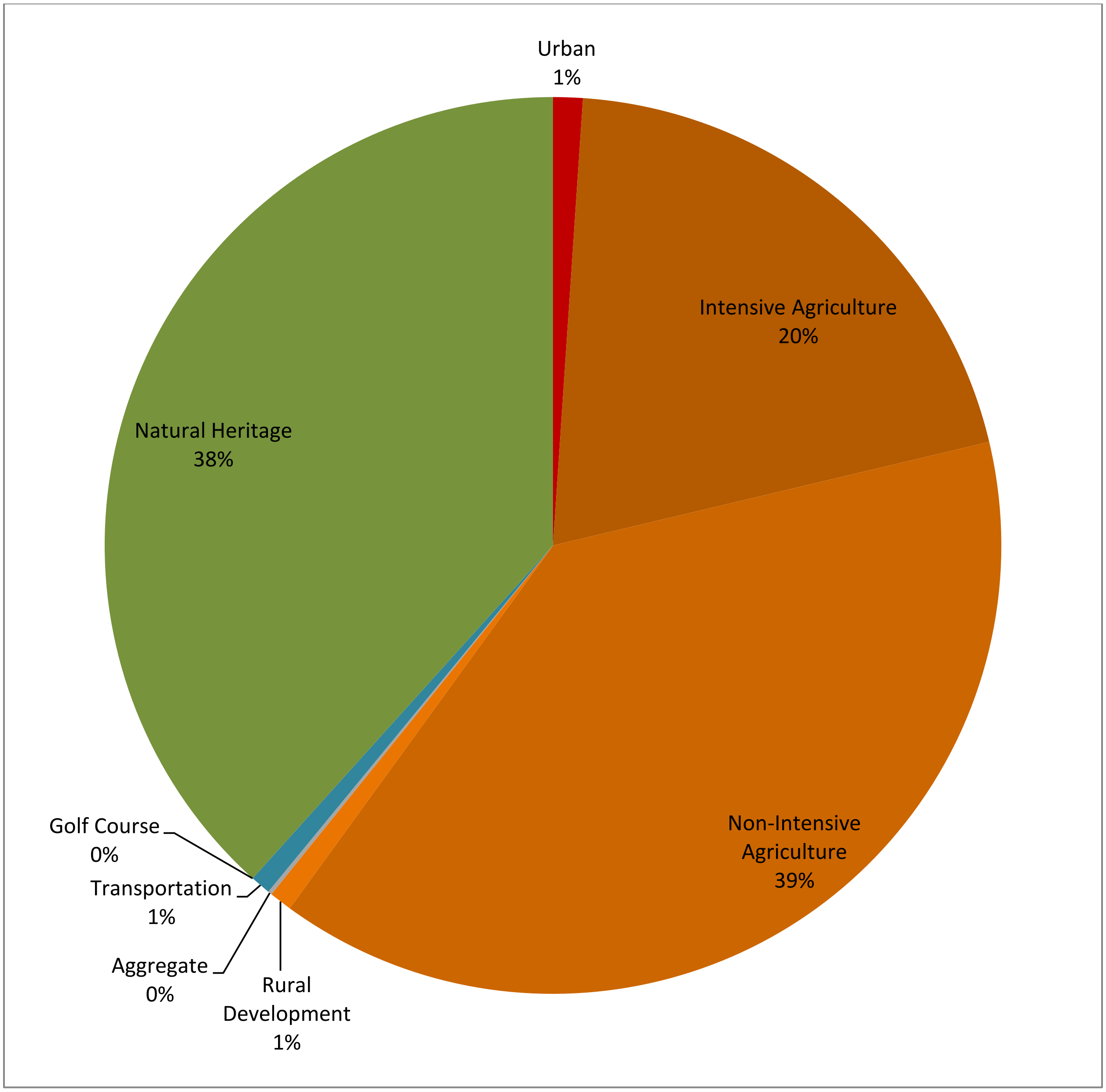

Figure 2-5 Land use distribution in the Whites Creek subwatershed

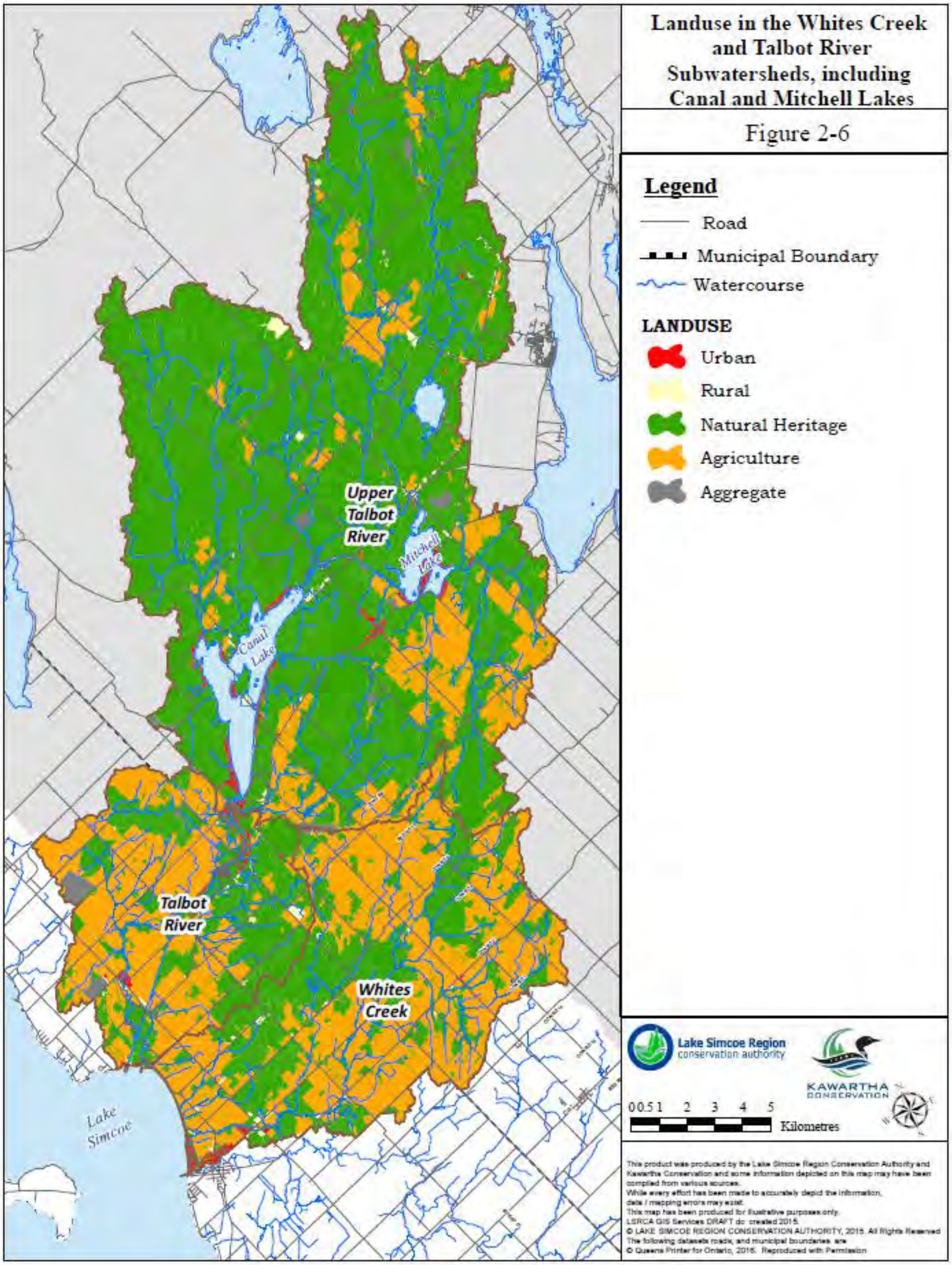

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Figure 2-6: Land uses in the Whites Creek and Talbot River subwatersheds, including Canal and Mitchell Lakes

To see how these subwatersheds compare to the other subwatersheds in the Lake Simcoe watershed Figure 2-7 to Figure 2-9 illustrate all 18 of the Lake Simcoe subwatersheds from the subwatershed with the highest percentage of urban, natural heritage, and rural land uses to the subwatershed with the lowest percentage. The Talbot River and Whites Creek subwatersheds are outlined in black.

As can be seen in Figure 2-7, the Barrie Creeks has the highest percentage (62%) of urban land use, while the Talbot River and Whites Creek have the second lowest and lowest proportion, each with just over 1%.

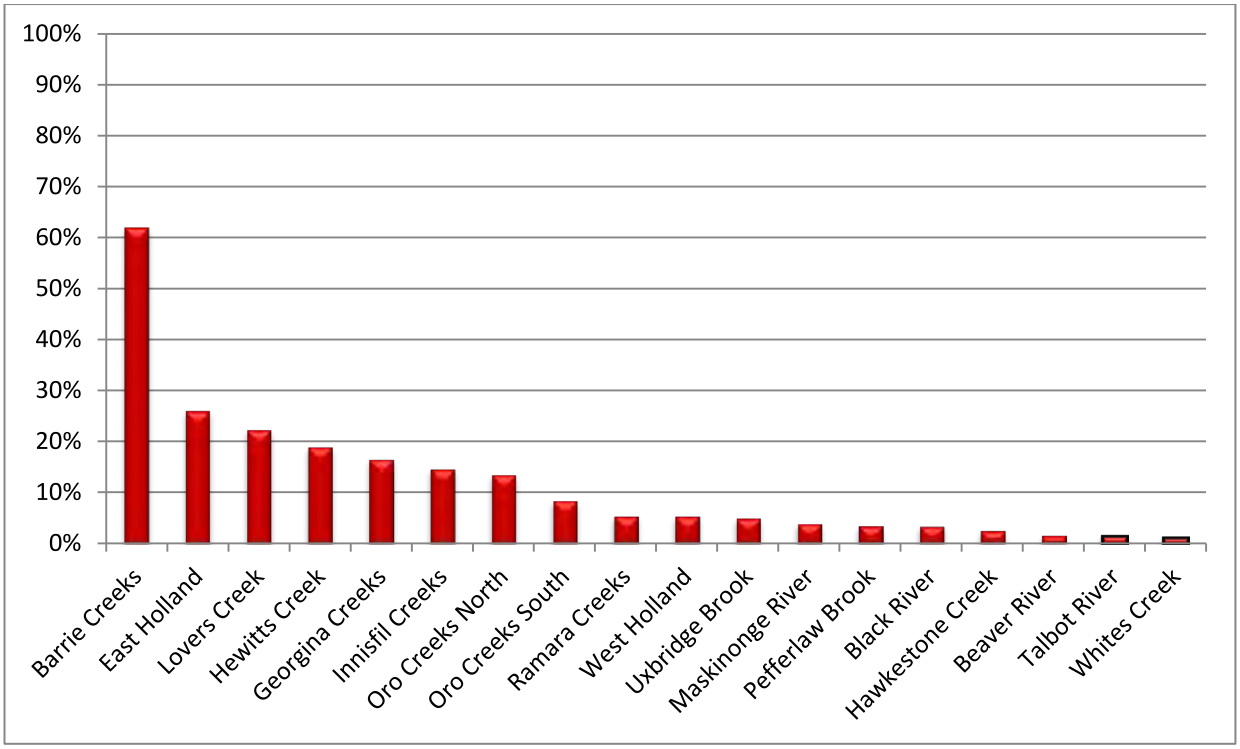

Figure 2-7: Urban land use in the Lake Simcoe subwatersheds.

The Talbot River subwatershed has the highest level of natural heritage cover in the Lake Simcoe watershed, by a fair margin, with 76%. The Whites Creek subwatershed falls around the mid-range of the subwatersheds, with the ninth lowest level, at 38%. This is in stark contrast to the Barrie Creeks subwatershed, which has the lowest level of natural cover in the watershed, with only 17% (Figure 2-8).

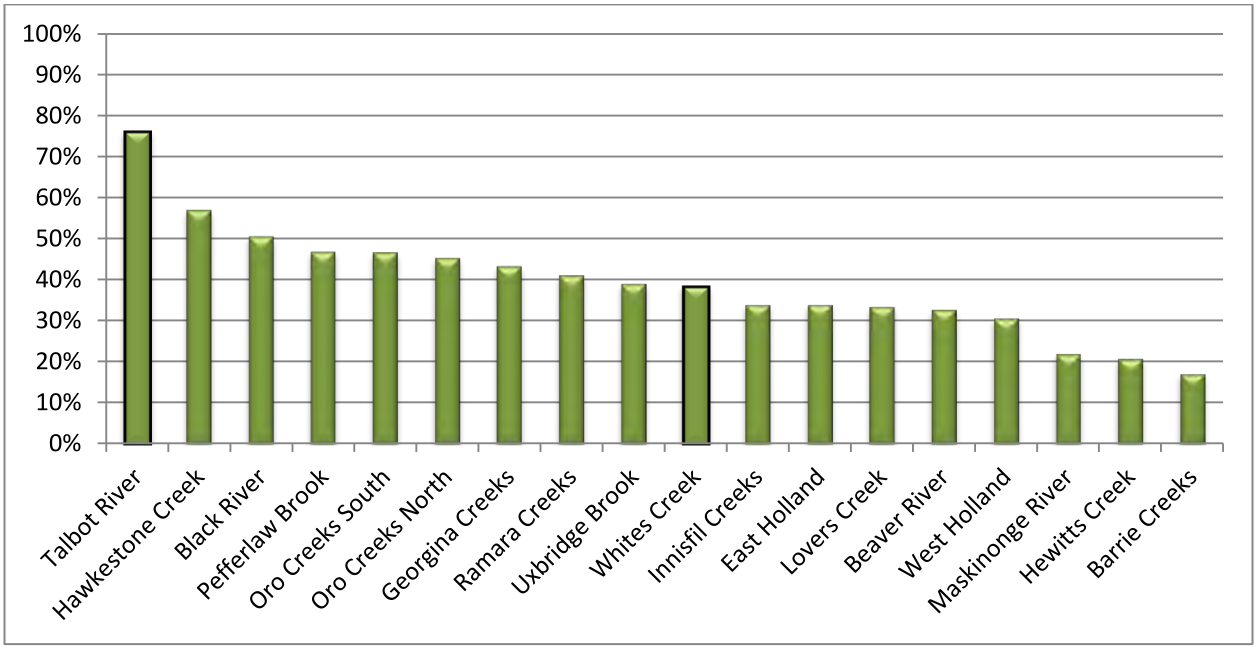

Figure 2-8: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-9 illustrates the rural land use in the Lake Simcoe subwatersheds. The Maskinonge River subwatershed in the southern part of the watershed has the highest percentage with 73%, while the Barrie Creeks subwatershed has the lowest (5%). There is a large percentage gap between the two lowest (Barrie Creeks at 5% and the Talbot River at 12%) and of the third lowest subwatershed (East Holland subwatershed) which has 34%. At close to 60%, the Whites Creek subwatershed has the fourth highest level of rural land use in the watershed; an indication that this land use is contributing to some of the issues being seen in the subwatershed.

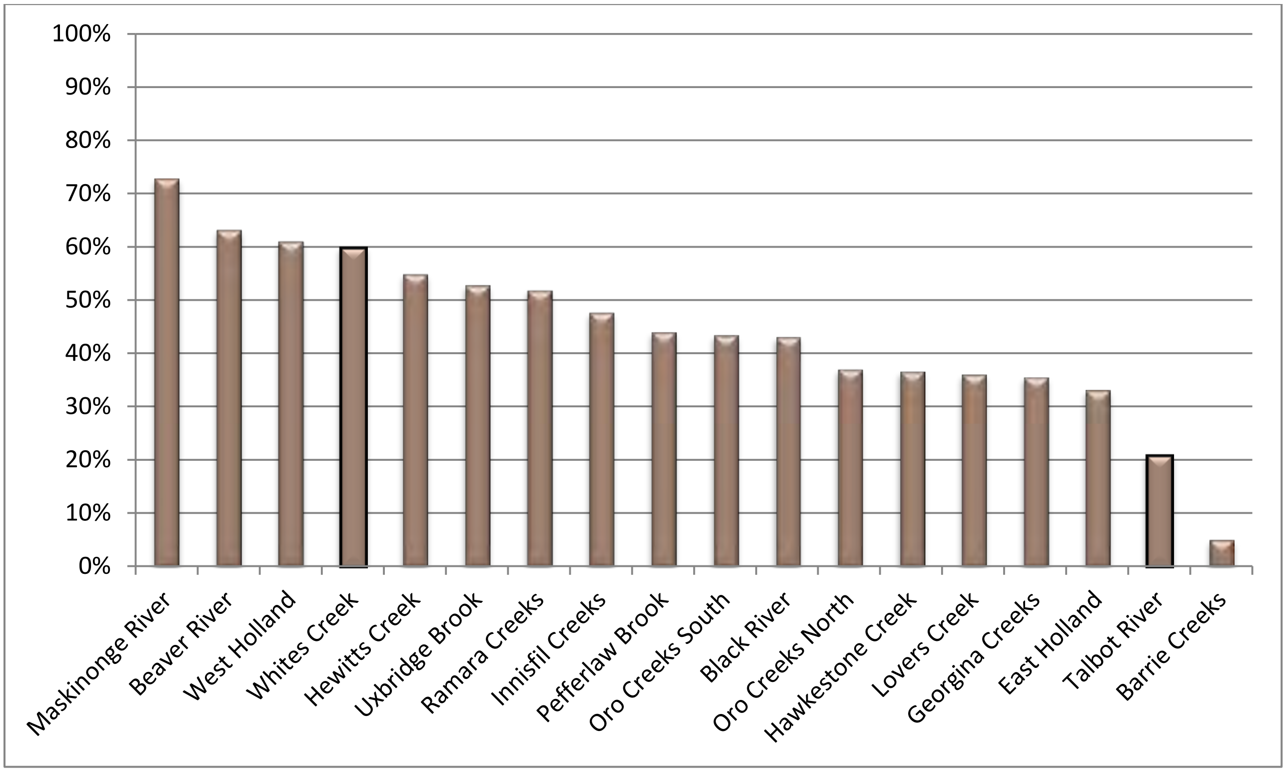

Figure 2-9: Rural land use in the Lake Simcoe subwatersheds.

2.6.1 Impervious Surfaces

Impervious surfaces refer to hardened surfaces, such as roads, parking lots, and rooftops, which are made of (or covered in) a material impenetrable by water (i.e. asphalt, concrete, brick, rock, etc) [2]. As these surfaces reduce the amount of water infiltrating down into the groundwater supplies and increases surface runoff, the hydrologic properties or drainage characteristics of the area are significantly altered.

Increasing levels of impervious surfaces, generally associated with urban growth, can impact the surrounding environment in a number of ways. These impacts include decreases in evapotranspiration, as there is little vegetation and the permeable soil is paved over; decreases

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[2] For the majority of this report, impervious surfaces do not include features such as wetlands. These are sometimes considered impervious in hydrogeological models, such as those presented in Chapter 4 – Water Quantity.

in groundwater recharge; increases in the volume and intensity of surface runoff, leading to an increase in flow velocities and energy (which can alter the morphology of the stream through channel widening, under cutting of banks, sedimentation, and braiding of the stream); thermal degradation of the watercourses; decreases in water quality as pollutants are washed off streets into storm drains or ditches which discharge to watercourses or the lake; and impairment of aquatic communities (which can be negatively affected by all impacts listed above).

Environment Canada's '*How Much Habitat is Enough?'* guidelines (2013), suggest a limit of 10% imperviousness for urbanized subwatersheds, where subwatersheds should still be able to maintain surface water quality and quantity, and preserve the density and biodiversity of aquatic species. These guidelines further recommend an upper limit of 25-30% impervious cover as a threshold for degraded systems that have already exceeded the 10% impervious guidelines.

The Talbot River and Whites Creek subwatersheds all fall below the 10% guideline, with 2.2% and 2.5% impervious area, respectively. This is in large part due to the prevalence of natural features, as well as agricultural land uses in the study area and relatively low level of developed areas. Some new urban areas are projected for the study area; it will be important to undertake measures to maintain this low level of imperviousness in order to preserve groundwater recharge and flow patterns. This is of particular importance in portions of the study area, such as Whites Creek where low flows are an issue, as will be discussed in later chapters. Figure 2-10 illustrates the impervious cover within the subwatershed.

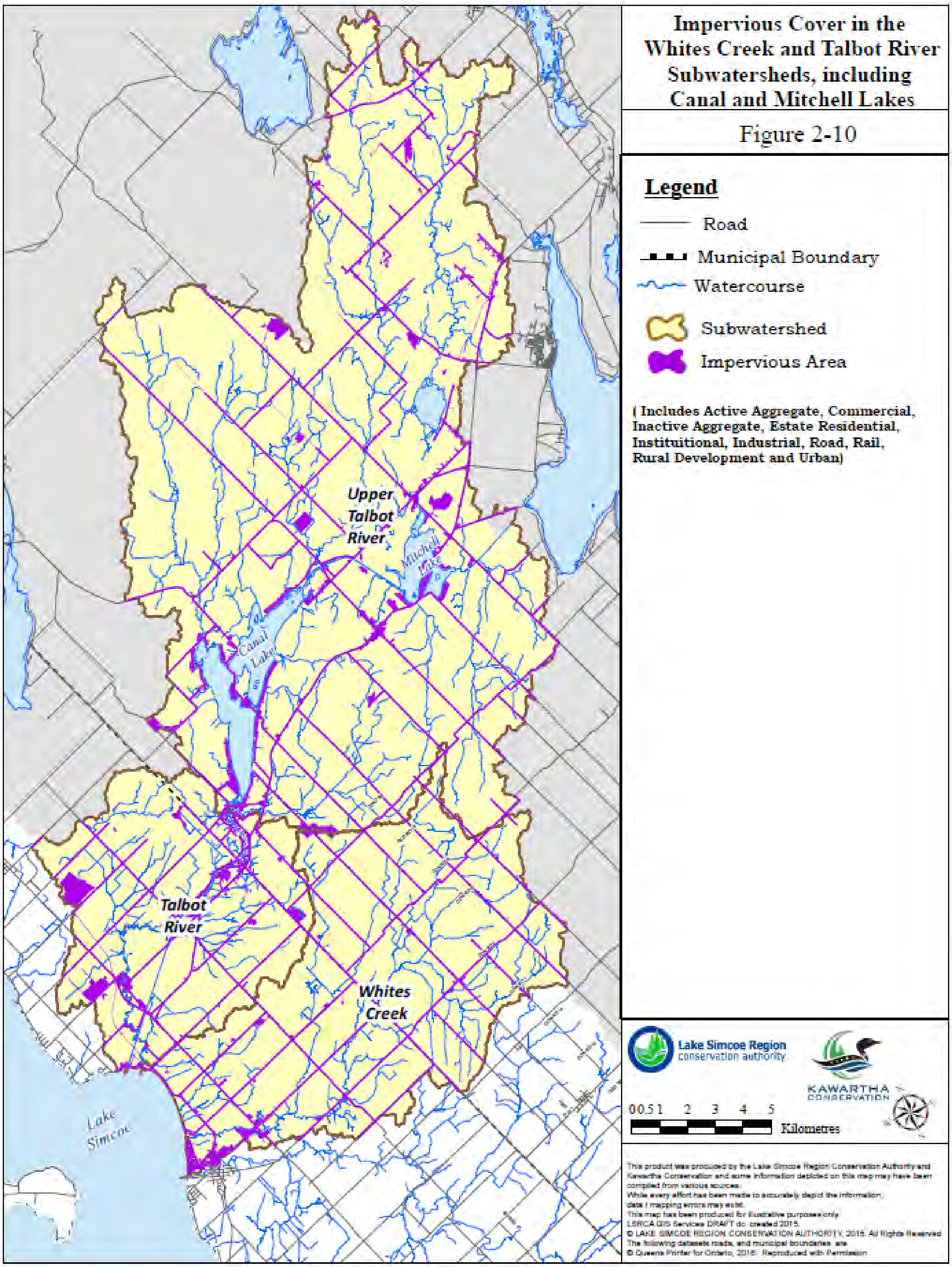

Figure 2-10: Impervious cover in the Whites Creek and Talbot River subwatershed, including Canal and Mitchell Lakes

3 Physical Characteristics

3.1 Geology and Physical Geography

The geology, topography, and other physical features of a subwatershed provide the foundation for the subwatershed's hydrological and ecological processes, as they provide a strong influence on factors such as local climate patterns, types of land cover, land use practices, and surface water and groundwater flow paths.

3.1.1 Geology

A number of studies have contributed to the geologic understanding in the study area. A generalized description of the bedrock geology, quaternary geology, and conceptual stratigraphic units within the Whites Creek and Talbot River subwatersheds is provided below. For more detailed information the reader is referred to Finamore and Bajc (1983,1984), Johnson *et al*. (1992), Armstrong (2000), and Easton (1992).

3.1.2 Bedrock Geology

The Precambrian bedrock in the Whites Creek and Talbot River subwatersheds forms the foundation to a sequence of younger Paleozoic sedimentary rocks. The Precambrian 'basement' rocks form part of the Central Gneiss Belt, which is a major subdivision of the Grenville Structural Province. The rocks of the Grenville Province constitute one of the main geological provinces of the Canadian Shield. In the study area, these Canadian Shield 'basement' rocks are characterized by metaplutonic and metasedimentary gneisses and migmatites of medium to high metamorphic rank. The Precambrian igneous and metamorphic rocks outcrop extensively north of the study area.

A sequence of Middle Ordovician Paleozoic rocks overlay the Precambrian basement. These Paleozoic units predominantly consist of carbonate and clastic sedimentary deposits thought to have formed under marine conditions. East to west trending subcrop belts of progressively younger Ordovician units occur as one moves southward through the region. The Ordovician sequence in the study area consists of seven formations that dip gently towards the south, from oldest to youngest. The seven formations from oldest to youngest include: the Lower Gull River Formation, the upper Gull River Formation,the lower, middle, and upper Bobcaygeon Formation, the Verulam Formation, and the Lindsay Formation.

Gull River Formation

The Gull River Formation overlies the Shadow Lake Formation and consists of micritic to fine grained limestones. The formation can be divided into a lower and upper unit , with an overall thickness of up to 25 m (Armstrong, 2000). The lower member measures up to 14 m thick, while the upper member has a maximum thickness of about 10 m. At the top of the lower member, there is a distinctive horizon about 1.5 m thick of light green dolostone or dolomitic limestone, known informally as the 'green marker bed'. The Upper and Lower members are represented by the light purple and darker purple colour in , respectively.

Bobcaygeon Formation

The Bobcaygeon Formation is the next unit in the sequence and is mainly composed of limestone that is generally more fossiliferous and coarser grained than the underlying Gull River Formation. It is divided into three members. The composition of the formation includes very fine to coarse-grained limestones in the lower and upper members, and interbedded shale and fine- to medium-grained limestones in the middle member. The composition of the upper member is characterized by limestones with shaly partings and a few thin shale beds. In terms of areal extent, this formation is the most significant Paleozoic unit subcropping in the study area. The Upper, Middle, and Lower Bobcaygeon formation is represented by the three shades of green in Figure 3-1.

Verulam Formation

Overlying the Bobcaygeon Formation is the Verulam Formation, which ranges between 45 to 60 m in thickness and is divided into two subgroups. The lower unit consists of interbedded calcareous shale and limestones that range from micritic mudstones to coarse-grained packstones and grainstones. The upper units consists of coarse-grained limestones and measures up to 10 m in thickness. The Verulam Formation forms a broad subcrop belt across the southern part of the study area. Due to its high shale content, the lower member of the Formation weathers easily and only the upper member forms good outcrops. The Verulam formation is represented by the colour grey in Figure 3-1.

Lindsay Formation

The Lindsay Formation is the youngest bedrock unit in the study area. The unnamed lower member consists of very fine grained to coarse grained, fossiliferous limestone with a distinctly nodular appearance (Johnson et al., 1992). The upper member of the formation in present in the southern portion of the study area.

Karst

Karst topography refers to limestone regions with underground drainage and cavities caused by the dissolution of limestone rock. Karst landscapes are characterized by features such as sinkholes, caves, and solutionally enlarged joints in the bedrock called “grikes”. Karst features are largely prominent in the Upper Talbot River subwatershed, across the Carden Plain physiographic region. The Carden Plain physiographic region is further discussed later in this chapter.

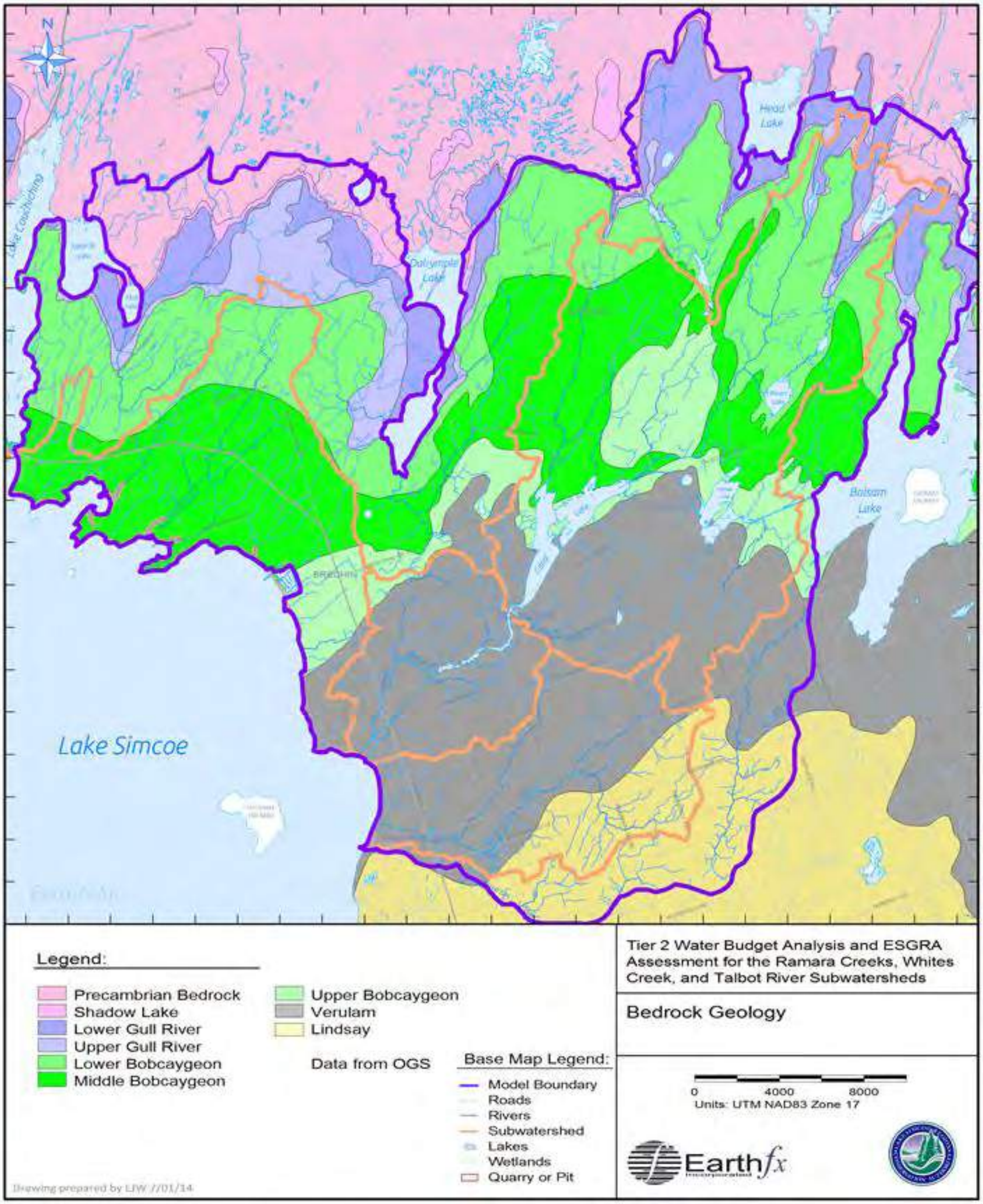

Figure 3- 1: Bedrock geology in the Whites Creek and Talbot River subwatersheds (Earthfx, 2014).

3.1.3 Bedrock Topography

The bedrock surface is thought to have been the result of a long period of non-deposition and/or erosion activity that occurred between the deposition of the sedimentary bedrock and the overlying sediments. On a regional basis, the surface of this unit dips gently to the south-southwest (Armstrong, 2000). Based on Figure 3-2, the bedrock surface of the Whites Creek and Talbot River subwateshed has a general elevation range of 200 to 350 masl. The highest elevation of the bedrock surface coincides with the northern portion of the Upper Talbot subwatershed with gradually declining elevations towards the south western portion of the study area, along the shoreline of Lake Simcoe.

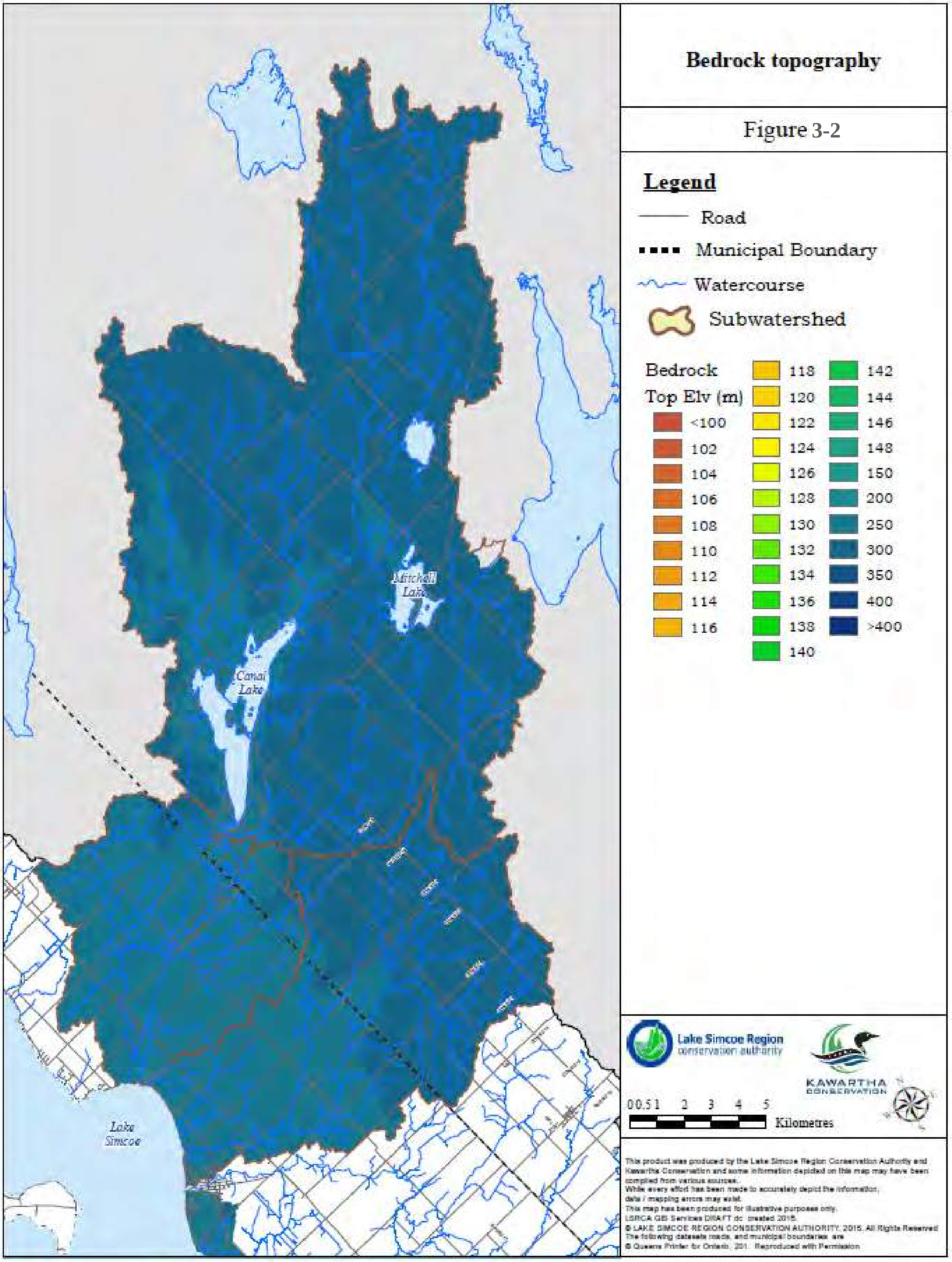

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Figure 3-2: Bedrock topography in the Whites Creek and Talbot River subwatersheds.

3.2 Quaternary Geology

3.2.1 Glacial History

Like all of southern Ontario, the study area was repeatedly glaciated during the Pleistocene Epoch, although locally there is only clear evidence of glacial activity during the Wisconsinan Episode, the final major glacial episode. Regionally, sediments of Quaternary age form a complex blanket of sediment deposits on the bedrock surface. As seen in Figure 3-3, Quaternary sediments are thicker in the western and southern parts of the study area, and thin to absent in the northern portions. These northen portions of the study area are largely associated with the unique physiographic region known as the Carden Plain. The Carden Plain is thought to be one of the key karst regions of Southern Ontario.

Most of the quaternary sediments in the region were deposited either directly from glacier ice, in meltwater streams, or in ice-marginal or ice-dammed lakes (Earthfx, 2014). The Whites Creek and Talbot River subwatersheds are thought to have been occupied by ice for most of the Late Wisconsinan period. Glacial ice movement in the area was out of the northeast.The pattern of glaciation in the Great Lakes region was typically lobate, with relatively thin glacier ice flowing from the north filling the lake basins and then spreading out radially as the ice mass became thicker. The extent of ice recession during the Erie phase following the glacial maximum is not well understood.

In the study area the bedrock is overlain by unconsolidated sediments, known as the overburden, which were deposited during the Quaternary Period. The Quaternary period is the most recent time period of the Cenozoic Era on the geologic time scale. The Quaternary Period can be divided into the Pleistocene (Great Ice Age) and the Holocene (Recent) Epochs. During the Pleistocene, at least four major continental-scale glaciations occurred, which include, from youngest to oldest, the Wisconsinan, Illinoian, Kansan, and Nebraskan Stages (Dreimanis and Karrow, 1972).

All of the surficial deposits within the study area subwatersheds, and within most of southern Ontario, are interpreted to have been deposited by the Laurentide Ice Sheet during the Wisconsinan glaciation. The Laurentide Ice Sheet is the glacier that occupied most of Canada during the Late Wisconsinan period, approximately 20,000 years ago (Barnett, 1992).

The quaternary deposits within the study area are shown on Figure 3-3. Much of the surfical geology described below is based on mapping and descriptions by the Ontario Geologic Survey Armstrong and Dodge (2007), and Armstrong (2000). As illustrated in the figure, one of the major surficial units in the study area, particularly in the Lower Talbot River and Whites Creek subwateshed, is the Newmarket Till sheet- a compact and fissile low conductivity till diamicton characterized by sandy silt to silty sand conditions. It is represented by the green colour on Figure 3-3. Another prominent unit in the southern portion of the study area is described as a well laminated, fine grained glaciolacustrine silt and clay unit thought to have been deposited in a post-glacial lake environment. This silt clay unit is represented by the turquoise colour on Figure 3-3. As the Late Wisconsinan ice receded much of the area was inundated by the waters of Early Glacial Lake Algonquin, the first in a series of major post-glacial lakes in the region. The silt and clay deposits present across the Whites Creek and Talbot River subwatersheds are thought to be the result of glacial sedimentation processes that occurred in these early post-glacial lakes. Together the Newmarket Till unit and glaciolacustrine silt clay sediments characterize a large area of the southern portion of the study area.

Several concentrated areas of sand deposits are also present across the study area. These sandier units are represented by the yellow colours in Figure 3-3. These sandy to gravelly beach deposits developed where wave action reworked older sediments present on the shorelines of pre-existing post-glacial lakes.

Unique ice contact deposits such as the southwest trending eskers found north of Mitchell Lake can also be observed across the study area. These stratified ice contact deposits developed in the waning stages of glaciation, when meltwater streams either on or within the glacier deposited bodies of sand and gravel. Ice contact deposits are represented by the colour orange on Figure 3-3. Other glacial recession features include a large number of southwest trending drumlins, found extensively across the study area subwatersheds.

Sediments of recent age mainly in the form of organic deposits also occur in subwatershed, predominantly along the southwest trending wetland complex that runs along much of the eastern boundary of the study area .

In the northern portion of the study area, overburdern deposits are largely absent and the area is characterized by the presence of a largely bare paleozoic Ordovician aged bedrock. Due to its limestone geology ,the bedrock features a number of Karst features such as solutionally developed joints and fractures.

Other unique features in the area include a network of erosional channels known as tunnel valleys. Late in the Wisconsinan period, there were widespread, vigorous subglacial drainage events in sounth-central Ontario that produced a network of these erosional channels (refered to as tunnel valleys or tunnel channels). In the northern portion of the study area , where surficial deposits are limited, these tunnel channels were cut into the Paleozoic bedrock. Generally the tunnel channels in the area are relatively shallow- from 5 - 20 m deep, trend southwest, and range from less than 500 m to more than 2.5 km wide (Earthfx, 2014). After the erosion of the channels many were infilled with local till deposits. Today the tunnel channels house many of the streams, tribuatires, and wetlands that characterize the area.

3.2.2 Quaternary Sediment Thickness

Within the subwatersheds, the Quaternary sediment thickness is the difference between the ground surface and the bedrock surface, as determined from borehole and water well information within the subwatershed. Figure 3-4 shows that the overburden thickness across the study area is relatively thin, ranging from 0 in the upper portions of the study aream where the bedrock is found at the surface, to 25 m in the south-western portions of the study area. Overall, Quaternary sediment layers are thinner in areas of Newmarket Till, and slightly thicker across areas of organic and glaciolacustrine silt and clay deposits.

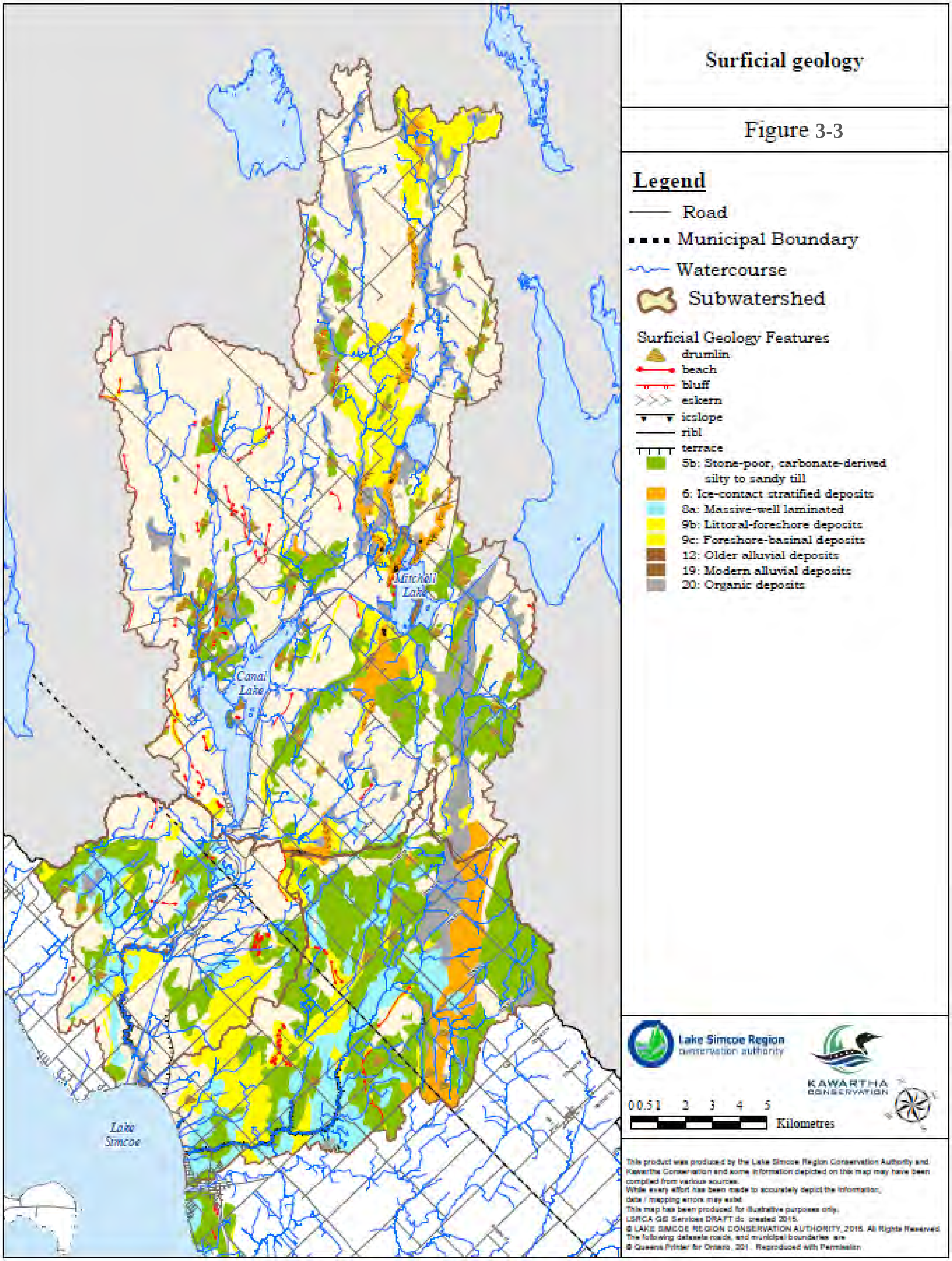


Figure 3-3: Surficial geology in the Whites Creek and Talbot River subwatersheds.

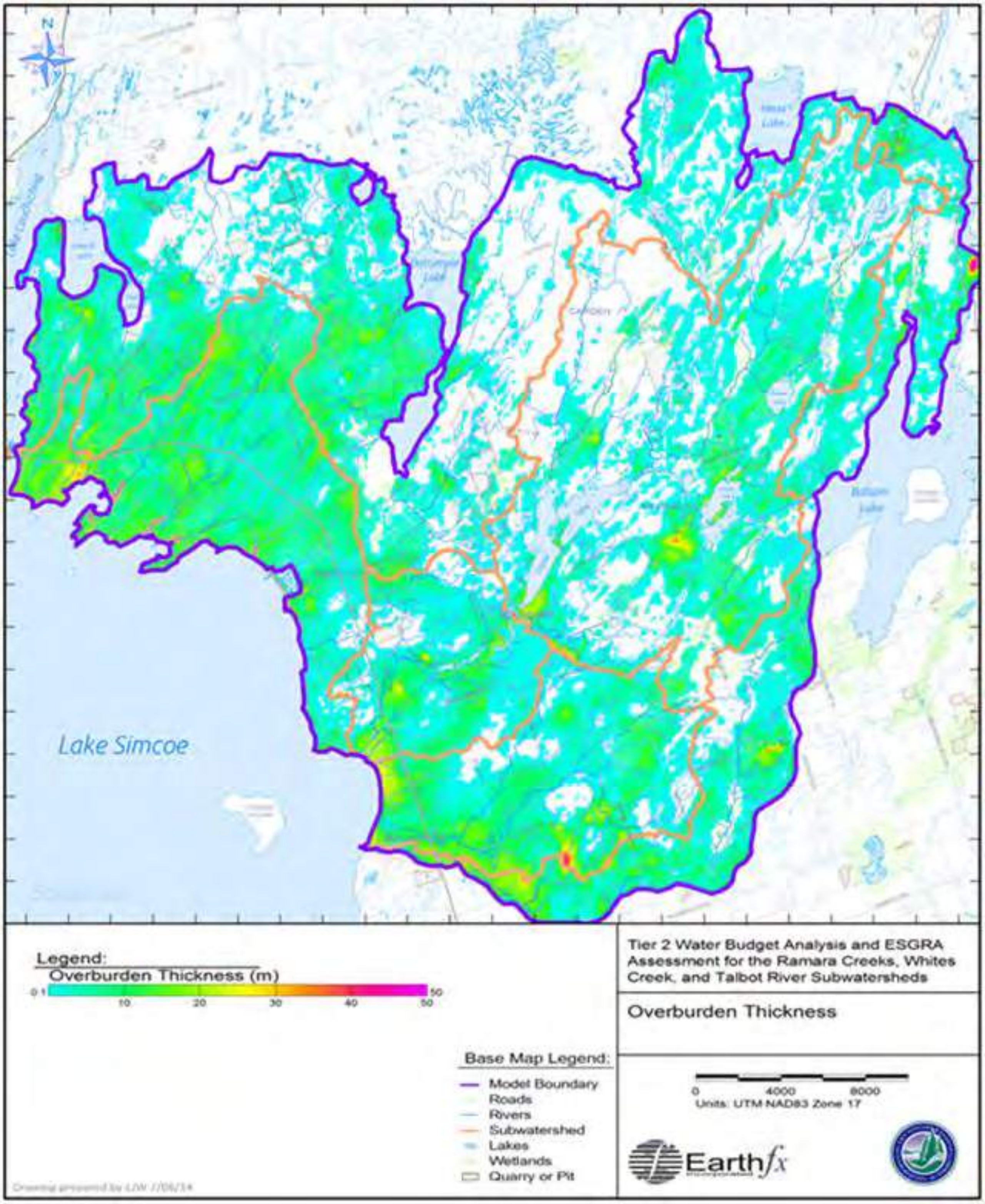


Figure 3-4: Overburden thickness (in metres) (Earthfx, 2014).

3.2.3 Hydrostratigraphy

The geology of the subwatersheds significantly influences the local hydrogeology, which is how the groundwater moves within the soil and rocks. Hydrogeologists study the geologic formations to understand how much water infiltrates into the subsurface, where it flows, how quickly it flows, and where it re-enters the surface water system. Changes in groundwater quantity and quality have potential impacts on natural functions that could affect the surface water flow regime, aquatic ecosystems, and use of the resource as a viable water supply.

Hydrostratigraphy is the spatial mapping of geologic formations based on their water-bearing properties. The hydrostratigraphy of the surficial deposits within the subwatersheds is complex as a result of the glacial history. The hydrostratigraphic model for the Whites Creek and Talbot River subwatersheds was derived using the stratigraphic mapping completed by the Ontario Geological Survey (Armstrong and Dodge, 2007), and (Armstrong, 2000).

Stratigraphic geology provides a framework for delineating the aquifer and aquitard layers for the study area. Figure 3-5 illustrates the generalized conceptual cross section for the Ramara Creeks, Lower Talbot River, and Whites Creeks subwatersheds (note the Ramara Creeks subwatershed is not discussed in this subwatershed plan; more information can be obtained from the Ramara Creeks Subwatershed Plan, LSRCA (2015)). Figure 3-6 illustrate the hydrostratigraphy of the Upper Talbot River subwatershed, while Figure 3-7 illustrates the location across which the cross section was developed. The conceptual hydrostratigraphic model developed by Earthfx (2014) is closely related to the stratigraphic model simply because stratigraphic units can generally be characterized as either aquifers or aquitards (Earthfx, 2014). An aquifer is an underground saturated permeable geological formation that is capable of transmitting water in sufficient quantities under ordinary hydraulic gradients to serve as a source of groundwater supply. Aquifers in the study area are generally associated with weathered and fractured bedrock and sandy channel sediment units while unweathered bedrock and silty sand till formations are generally associated with aquitards. A description of the interpreted hydrostratigraphic framework is provided below.

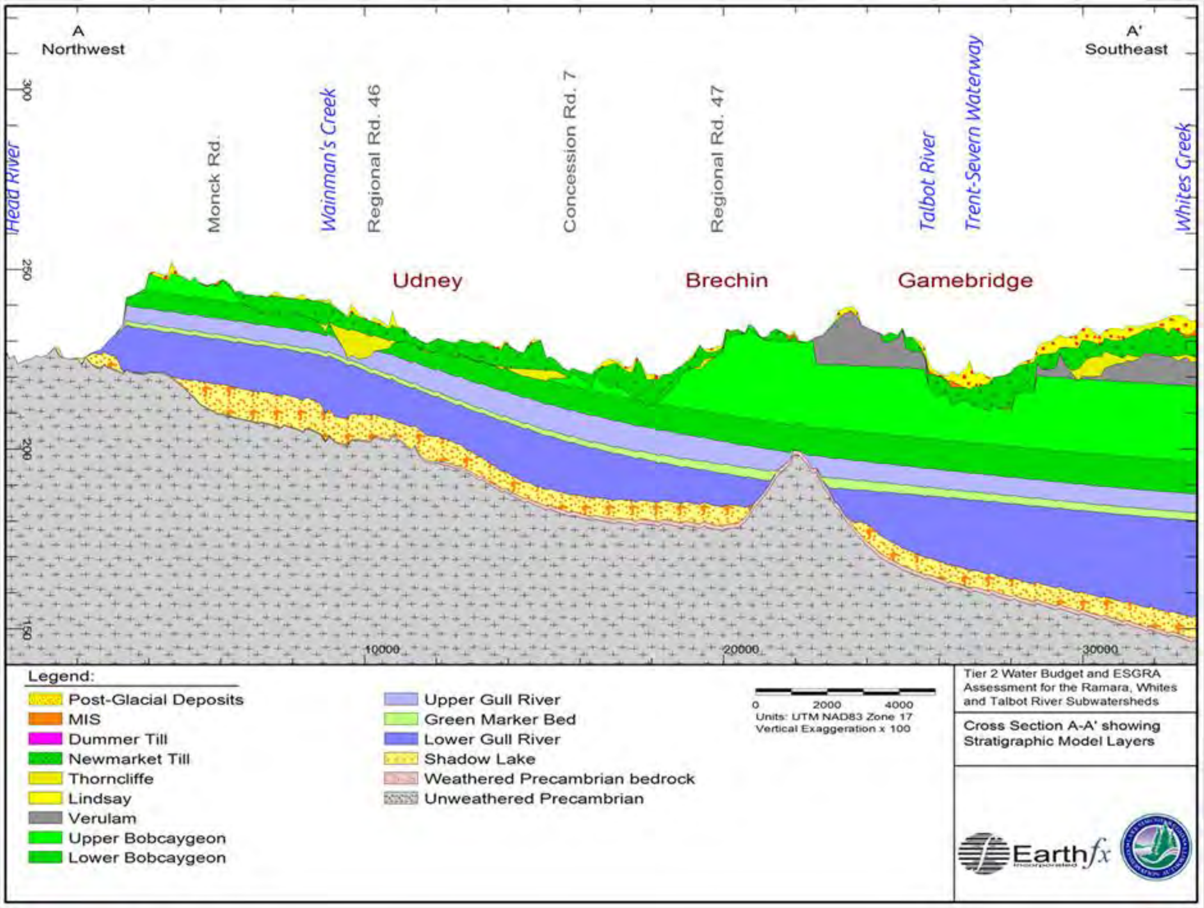


Figure 3-5: Generalized conceptual stratigraphy of the Ramara Creeks, Lower Whites Creek, and Talbot River subwatersheds (cross section location A –A') (Earthfx, 2014)

*** Note the stratigraphy of the Whites Creek and Lower Talbot subwatersheds is only depicted on the right hand side of the schematic (the portion beginning at Regional Rd. 47 to Whites Creek). The remainder of this schematic represents the stratigraphy of the Ramara Creeks subwatershed. More information on the Ramara Creeks subwatershed can be obtained from the Ramara Creeks Subwatershed Plan (LSRCA, 2015).**

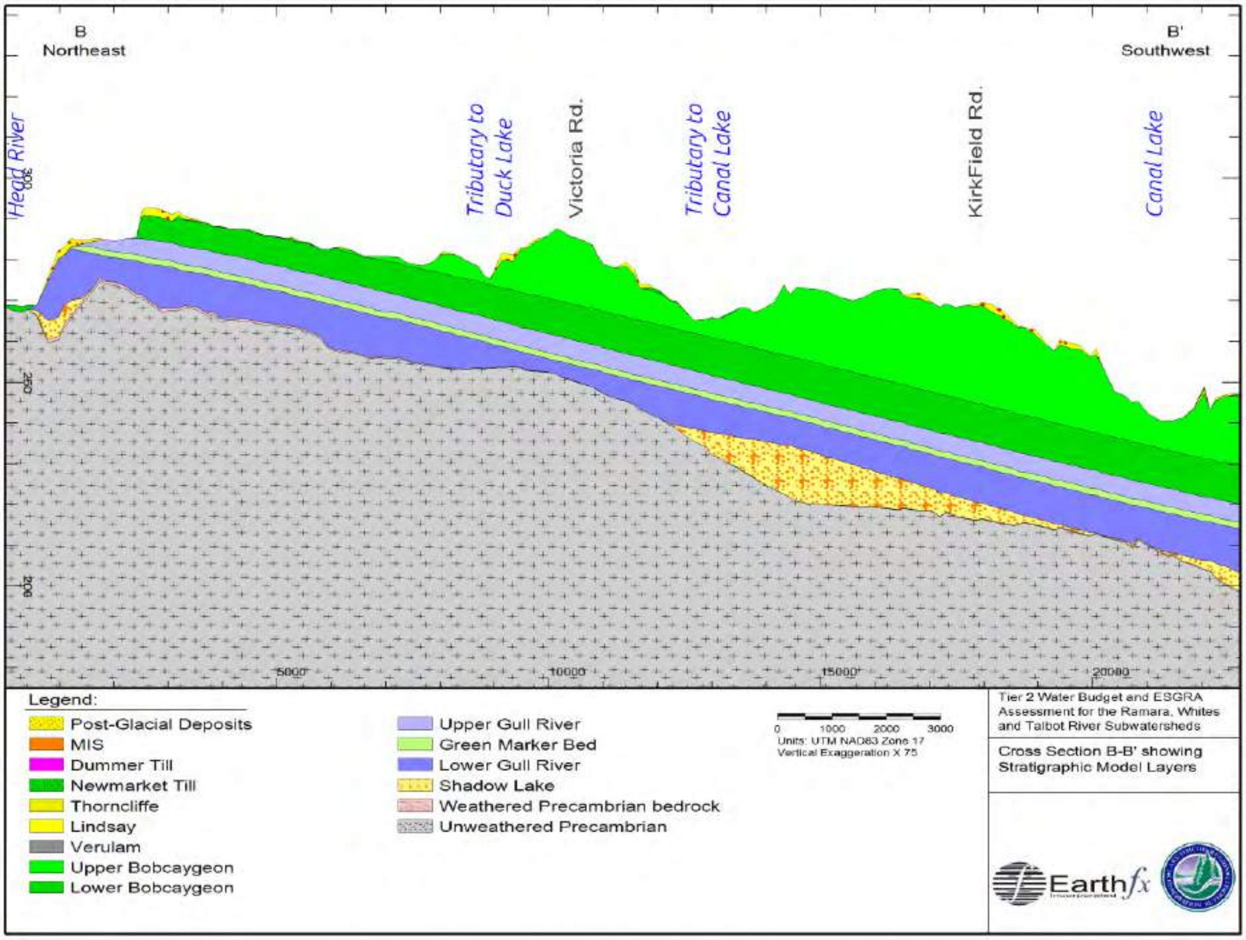


Figure 3-6: Generalized conceptual stratigraphy of the Upper Talbot subwatershed (cross section location B-B') (Earthfx, 2014).

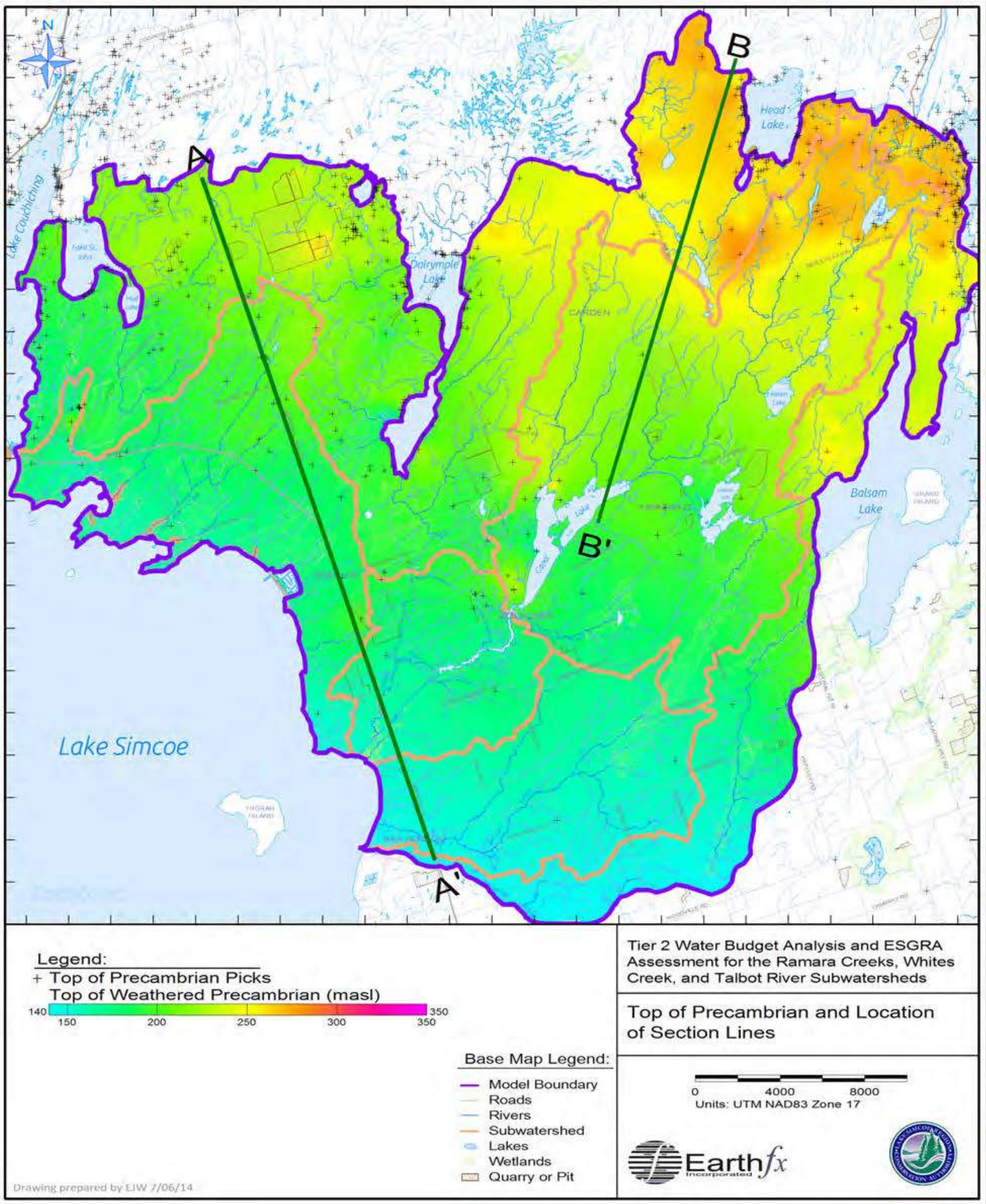


Figure 3-7: Cross-section locations (Earthfx, 2014)

***Note the northen portion of the cross section delineation A-A' is not covered in this subwatershed plan, as it is outside of the Whites Creek and Talbot River subwatershed boundaries.**

The study area was subdivided into seven hydrostratigraphic conceptual model layers (from youngest to oldest), where each layer was occupied by one or more of the fourteen hydrostratigraphic units identified across the study area . The conceptual hydrostratigraphic model layers are:

- Surficial Deposits – Mackinaw Interstadial Sediments
- Surficial Deposits – Newmarket Till
- Weathered Bedrock Interface Aquifer - Lindsay/Verulam bedrock and tunnel channel sands and gravels.
- Upper Bedrock Aquitard - Interbedded Limestone and Shale of Verulam and Lindsay Formations / Unweathered limestone of Bobcaygeon Formation and Upper Gull River Formation
- Green Marker Bed Aquifer
- Lower Gull River Aquitard
- Shadow Lake/ Fractured Precambrian Aquifer
- Precambrian Bedrock (Model Base)

Due to its unique characteristics, the Carden Plain region of the Upper Talbot subwatershed was represented by a distinct conceptualization that is different from the regional conceptualization outlined above. Unlike the regional model , where the top two layers of the conceptual model are assigned properties of the overburden materials, the top two layers in the Carden Plain model instead represent the solutionally weathered Paleozoic bedrock (often referred to as the “Alvar”). The remainder of the layers between the two conceptualizations are largely the same and represent the aquifers and aquitards present in the bedrock units. Each of the conceptual hydrostratigraphic model layers are further described below.

Surficial Deposits - Mackinaw Interstadial Sediments

The Mackinaw Interstadial Sediments are characterized by regionally variable glacio-lucustrine and glacio-fluvial overburden deposits found intermittently across the the study area. Generally, the material associated with these depositis consists of glaciolacustrine desposits in the subsurface, and glaciofluvial sand and gravel at the surface. Post-glacial deposits such as fine-grained silts and clays, interpreted to have originated from post-glacial lakes are also represented in this layer. Where present, the materials in this unit are the shallowest of the overburden units. These fine grained silts and clays are discontinuous across the study area and represent a poor aquitard.

Surficial Deposits - Newmarket Till

The Newmarket Till covers large portions of the southern and western ends of the study area (particularily the Lower Talbot River and Whites Creek subwatersheds). The Till generally represents a regional aquitard that confines the underlying bedrock aquifers. The unit is characterized by a relatively low hydraulic conductivity that results from the unit’s high density sandy silt to silt sand composition (Earthfx, 2014). This surficial deposit unit is not represented in the Carden Plain Alvar conceptualization, as it is absent in this portion of the study area.

Weathered Bedrock Interface Aquifer

The composition of the weathered bedrock interface aquifer is dependent on the location in the study area. In the southern parts of the study area, the aquifer is characterized by weathered bedrock from the Lindsay and Verulam formations, and overburden sand and gravel sediments. The permeable composition of the unit serves as a regional shallow aquifer and is exploited by a number of private wells in the study area (Earthfx, 2014). The overlying sands and gravels of the unit are generally associated with tunnel channel features that formed as a result of high –energy sub-glacial drainage events that worked to erode earlier deposits. As flow waned, and the erosional processes subsided, these tunnel channels were infilled with the glacial sand and gravel sediments represented by Layer 3 in the model. In the northern end of the study area,where the Carden Plain characterizes the local geology, the weathered bedrock interface aquifer is representative of the interface between the Paleozoic limestone bedrock (Alvar) and the deeper bedrock units in the region.

Upper Bedrock Aquitard

The Upper Bedock Aquitard is composed of the upper member of the Gull River Formation, as well as the overlying Bobcaygeon, Verulam and Lindsay Formations. These units are all considered to represent regional aquitards where they are intact and unweathered (Earthfx, 2014). Although the limestones and shales of the Verulam and Lindsay Formations are geologically distinct from the thickly bedded limestones of the underlying Bobcaygeon and upper Gull River Formations, these units all have similarily low hydraulic conductivity and are generally not exploited by water wells in the area (Earthfx, 2014).

Green Marker Bed Aquifer

The Green Marker Bed Aquifer characterizes the zone between the upper and lower members of the Gull River formation. This zone consists of fractured limestones of generally high hydraulic conductivity. The Formation is a productive aquifer for the domestic water supply, despite the Formation’s limited thickness of less than 1.5 m.

Lower Gull River Aquitard

The composition of the Lower Gull River aquitard varies from fine grained dolostone to limestones high in clay content. The formation’s fine grained composition is responsible for the unit’s low hydraulic conductivity.

Shadow Lake/ Fractured Precambrian Aquifer

The Shadow Lake Formation and weathered Precambrian basement rocks form the final layer of the hydrostratigraphic model. The composition of the Shadow Lake Formation is highly variable but can generally be associated with coarse grained sandstones, while the weathered Precambrian basement rocks are representative of a zone of increased permeability at the Paleozoic- Precambrian contact. This final model overlies the Precambrian base of the model.

Precambrian Bedrock (Model Base)

The Precambrian model base is characterized by unweathered Precambrian age bedrock found extensively throughout the model area. This low permeability basement is not explicitly represented in the model.

3.3 Physiography, Topography and Soils

3.3.1 Physiography

Physiography is the study of the physical structure of the surface of the land. A physiographic region is an area with similar geologic structure and climate, and which has a unified geomorphic history. The study of physiography is important from a water resource perspective as the knowledge gained from understanding the land composition aids hydrogeologists and hydrologists in understanding the groundwater and surface water flow systems. The physiography of an area is also important from a land use perspective as the sediments and landforms present at the surface influence the types of activities that are present in the study area, such as agriculture and aggregate extraction.

The physiographic regions within the Whites Creek and Talbot River subwatersheds are a direct result of the deposition and erosion of the quaternary sediments (overburden) during glacial and post-glacial events, and closely correspond to the topography discussed in the following section. According to Chapman and Putnam (1984), the study area subwatersheds lie mainly within the Carden Plain (limestone plain) and Simcoe Lowlands physiographic regions, with a small section of the southwestern part of the study area in the Peterborough Drumlin Field (Figure 3-8). The Lower Talbot River subwatershed is characterized by the clay plain physiographic unit . Lacustrine sand plains are common in lower lying areas and can be found intersecting both the Lower Talbot and Whites Creek subwatershed boundaries. Other physiographic units found in the Whites Creek subwatershed include the drumlinized till plain (to the south) and the Carden Plain (to the north). The till plain intersecting the Whites Creek subwatershed is part of the Peterborough Drumlin Field physiographic region and features numerous northeast to southwest oriented drumlins. In the Upper Talbot River, the extensive Carden Plain unit has flat to undulating topography and is characterized by a bare to very thinly soil-covered limestone (Earthfx, 2014). This type of landscape is known as Alvar.

3.3.2 Topography

The topography of the subwatershed closely corresponds to its physiographic regions (3-9). The topographic relief across the study area subwatersheds is generally subdued. The maximum elevation is approximately 300 masl in the northern portions of the Upper Talbot River subwatershed, while the lowest elevation is measured at 217 masl along the Lake Simcoe shoreline . The land rises gently from west to east (Earthfx, 2014). Much of the relief within the subwatersheds is due to the parallel sets of northeast – southwest trending tunnel valleys which strongly influence drainage patterns. Tunnel valleys are further discussed in section 3.1 above.

3.3.3 Soils

The soils present within a subwatershed influences the type and productivity of the vegetation communities commonly growing within it. Soils also influence the quality and quantity of water entering the ground and running along the surface. Traditionally, soils within the subwatersheds have been characterized based on the coarseness of their texture. Coarse-textured soils (gravel and sand) allow water to infiltrate better than finer-textured soils (clay, silty loam) do. The texture of the soil is important because it directly influences the landscape's ability to generate runoff. For example, during a heavy thunderstorm, rainfall that cannot infiltrate the ground will pool on the surface of an area with finer textured soils. Once enough water has collected it will start flowing overland as a result of gravity and in so doing can erode soil particles, washing them into ditches, streams, and lakes. Ontario Geological Survey surficial geology maps (OGS, 2003) were used to assign soil types found in the study area. Figure 3-10 depicts the spatial distribution of the soil types present throughout the study area subwatersheds.

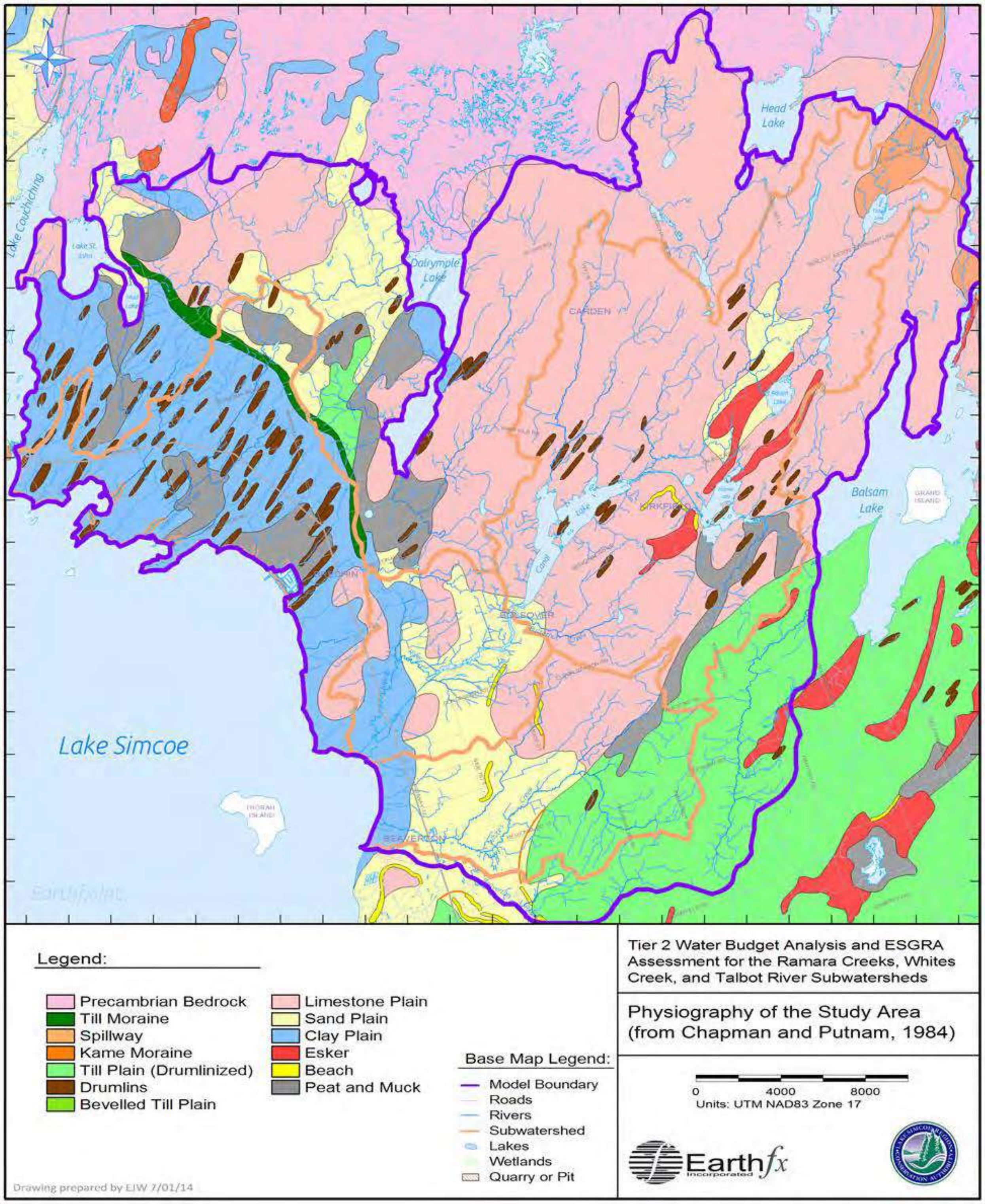
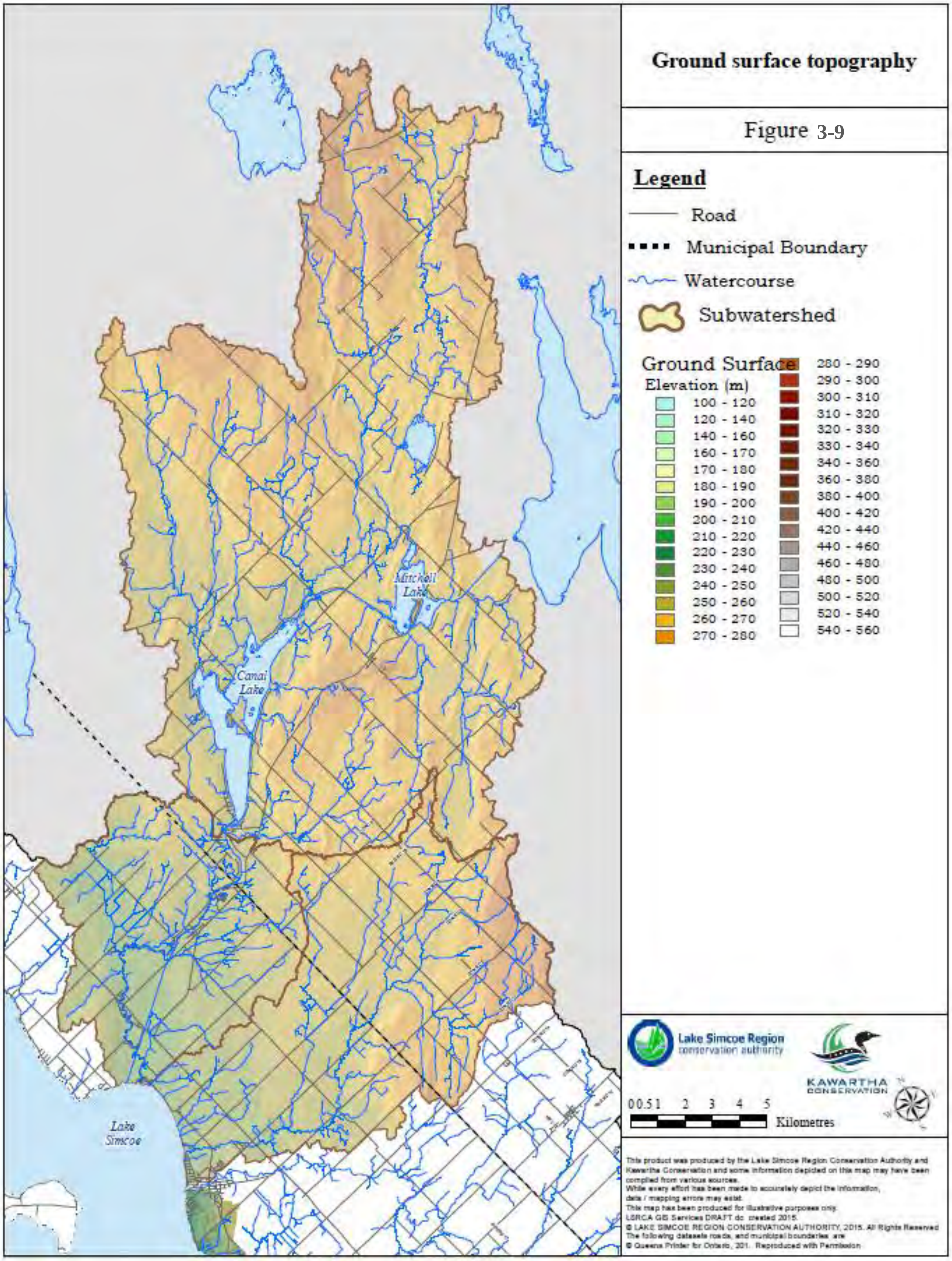


Figure 3- 8: Physiography (from Chapman and Putnam, 1984) (Earthfx, 2014).



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
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LSRCA GIS Services DRAFT dc created 2015.

Figure 3- 9: Ground surface topography (from 5-m Digital Elevation Model)

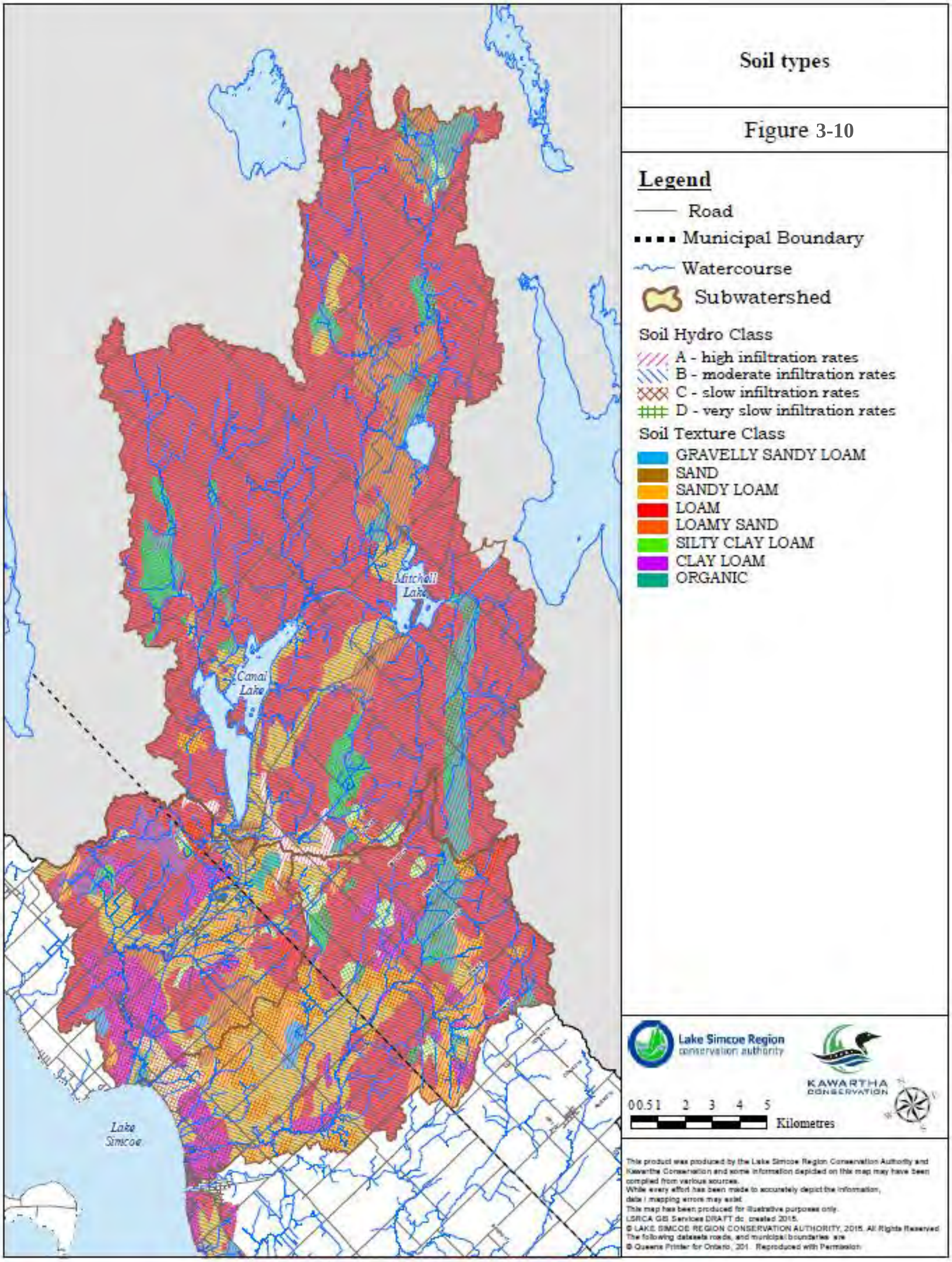


Figure 3- 10: Soil types in the Whites Creek and Talbot River subwatersheds

3.4 Fluvial Geomorphology

3.4.1 Introduction and background

Fluvial geomorphology is the study of the processes that influence the shape and form of streams and rivers. It describes the processes whereby sediment and water are transported from the headwaters of a watershed to its mouth. These processes govern and constantly change the form of the river and stream channels, and determine how stable the channels are. Fluvial geomorphology provides a means of identifying and studying these processes, which are dependent on climate, land use, topography, geology, vegetation, and other natural and human influenced changes.

An extensive understanding of geomorphic processes and their influences is required in order to protect, enhance, and restore stream form in a watershed. Changes in land use, and urbanization in particular, can significantly impact the movement of both water and sediment, and can thus cause considerable changes to the geomorphic processes in the watershed. Changes to the morphology of stream channels, such as accelerated erosion, can impact the aquatic community, which has adapted to the natural conditions, and can also threaten human lives, property, and infrastructure.

3.4.2 Geomorphic Processes

All streams and river systems are constantly in a state of transition, influenced by the flow of water and the amount of sediment entering into the system, which in turn are influenced by climate and geology. The amount of water delivered to the surface of a watercourse, as well as how and when it arrives is influenced by climate. Typical patterns are high flow events during the spring freshet, and low flow conditions during the winter and summer months.

The surficial geology of an area influences the path of water once it reaches the ground surface. The underlying geology establishes the volume and proportion of groundwater and surface water available to flow through a watershed through its effect on infiltration. Geology also shapes the amount and type of sediment that enters a watercourse, and the strength and erodibility of the surficial material through which the watercourse flows. A complex underlying geology and topography can result in considerable variation in channel character, as well as sensitivity to potential impacts, within the same drainage system.

Natural watercourses respond to continually changing conditions in flow and sediment supply with adjustments in shape and channel position. These changes take place through the processes of erosion and deposition. This ability to continually change is an inherent characteristic of natural systems that allows the morphology of the channels to remain relatively constant. The state in which flow and sediment supply are balanced to achieve this stable channel form is referred to as “dynamic equilibrium.” While in a state of dynamic equilibrium, channel morphology is stable, but not static, since it makes gradual changes as sediment is eroded, deposited, and moved throughout the watercourse. For example, many natural watercourses can be seen to “migrate” within their floodplain over time. This is due to the erosion of the outsides of channel bends, but with corresponding deposition of material on the insides of bends. This process maintains the balance between flow and sediment supply in the system. Riparian and aquatic biota are adapted to and depend on the habitats provided by a system in dynamic equilibrium.

3.4.3 Current Status

Specific fluvial geomorphology studies have not been completed for the Whites Creek and Talbot River subwatersheds, but some relevant information was available through other studies. The information and data provided within this section has been collected by LSRCA staff completing studies on the condition of the fisheries in the subwatersheds. While a fisheries study is specific in nature, it also tends to provide a "snap-shot" of the biological, chemical and physical characteristics of the system. It should also be noted that some sections of the watercourses in the subwatersheds have been moved, piped, channelized, eliminated or manipulated in some fashion to varying degrees. While specific data on the exact location and the degree to which a stream has been manipulated is not currently available, it is fair to say that the alteration of the watercourses has changed both the shape and functioning ability of them. Information on the impacts of manipulating watercourses is available in **Chapter 6, Tributary Health**.

3.4.3.1 Strahler Stream Order

Stream order is a measure of the magnitude of a stream within a watershed and allows for the comparison of rivers of different sizes or importance within or between systems (Dunne and Leopold, 1978). A first-order stream is an unbranched tributary that typically drains the headwater portion of the watershed. When two or more first order streams converge, the downstream segment is classified as a second order stream. A third-order stream is the downstream segment of the confluence of two or more second order streams, and so on. As the order of a stream increases, the characteristics of the watercourse typically change. Larger order streams are generally characterized by lesser elevation gradients, slower velocities, and an increased stream area to accommodate the flow from additional tributaries. The stream order of a watershed is determined by the stream order of its outlet.

Table 3-1 below presents the stream order and the total length of the creeks within the Whites Creek and Talbot River subwatersheds.

Table 3-1: Whites Creek and Talbot River subwatersheds stream order and stream length.

Subwatershed	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Talbot River	1st	66,751	52.4
	2nd	27,005	21.2
	3rd	14,370	11.3
	4th	2,254	1.8
	5th	16,944	13.3
	TOTALS	**127,324**	***100***
	Stream Order	**Length of Creek per Order (m)**	**% of Creek per Order**
Upper Talbot River	1st	199,928	47.7
	2nd	107,113	25.5

Subwatershed	Stream Order	Length of Creek per Order (m)	% of Creek per Order
	3rd	59,486	14.8
	4th	38,968	9.3
	5th	13,758	3.3
	TOTALS	**419,253**	***100***
	Stream Order	**Length of Creek per Order (m)**	**% of Creek per Order**
Whites Creek	1st	76,134	46.1
	2nd	49,056	29.7
	3rd	17,802	10.8
	4th	16,471	10.0
		5,512	3.3
	TOTALS	**164,975**	***100***

3.4.3.2 Drainage Density

Drainage density is a measure of how well a watershed is drained by its streams and is calculated as the total length of all streams within a watershed divided by the total area of the watershed. Typically, watersheds with high drainage densities are characterized by greater peak flows, high suspended sediments and bed loads, and steep slopes (Dunne and Leopold, 1978). The drainage density of the Whites Creek, Talbot River and Upper Talbot River subwatersheds are 1.6, 1.8 and 1.4, respectively (Table 3.2). These relatively low values are consistent with conditions in the subwatersheds, which have low relief and characteristically low flows.

Table 3-2: Whites Creek and Talbot River subwatershed stream length, subwatershed area, and drainage density.

Creek	Stream Length (km)	Watershed Area (km^2)	Drainage Density (km/km^2)
Whites Creek	165.0	105.4	1.6
Talbot River	127.3	70.1	1.8
Upper Talbot River	419.3	294.6	1.4
*Lake Simcoe watershed average	3672.3	2515.9	1.5

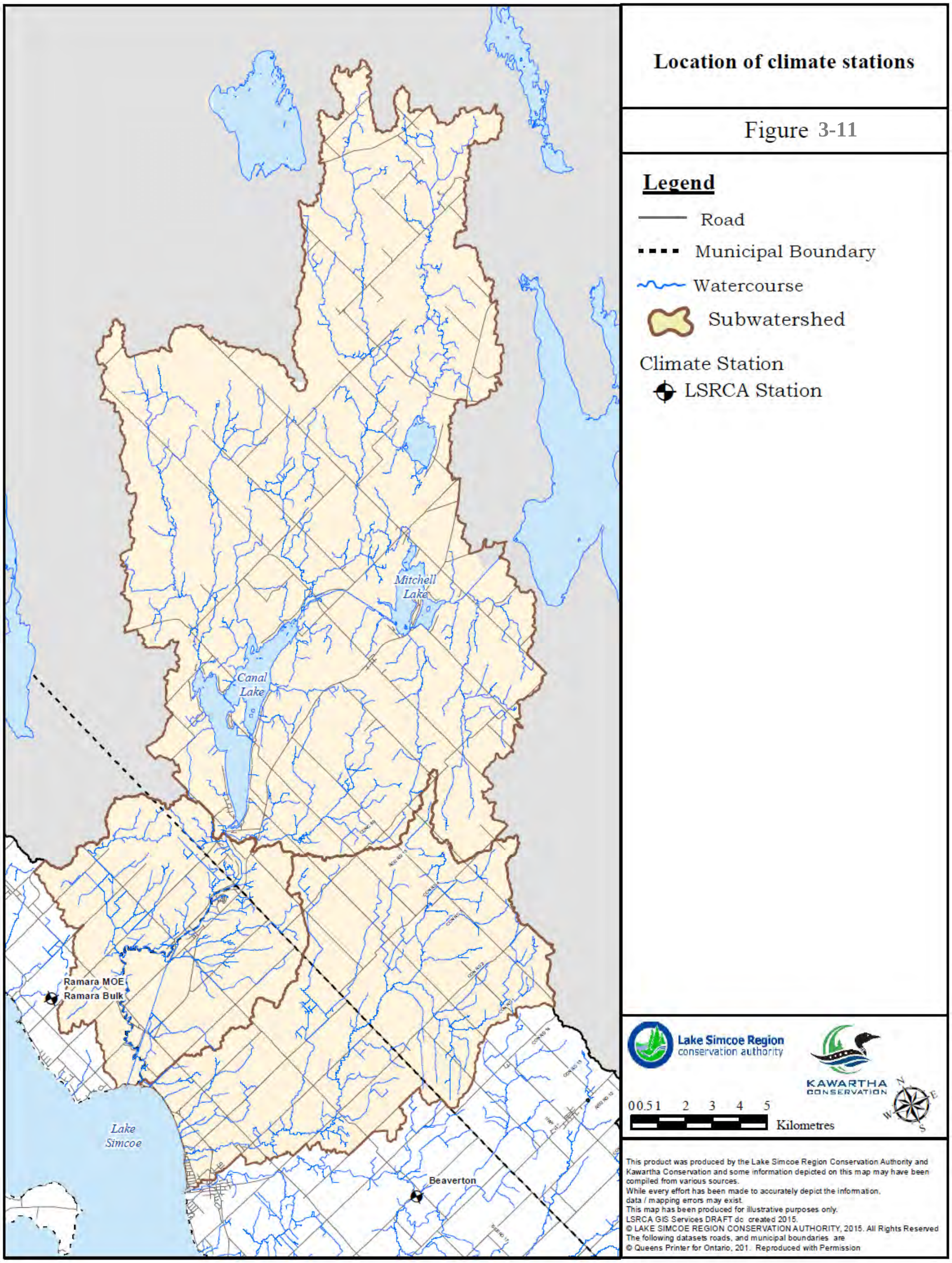
**The Lake Simcoe watershed average includes the subwatersheds of: Beaver River, Black River, East Holland River, Georgina Creeks, Georgina Island, Hawkestone Creek, Hewitts Creek, Innisfil Creeks, Lovers Creek, Maskinonge River, Oro Creeks North, Oro Creek South, Pefferlaw/Uxbridge Brook, Ramara Creeks, West Holland River, and Whites Creek.*

3.5 Climate and Climate Change

3.5.1 Current climate conditions and trends

The Whites Creek and Talbot River subwatersheds fall within the Simcoe and Kawartha Lakes climatic region as defined by Brown et al. (1980). The climate within the study area is characterized by moderate winters, warm summers, and long growing seasons with precipitation patterns that are usually reliable. Variations in topography, prevailing winds, and proximity to Lake Simcoe lead to local differences in climate across the study area.

While LSRCA does not currently have a climate station within the Whites Creek or Talbot River subwatersheds, two are located in the adjacent Ramara Creeks and Beaver River subwatersheds (Figure 3-11)



Location of climate stations

Figure 3-11

This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT dc created 2015.

Figure 3- 11: Location of climate stations in and around the study area.

3.5.2 Temperature

To examine temperature trends for the past 60 years, the daily average air temperature was averaged for each year (Figure 3-12) to compare the average annual, average maximum annual, and average minimum annual air temperature. Figure 3-12 gives a general overview of the temperature trends at the Barrie WPCC meteorological monitoring station, illustrating how all appear to fluctuate in relatively the same manner over the years.

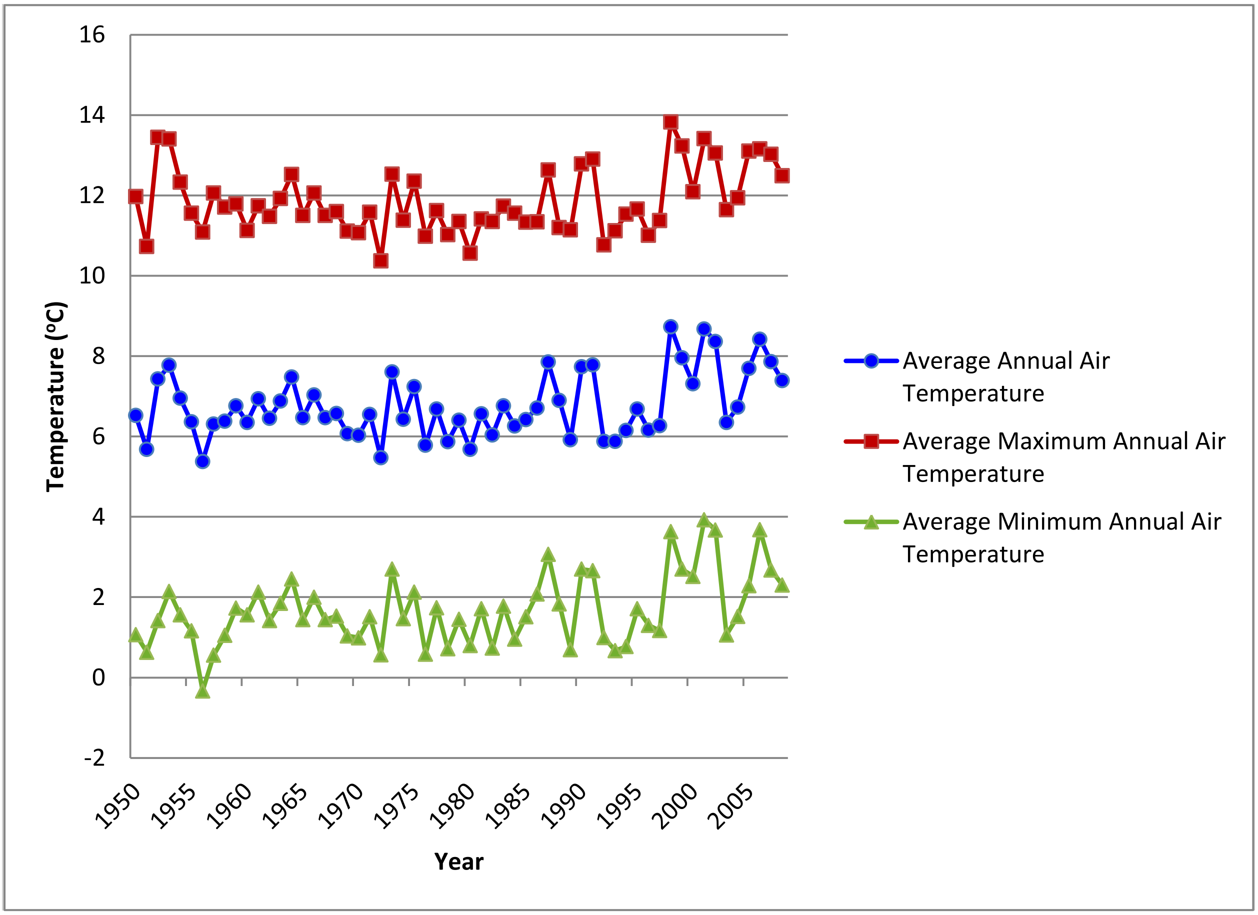


Figure 3- 12: Comparison of the average annual, maximum and minimum temperatures at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

Figure 3-13 displays only the average annual temperature, giving a closer look at the trend for the period of record. From it we can see that there is a gradual increase over the entire period, with this trend becoming more pronounced after 1980. There is a slight decrease at the beginning of the period of record from 1950 through the 1960s, followed by a plateau for the next 20 years or so before starting to increase. Overall, there has been an increase of 0.87°C over the past 60 years.

It should be noted that this is only a broad assessment of temperature trends at the Barrie WPCC meteorological monitoring station.

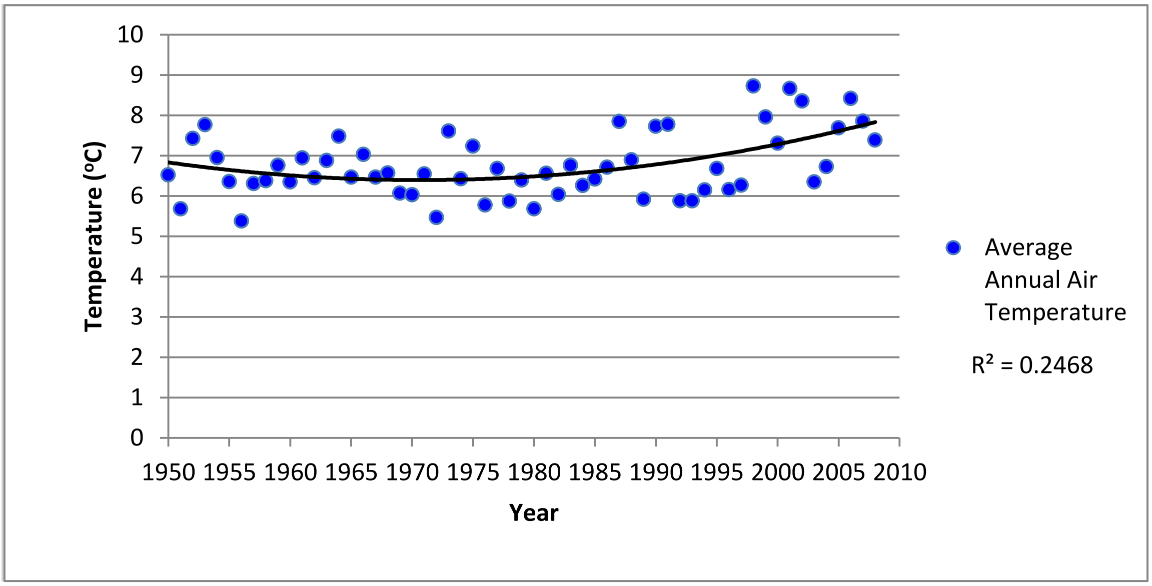


Figure 3- 13: Average annual temperature at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012

A similar trend was observed at the Lindsay Frost Climate Station (Environment Canada) over the past 30 years. The long-term daily minimum, daily maximum and yearly average temperatures all exhibited rising trends, with the most obvious rise detected for daily minimum temperatures (Figure 3-14).

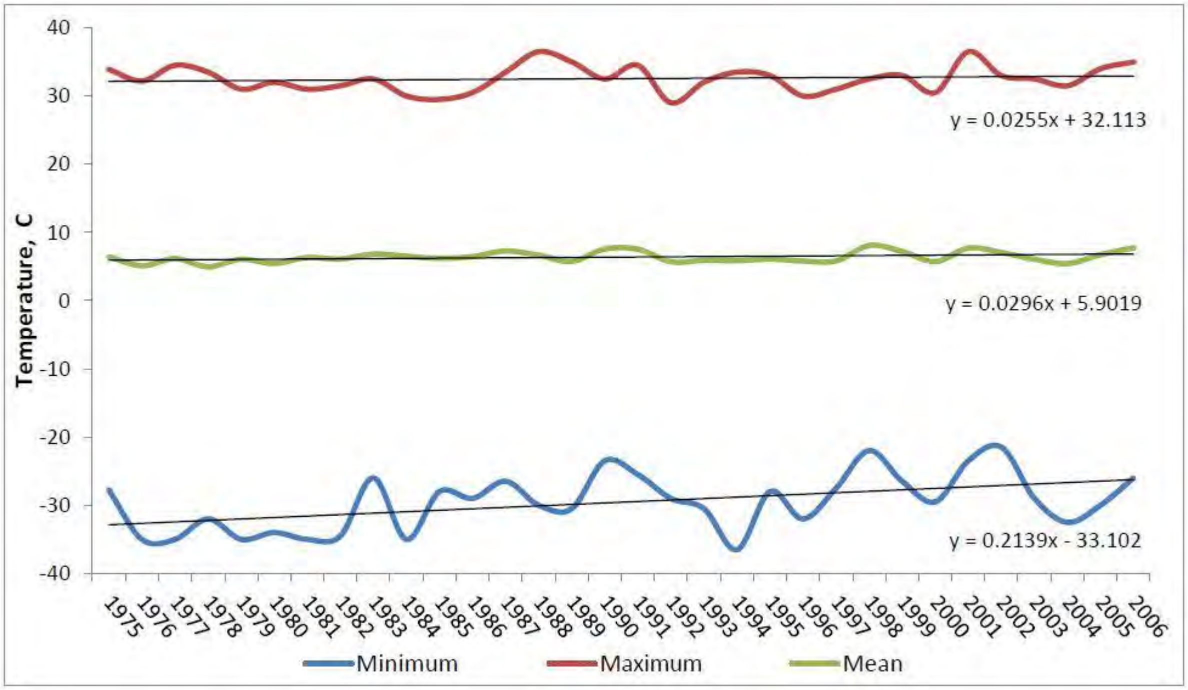


Figure 3- 14: Long-term daily minimum, daily maximum and yearly average temperatures and their trends for the Lindsay Frost Climate Station (Environment Canada), 1975-2006.

3.5.3 Precipitation

Rates of evaporation and precipitation as well as atmospheric circulation patterns can be altered as a result of Earth's warming temperatures. Warmer temperatures lead to greater potential evaporation of surface water, thus increasing the potential for surface drying and increasing the amount of moisture in the air. Because warmer air can hold more moisture, more intense precipitation events are expected.

A study of the precipitation data collected at the Lindsay Frost Climate Station has shown that overall annual precipitation has increased in recent decades. There has been a shift in precipitation type driven by warming temperates, and while precipitation in spring and fall has increased, winter precipitation has been declining as a result of decreasing winter snowfall. Figure 3-15 shows the long-term yearly precipitation for the Lindsay Frost Climate Station.

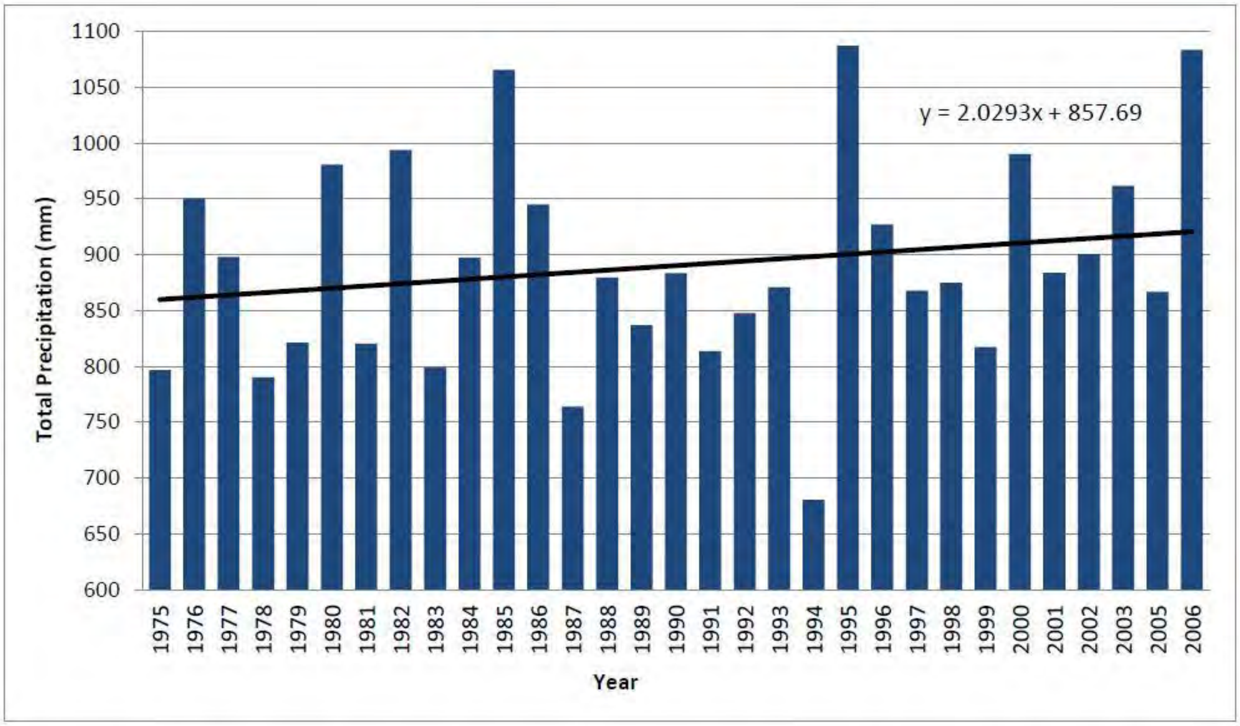


Figure 3- 15: Long-term yearly total precipitation and its trend from the Lindsay Frost Climate Station (Environment Canada), 1975-2006.

3.5.4 Thermal Stability of Lake Simcoe

The thermal stability of the lake is important as it can have significant impacts on biological communities, which in turn can impact the lives of those who rely on the lake as a resource. The thermal stability of the lake refers to the amount of energy needed for a water column to mix completely, overcoming the vertical density differences of thermal stratification. In a system where there is low stability, the lake completely mixes, whereas in a system where there is high stability there is little to no mixing (remains stratified). In Lake Simcoe, which is a dimictic lake, the water column is thermally stratified during the ice-free season, and mixes in the spring and fall. Most winters, it completely freezes over.

To determine if the thermal stability of Lake Simcoe was changing in relation to mean air temperatures (collected at Environment Canada's weather station at Shanty Bay), Stainsby *et al.* (2011) compared the water column stability of the lake at three locations (main basin, Kempenfelt Bay, and Cook's Bay), and the timing of stratification in the spring and turnover in the fall occurred over an approximate 30 year time period (1980-2008). For the purpose of this subwatershed plan, the focus will be on Kempenfelt Bay (and to some extent the main basin) as this is the area most closely connected to the subwatersheds within the study area.

Out of the three sampling areas, Kempenfelt Bay generally has higher thermal stability due to its deeper depths (max 42 m; mean 26 m), whereas Cook's Bay tends to have lower thermal stability because of its shallower depths (max 21 m; mean 8 m) and consequently smaller volume of water that needs to mix or stratify (Stainsby *et al.*, 2011).

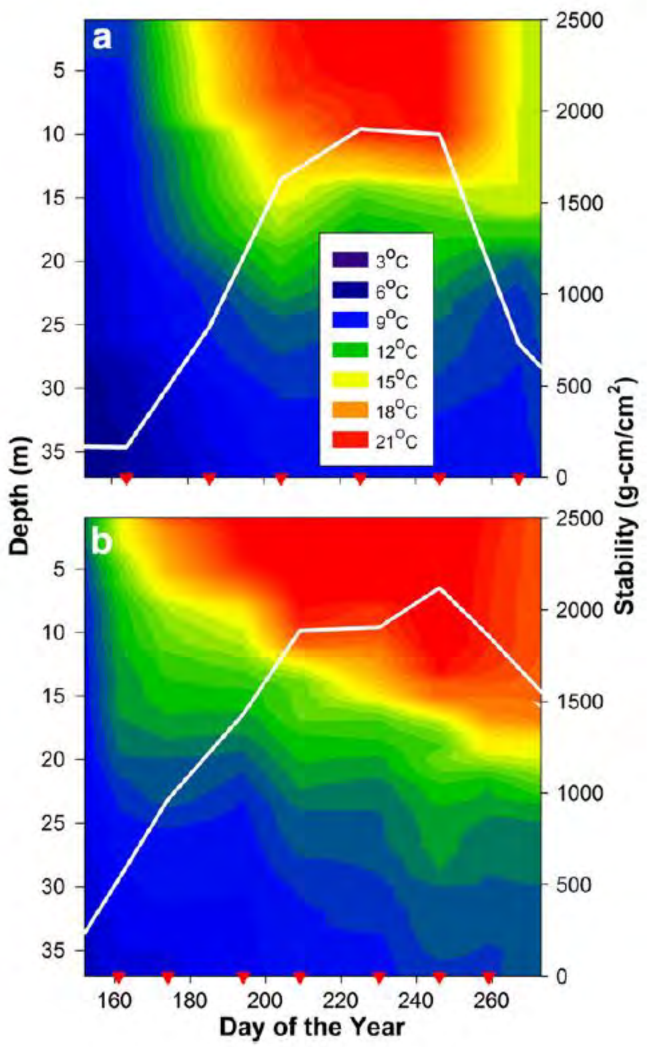


Figure 3- 16: Seasonal water column temperature contour (in degrees Celsius) and stability (white line) in Kempenfelt Bay in 1980 (a) and 2002 (b). Red triangles show the sampling dates along the x-axis. Source: Stainsby *et al.*, 2011

The first parameter studied was the temperature of Kempenfelt Bay during the ice-free period of the year. Figure 3-16 illustrates the temperature changes in Kempenfelt Bay from 1980 (a) and 2002 (b) as well as the stability of the lake. From it we can see that in comparison to the 1980 graph, in 2002 there is a high degree of red (warmer temperatures during the ice-free season) and wider contours (the lake begins to stratify earlier in the year and mixes later in the fall, increasing the overall time the lake remains stratified), all of which correspond with the recorded higher lake stability (white line) (Stainsby *et al.*, 2011).

To further support these findings, Figure 3-17a illustrates the timing of the onset of stratification in Kempenfelt Bay and the main basin (Figure 3-18b). It can be seen from the data that the lake is stratifying earlier in the year. As of 2002, stratification is occurring approximately 20 days earlier in Kempenfelt Bay (Figure 3-17a) than it was in 1980. In the main basin, stratification is occurring approximately 13 days earlier (3-17b).

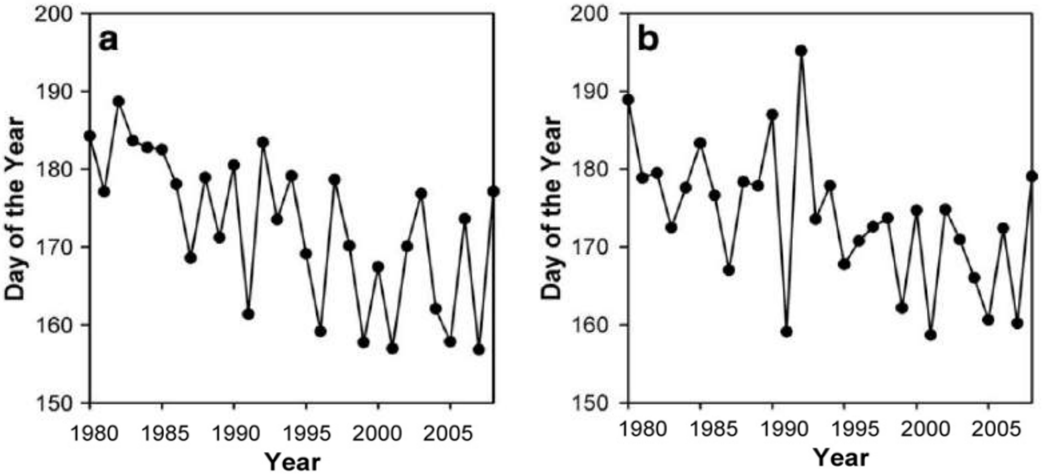


Figure 3- 17: The timing of the onset of stratification in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011

When looking at the fall turnover, Figure 3-18 shows it to be occurring later and later each year. Between 1980 and 2002, mixing of the water column in the fall is occurring approximately 15 days later in Kempenfelt Bay and approximately 18 days later in the main basin.

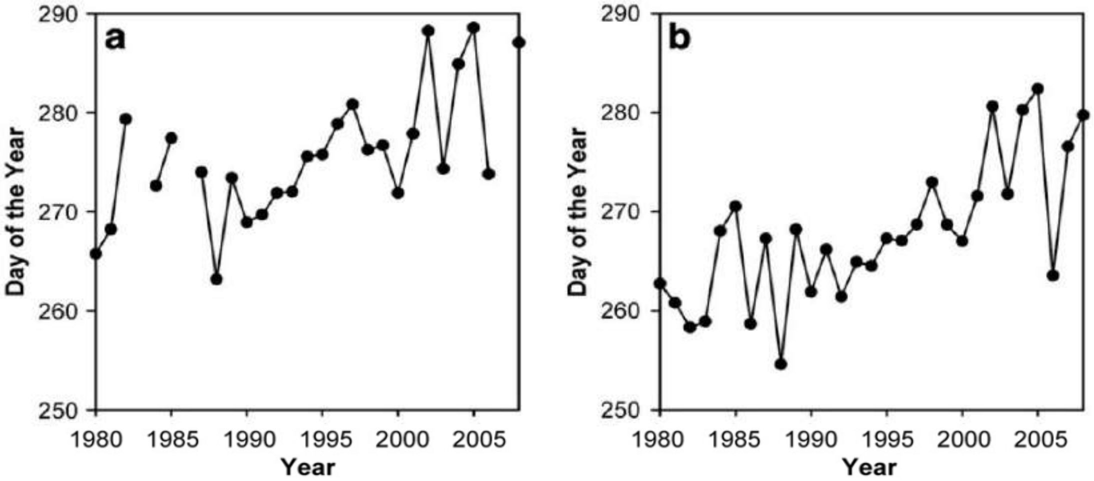


Figure 3- 18: The timing of fall turnover in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011

Together this means that the lake remains stratified for a longer period of time. A longer stratified period can result in an increase in oxygen depletion in the hypolimnion, which in the deeper zones may create “dead zone” areas where conditions are anoxic. These conditions can also potentially increase the release of nutrients (such as phosphorus) and contaminants from sediments. The impacts of this can include large fish die-offs, changes in the fish communities, algal blooms (which, when dead and decomposing at the bottom further decrease oxygen levels) and can deteriorate drinking water (Kling *et al*., 2003). In Kempenfelt Bay and the main basin of Lake Simcoe, the water column remains stratified approximately 33 days longer in 2008 than in 1980 (Figure 3-19 a and b).

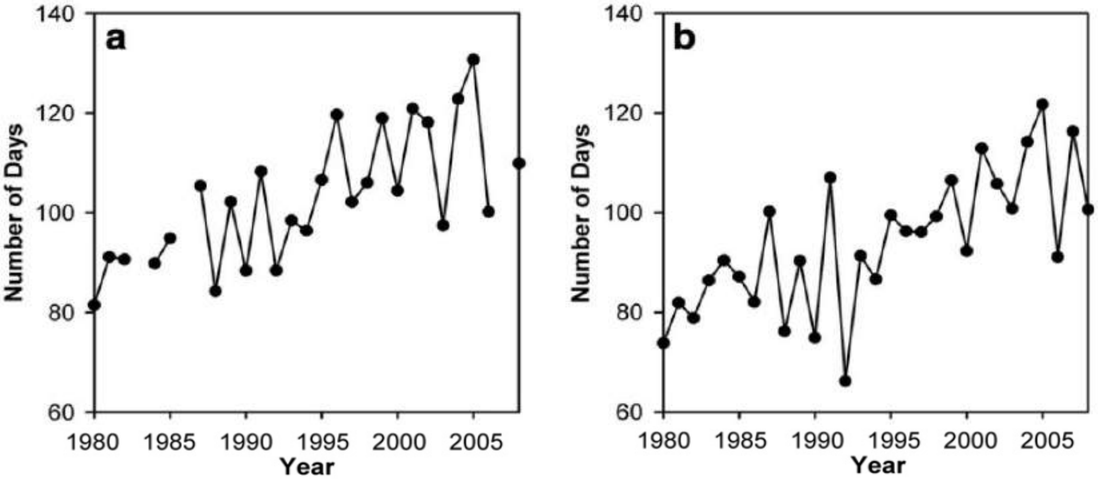


Figure 3- 19: The length of the stratified period in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011

Many of the impacts already being observed in the Lake Simcoe watershed counteracts much of the work the LSRCA and partner municipalities have done to increase dissolved oxygen concentrations and decrease phosphorus levels in Lake Simcoe. To ensure that efforts are successful, despite the impacts of climate change, projects undertaken on tributaries, particularly those that are managed as coldwater, need to focus on reducing the temperature and the amount of phosphorus input. This can include an increase in riparian habitat, improved stormwater management, and improved practices in construction and agricultural activities. Additionally, municipalities are encouraged to include climate change adaptation policies in the Official Plans, to plan for the future and implement pre-emptive measures.

3.5.5 Climate change and predicted scenarios

Climate change can have numerous impacts on ecological systems and those who depend on them. As mentioned in the previous section, an increase in air temperature can increase the thermal stability of the lake, extending the stratified period, as well as changing the composition of biological communities and creating ideal growing conditions for algae and bacteria. An increase in temperature can also cause an increase in evaporation and evapotranspiration, decreasing the amount of water infiltrating into the ground and recharging the groundwater system. Changes in precipitation patterns will also impact the hydrologic cycle, whether these changes show less or more precipitation. Where less precipitation is falling, habitats will experience drought, and be susceptible to fires (terrestrial) and reduction in area (watercourses and wetlands), and less water will be available to replenish aquifers. Where more precipitation falls, it is likely that flows will be altered (potentially changing the stream morphology), stormwater retention areas may overflow (releasing contaminants), and there is an increased risk of flooding and property damage. Further impacts of climate change can be found in the following chapters, where applicable, in the stressors section. An important part of addressing these stressors is to gain an understanding of what the changes will be in the future and act accordingly to minimize the impacts. Climate models, used worldwide, give us an estimate of what these possible changes are.

To obtain more accurate projections for parameters such as seasonal and annual temperature and precipitation, an ensemble of climate models are typically run together. The report "Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan" was released by the Expert Panel on Climate Change in November 2009 (EPCCA, 2009). The study included a review of climate change model projections for Ontario, completed by Environment Canada's Canadian Climate Change Scenarios Network (Environment Canada, 2009). The projections were based on a combination of 24 models and divides Ontario into 63 grid cells, one of which covers the Lake Simcoe watershed. Three scenarios were produced based on future amount of greenhouse gas (GHG) emissions (Low, Medium, and High).

Table 3-3 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to the 2050s. Under high GHG emissions there is a projected increase in temperature of 3°C for the area. All seasons are expected to see at least a 2.2°C temperature increase; however the most significant increase is seen during the winter, where there is a projected increase of 2.5-3.4°C based on Low to High GHG emissions.

Table 3-3: Summary of projected change in average annual temperature (°C) in the 2050s compared with 1961-1990 (Environment Canada, 2009).

	Projected change in air temperature (°C)		
	GHG emission scenario		
Season	**Low**	**Medium**	**High**
Annual	2.3	2.7	3.0
Winter	2.5	3.0	3.4
Spring	2.2	2.5	2.8
Summer	2.2	2.6	2.9
Autumn	2.3	2.6	2.8

Table 3-4 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to the 2050s. Under the high GHG emission scenario, annual precipitation is projected to increase by 5.51%. All seasons are expected to increase by at least 3.06%, with the exception of summer precipitation. As the amount of GHG emissions increase, there is only a slight increase predicted for the Low and Medium emission scenarios, and a decrease in the amount of precipitation of -0.62% under the High GHG emission scenario.

Table 3-4: Summary of projected change in precipitation (%) in 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in precipitation (%)		
	GHG emission scenario		
Season	**Low**	**Medium**	**High**
Annual	5.15	5.45	5.51
Winter	9.38	10.19	10.76
Spring	8.58	9.1	9.65
Summer	0.92	0.11	-0.62
Autumn	3.06	3.79	3.82

Despite the use of a combination of multiple models, it is important to note that there is still a very high level of uncertainty associated with the projections. As scientists continue to understand the smaller interactions (i.e. what role clouds play in climate change) and are able to integrate them into the models, this uncertainty will decrease.

4 Water Quality

4.1 Summary of Observations and Issues

Results and observations presented in this summary and the following chapter were obtained from water quality monitoring completed by the Lake Simcoe Region Conservation Authority and Kawartha Conservation within the Talbot River and Whites Creek subwatersheds. The Talbot River subwatershed can be further divided into the Upper Talbot River subwatershed and the downstream area of the Lower Talbot River subwatershed. The monitoring network in the Upper Talbot River subwatershed includes three water quality stations on major tributaries, two stations at the Canal Lake and Mitchell Lake outlets and three water quality stations on the lakes (two on Canal and one on Mitchell). Within the Lower Talbot River and Whites Creek subwatersheds three long-term stations and nine spot check stations were used for water quality monitoring.

OBSERVATIONS

- Both Canal and Mitchell lakes can be characterized as mesotrophic water bodies with relatively good water quality but there is room for improvement.
- Water quality in the Talbot River is quite good. Phosphorus concentrations are mostly below 0.030 mg/L, however there have been some exceedances of the objective.
- Phosphorus concentrations in Whites Creek are mostly below 0.030 mg/L; however there have been some exceedances of the objective.
- Total nitrogen concentrations in the water of both lakes fluctuate within a lower range, mostly below 0.60 mg/L.
- Total nitrogen concentrations in tributaries of the Upper Talbot River subwatershed (short-term sites) are usually low with average concentrations being in the range of 0.49-0.67 mg/L and mostly represented by organic nitrogen (72-95% of total nitrogen amount).
- Nitrate concentrations are always below the objective in the Lower Talbot River subwatershed (long-term sites). There are just a few exceedances in Whites Creek.
- Long-term chloride concentrations in the tributaries of both subwatersheds (Lower Talbot River and Whites Creek) are well below the objectives.
- Total suspended solid concentrations are usually low in the tributaries of all three subwatersheds (Upper and Lower Talbot River and Whites Creek), but occasionally exceed the objective.

KEY ISSUES

- The Talbot River quite often has elevated phosphorus levels during spring freshet and summer time.
- The most significant anthropogenic source of phosphorus to Canal and Mitchell lakes includes septic systems around the lakes.
- The Talbot River receives surface water from the Gull River watershed due to operations of the Trent Severn Waterway. The water quality of the Gull River system is good, but the additional water volume increases the Talbot River phosphorus load.

4.2 Introduction and Background

Water quality of any surface water body or groundwater can be defined as an integrated index of chemical, physical and microbiological characteristics of natural water. Water quality is a function of natural processes and anthropogenic impacts. Natural processes such as weathering of minerals and erosion can affect the quality of ground and surface waters. Factors such as the type of bedrock and soil type can impact water quality as well. For instance, water samples from the northern part of the study area have naturally higher levels of metals than those in the south because of the Canadian Shield bedrock. Natural background concentrations of water quality parameters in Southern Ontario usually do not pose any threat to the health of aquatic ecosystems or humans.

Human activities often have direct and indirect impacts on water quality that can result in changes to the natural environment. Anthropogenic sources of pollution are generally classified as either point or non-point source pollution. Point sources may include municipal and industrial wastewater discharges, ruptured underground storage tanks, septic tanks and landfills. Point sources of pollution are typically more easily identified and managed. In contrast, a non-point source of pollution reflects land use and refers to diffuse sources such as agricultural drainage, urban runoff, land clearing and the application of manure and chemical fertilizers to fields. Non-point sources can be more difficult to identify and manage than point sources because they are often difficult to pinpoint to a specific site.

Contaminants delivered by point and non-point sources can travel in suspension and/or solution and are characterized by routine sampling of surface waters in the Talbot River and Whites Creek subwatersheds, and throughout the Lake Simcoe watershed.

The Lake Simcoe Protection Plan (LSPP) identifies a number of targets and indicators related to water quality in Lake Simcoe and its tributaries, which include:

- Reducing phosphorus loadings to achieve a target for dissolved oxygen of 7 mg/L in the lake (long-term goal currently estimated at 44 tonnes per year)
- Reducing pathogen loading to eliminate beach closures
- Reducing contaminants to levels that achieve Provincial Water Quality Objectives or better

For the most part, these targets are established to preserve the health of the Lake, rather than its tributaries. As such, the LSPP has also provided indicators to evaluate progress in achieving the water quality targets that can be evaluated in a subwatershed basis. These include:

- Total phosphorus
    - Concentration
    - Loading
- Pathogens
    - Beach closures

- Other water quality parameters, including:
    - Chlorides
    - Other nutrients (e.g. nitrogen)
    - Total suspended solids
    - Heavy metals
    - Organic chemicals

Where information is available, current conditions and trends are provided for the main water quality indicators, as identified by the LSPP.

4.3 Current Status

4.3.1 Measuring Water Quality and Water Quality Standards

There is currently only one groundwater monitoring station within the study area, however it is a very shallow well and is likely not representative of groundwater conditions in the area; therefore only surface water quality will be reported in this plan. Information on surface water quality monitoring and the current status in the study area are described in the sections below.

Water quality monitoring plays an important role in meeting the objectives of the Talbot River and Whites Creek Subwatershed Plan, including the areas of Canal and Mitchell Lakes. Water quality data are obtained by collecting water samples at monitoring sites across the study area. The Talbot River subwatershed, which includes Canal and Mitchell lakes, has two long-term monitoring sites at the lower stretch of the Talbot River sampled in the framework of the Lake Simcoe Protection Plan (LSPP) monitoring program. Water quality sampling started in 1993/1994 at the LSPP sites. There is one long-term monitoring site in the Whites Creek subwatershed as part of the LSPP monitoring program; sampling started in 1994. Additional sampling was undertaken in support of plan development in 2013-2015 at four sites. There are also two open water sampling sites on Canal Lake and two sites on Mitchell Lake (see Chapter 7 – Lake Health for more details). Tables 4-2 and 4-3 and Figure 4-1 summarize the locations of water quality monitoring sites in the study area, for these two programs*.* Another set of samples was collected in May 2013 (spot check samples) to increase understanding of spatial variation of water quality in the subwatersheds. For this temporary program, there were four sites in the Lower Talbot River subwatershed and five sites in the Whites Creek subwatershed. The sites were chosen to represent separate drainage areas and were therefore located on different tributary branches that flowed either directly into Lake Simcoe or into the main tributary. In summary, monitoring stations are dispersed across the watershed at key locations covering all major tributaries. The monitoring stations on the lakes are located in such way as to cover all main parts of the water bodies.

Samples for the lake management planning monitoring program are collected bi-weekly year round from tributaries and monthly from May to October from lake monitoring sites. At each site, water samples are collected by grab method according to the planned monitoring schedule and then sent to a certified private laboratory to be analyzed for total suspended solids and nutrients including ammonia, nitrites, nitrates, total Kjeldahl nitrogen, and total phosphorus.

Samples for the LSPP program are collected bi-weekly during the ice-free season and tri-weekly during the winter. Sampling dates are shifted and added year round to coincide with high flow events especially during the spring freshet. One of the LSPP Talbot sites (at Lock 41) is collected only seasonally (May to October), when the lock system is operational. Samples for this program are sent to the MOECC Laboratory Services Branch to be analyzed for total suspended solids, nutrients and chloride. Furthermore, pH, dissolved oxygen, conductivity, turbidity and temperature readings are taken at the time of sampling for each program using a hand held water quality sonde.

Samples for the temporary spatial program were collected twice for each site in May of 2013, once during low flow conditions and a second time during high flow conditions. Samples were sent to a private laboratory and analyzed for the same water chemistry species as the other programs but also included metals (for the low flow samples only). A water quality sonde was used at these sites as well.

Some of the water quality variables that can be a concern for the Talbot River and Whites Creek subwatersheds are summarized in Table 4-1***.***

By sampling a wide variety of parameters it is possible to get an accurate, overall assessment of the water quality at a given point in time. To broaden the perspective, numerous samples are taken at different locations and periods of time to account for changes in parameters such as air and water temperature, flow volume, precipitation and land uses that vary throughout the year. Current results can be compared against historical results to establish trends in water quality over time. Results can also be compared to the Provincial Water Quality Objectives (PWQOs) (MOECC, 1994) and Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQGs) (CCME, 2001).

The Provincial Water Quality Objectives represent a desirable level of water quality that the MOECC strives to maintain in surface waters. The PWQOs are set at a level of water quality which is protective of all aquatic species at all stages of their life cycle and are helpful in assessing the degree of impairment to a surface water body. In some cases they are established to protect recreational water uses, which are based on public health and/or aesthetic values (MOECC, 1994).

Meeting the PWQO is generally a minimum requirement, as one has to take into account the effects of multiple guideline exceedances, overall ecosystem health, and the protection of site-specific uses. In instances where a chemical parameter is not included in the PWQO, the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG) are applied (CCME, 2001).

Canadian Water Quality Guidelines are intended to provide protection of freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical components (e.g., pH, temperature, and debris). Guidelines are numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameter of interest. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term. Ambient water quality guidelines developed for the protection of aquatic life provide the science-based benchmark for a nationally consistent level of protection for aquatic life in Canada (CCME, 2001).

Finally, it can be said that the main goal of the water quality data analysis is to convert water quality observations into information for educational purposes and decision-making at various levels of government.

Statistical analysis of data was completed for chloride, total phosphorus (TP), nitrates, and total suspended solids (TSS) for sites with enough samples for analysis. Table 4-2 shows the site ID, location, number of samples and date of the most recent sample for the short-term sites. Table 4-3 shows site ID, location and average number of samples per year for the LSPP sites. Note that over time there have been two slightly different locations for the LSPP Talbot River near Hwy 12 site (Gamebridge and the Park), as depicted in Table 4-3. Data from these two sites have been combined for analysis. The other LSPP site is Talbot at Lock 41.

Table 4-1: A Summary of Surface Water Quality Variables and their Potential Effects and Sources

Variable	Effects	Sources	Objective/Guideline
Chloride	Control of excess chloride levels is important to protect the aesthetics and taste of drinking water. High levels may also have an impact on aquatic life. Background concentrations in natural surface waters are typically below 10 mg/L.	The largest source of chloride is from road salt applications during the winter months. Other sources include waste water treatment, industry, potash used for fertilizers.	CCME (2011): 120 mg/L – long-term concentration and 640 mg/L – short-term concentration for the protection of aquatic life.
Total Phosphorus	Phosphorus promotes eutrophication of surface waters by stimulating nuisance algal and aquatic plant growth, which deplete oxygen levels as they decompose resulting in adverse impacts to aquatic fauna and restrictions on recreational use of waterways.	Sources include fertilizers, animal wastes, eroded soil particles and sanitary sewage.	Interim PWQO: 0.030 mg/L to prevent excessive plant growth in rivers and streams; 0.020 mg/L to avoid nuisance concentrations of algae in lakes and 0.010 mg/L for lakes that have natural phosphorus levels below this value.
Total Nitrogen	Nitrogen is one of two nutrients vital for the development of algae and aquatic plants. Total nitrogen includes both inorganic (NH_3, NO_2^-, NO_3^-) and organic forms of nitrogen.	Sources include fertilizers, agricultural and urban runoff, septic systems and municipal sewage treatment plants.	Alberta Environment (1999): 1.0 mg/L. This guideline was also used by Environment Canada for reporting on water quality in Lake Winnipeg (2013).

			CCME (2012) for nitrates: 2.9 mg/L NO_3^--N (or 13 mg/L NO_3^-)
Total Suspended Solids	Elevated concentrations reduce water clarity that can inhibit the ability of aquatic organisms to find food. Suspended particles may cause abrasion on fish gills and influence the frequency and method of dredging activities in harbours and reservoirs. As solids settle, rock and gravel spawning and nursery areas become coated with fine particles, limiting the ecological function of these areas. Many pollutants are readily adsorbed by suspended solids, and may become available to benthic fauna.	TSS originates from areas of soil disturbance, including construction sites and farm fields, lawns, gardens, eroding stream channels, and grit accumulated on roads.	CWQG: 25 mg/L + background (3-5 mg/L) for short term (<25 hr) exposures. EPA (1973): no harmful effects on fisheries below 25 mg/L.
Metals	Heavy metals generally have a strong affinity to sediments and can accumulate in benthic organisms, phytoplankton, and fish. Several heavy metals are toxic to human health, fish and other aquatic organisms at low concentrations.	Most metals in surface runoff are associated with automobile use, windblown dusts, roof runoff and road surface materials.	PWQOs: ▪ Iron: 300 µg/L ▪ Zinc: 20 µg/L ▪ Copper: 5 µg/L ▪ Lead: 5 µg/L ▪ Cadmium: 0.5 µg/L ▪ Chromium: 8.9 µg/L

Table 4-2: Short-term water quality monitoring stations in the Upper Talbot River subwatershed (2013-2015)

Station ID	Location	No. of Samples	Most Recent Sample
MC1	Grass Creek at Fenel Road	47	June-2015
MC2	Mitchell Lake Outlet Upstream of Victoria Road	54	Sep-2015
MC3	Upper Talbot River at McGuire Beach Road	52	June-2015
MC4	Northern Tributary at Centennial Park Road	39	June-2015
MC5	Canal Lake North Site at Centennial Park Road	25	Sep-2015
MC6	Canal Lake South Site at Centennial Park Road	30	Sep-2015
MC7	Canal Lake Outlet at Bolsover Road (Lower Talbot)	49	Sep-2015
MC8	Mitchell Lake under County Road 48 Bridge	29	Sep-2015

Table 4-3: Long-term water quality monitoring stations in the Lower Talbot River and Whites Creek subwatersheds (Lake Simcoe Protection Plan monitoring program)

Station ID	Map ID	Location	Average No. of Samples per Year	Sampling Periods
		Talbot River near Hwy 12 (comprised of two stations below)	32	1994-1999 and 2006-2014
99994783802	3802	Talbot River at Gamebridge		
99994783902	3902	Talbot River at the Park		
99994784902	4902	Talbot River at Lock 41	13	1993-1996 and 2006-2014
99994784402	4402	Whites Creek at Regional Rd. 23	30	1994-1999 and 2002-2014

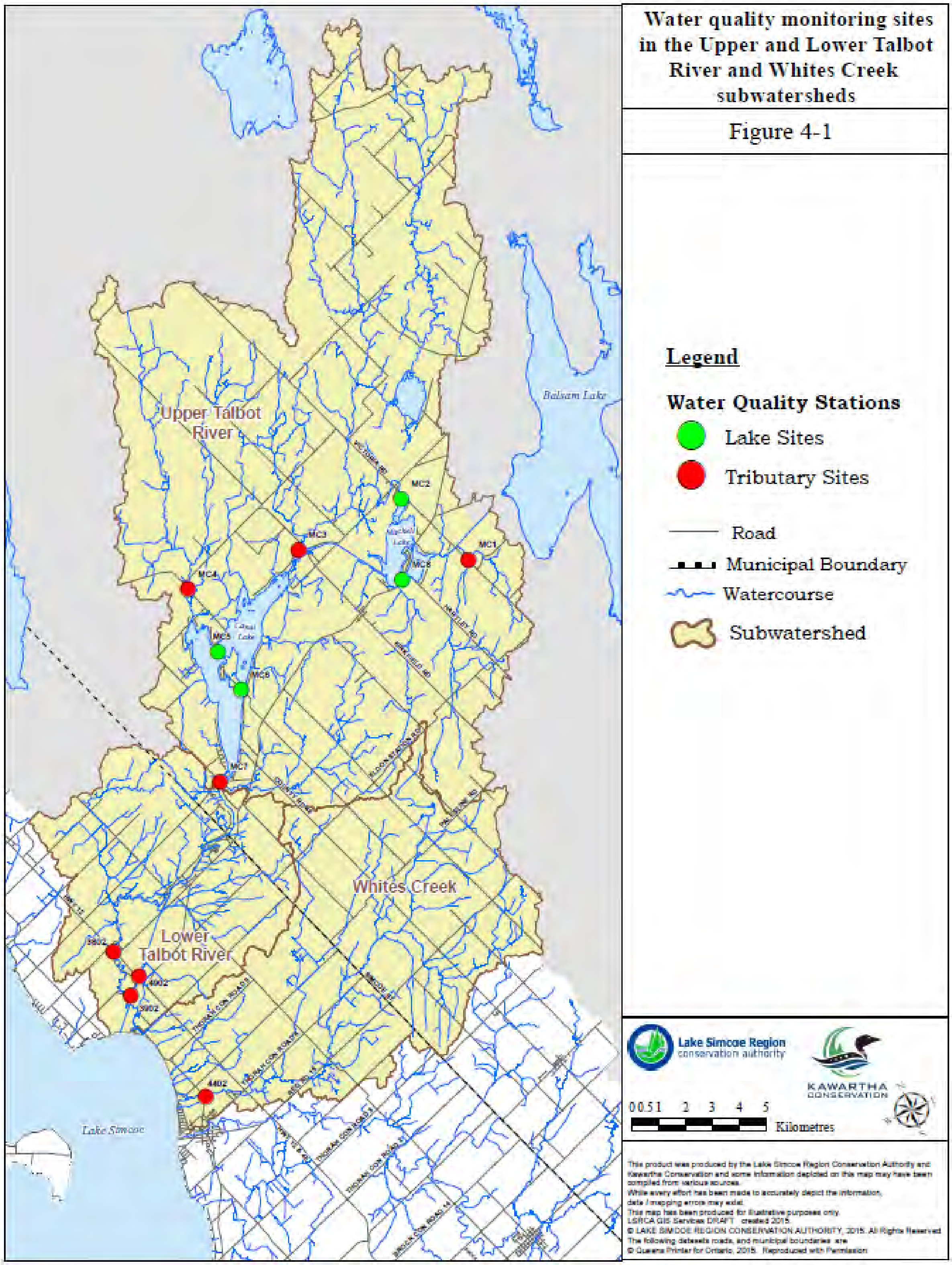


Figure 4-1: Water quality monitoring stations in the Talbot River and Whites Creek subwatersheds

*Spot-check sample locations not shown

4.3.2 Temperature Collection

The MNRF/DFO protocol, "*A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams*" (Stoneman, C.L. and M.L. Jones 1996), Figure 6-1 in **Chapter 6 - Aquatic Natural Heritage** suggests that trout streams are considered to be coldwater if they have an average maximum summer temperature of approximately 14°C. Cool water sites are considered to have average maximum summer temperatures of 18°C. Warm water sites have an average maximum daily water temperature of 23°C.

To monitor these temperatures, electronic data loggers are installed throughout the Lake Simcoe watershed during the hot summer months. They are installed in late May/early June and then retrieved in late September/early October each year. The loggers are used to monitor the daily fluctuations in water temperature of the watercourse over the summer. They are set to take a temperature reading every hour for the entire study period. Periodic checking of the loggers throughout the summer is necessary for quality control purposes. Once the loggers are retrieved in early fall, the data is downloaded and then compared to the air temperature data over the same period of time. Using an Excel spreadsheet, the maximum, minimum, and mean temperatures for each day are graphed. There is some emphasis placed on the daily high temperatures and average maximum temperatures, specifically in cold water stream conditions. The streams can then be classified as cold, cool, or warm (see **Chapter 6 - Aquatic Natural Heritage** for figure displaying temperature of creeks). Daily minimum stream temperatures are used to observe stream recovery from periods of extended warming and the influence of groundwater/baseflow in the individual system.

The LSRCA has been collecting temperature data since 2004 in the Whites Creek subwatershed, and since 2011 in the Talbot River subwatershed. While this has enabled us to classify these streams, it is difficult at this point to see any trends or patterns in the data. There are factors influencing water temperature in addition to upstream and surrounding land use, including air temperature and the amount of precipitation, which make it difficult to analyze trends in water temperature.

4.3.3 Surface Water Quality Status - Lakes

The catchments of Canal and Mitchell Lakes are part of the bigger Talbot River subwatershed (Figure 4.1). Once it flows through Canal and Mitchell Lakes, the Talbot River flows into Lake Simcoe. This study area includes the Grass Creek subwatershed (part of the Mitchell Lake watershed), Canal Lake Northern Tributary subwatershed and the upper portion of the Talbot River subwatershed as well as drainage areas adjacent to the both lakes.

The Canal and Mitchell lakes watershed occupies the central portion of the Talbot River subwatershed. The total area of the Upper Talbot River subwatershed is 294.6 km^2 including the surface water area of the lakes, which is 11.83 km^2 for both lakes (8.48 km^2 for Canal Lake and 3.35 km^2 for Mitchell Lake). The major human land use in the watershed is agriculture, which occupies 12% of the land portion of the watershed. Rural and urban development represents 0.7% and 1.2% of the watershed, respectively. Natural areas such as forests (37%) and wetlands (23%) also cover a considerable portion of the study area.

The only water quality parameter in the Canal and Mitchell lakes watershed that is of concern is phosphorous, which occasionally has elevated concentrations in the lakes and in the Talbot River. Another parameter which could be a concern from an ambient water quality perspective is *Escherichia Coli* at public beaches on Canal Lake. All other parameters have concentrations far below the corresponding PWQOs or CWQGs and do not currently present any threat to aquatic life or human health.

The water quality of Canal and Mitchell Lakes is discussed in further detail in **Chapter 7 – Lake Health.**

4.3.4 Surface Water Quality Status - Tributaries

There are three long-term surface water quality monitoring stations in the Whites Creek and Lower Talbot River subwatersheds (LSPP monitoring program) (Figure 4-1). This period of monitoring allows us to examine trends in the main parameters of concern (chloride, phosphorous, nitrates and total suspended solids) over time. The data are also compared to water quality guidelines for a number of parameters and results are discussed in the following subsections.

Water quality sampling has also been undertaken throughout the Lake Simcoe watershed since the 1960s, in some subwatersheds. It is worthwhile to look at the data for these stations to understand conditions around the watershed, and how conditions in the Whites Creek and Talbot River subwatersheds compare to these. Analysis of Lake Simcoe stations have been completed for the long-term (entire period of record for all stations) and short-term (including data for the period from 2005-2014), and are shown in Table 4-4 and Table 4-5.

Table 4-4: Historic surface water quality conditions for tributaries in the Lake Simcoe watershed.

Monitoring station (period of record)	Historic Conditions (Entire Station Record) Percentage of samples that meet objectives (PWQO or CWQG): Orange = median Concentration ≥objective Green = median Concentration <objective							Historical Trends Analysis (entire station record) 🟨 Yellow = Increasing ▨ Grey = no significant trend 🟦 Blue = Decreasing			
	Chloride	**Phosphorus**	**Nitrate**	**TSS**	**Iron**	**Zinc**	**Copper**	**Chloride**	**Phosphorus**	**Nitrate**	**TSS**
Tannery Creek (1965 – 2014)●	60	14	86	47	33	75	69	▨	🟦	🟦	🟨
West Holland River (1966 – 2014)●◊	97	3	93	81	51	97	84	🟨	🟦	🟨	🟦
Mt. Albert Creek (1971 – 2014)●	100	10	100	89	56	99	88	🟨	▨	🟨	▨
Beaver River (1972-2014)●◊	100	65	98	94	90	97	85	🟨	🟦	🟨	🟦
Pefferlaw Brook (1973-2014)●◊	100	50	100	96	88	97	86	🟨	🟦	🟨	🟦
Lovers Creek (1974-2014)●◊	82	74	100	90	80	95	82	🟨	🟨	▨	▨
Schomberg River (1977-2014)●◊	99	7	97	68	37	97	77	🟨	🟦	🟦	🟦
East Holland River (1982-2014)●◊	27	1	100	38	78	90	81	🟨	🟦	▨	▨
Kettleby Creek (1982-2014) ◊	100	53	100	72	N/D			🟨	🟦	▨	N/D
North Schomberg River (1982-2014) ◊	31	24	51	58	N/D			▨	🟦	▨	N/D
Maskinonge River (1985-2014)●◊	90	12	100	92	29	92	90	🟨	🟨	🟨	🟨
Black River (1993-2014)●◊	98	37	100	99	67	99	99	🟨	▨	▨	🟨
Hawkestone Creek (1993-2014)●◊	100	89	100	97	91	100	99	🟨	▨	▨	▨
Talbot River at Lock41 (1993-2014) ◊	100	97	100	100	N/D			N/D			
Talbot River near Hwy 12 (1994-2014) ◊	100	80	100	98	N/D			N/D	🟦	N/D	
Whites Creek (1994-2014) ◊	100	69	97	97	N/D			▨	▨	🟨	N/D
Uxbridge Brook (2002-2014)●	100	26	98	86	67	93	99	🟨	🟨	🟦	🟨
Bluffs Creek (2008-2014) ◊	100	88	100	93	N/D			N/D			
Hewitts Creek (2008-2014) ◊	78	55	74	88	N/D			N/D			
Hotchkiss Creek (2008-2014) ◊	7	54	99	80	N/D			N/D			
Leonards Creek (2008-2014) ◊	98	56	99	93	N/D			N/D			
Ramara Drain (2009-2014) ◊	100	37	100	90	N/D			N/D			
Objective	120 mg/L	0.030 mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L				

Notes for Table 4-4:

- ● PWQMN Station (Metals are monitored at PWQMN stations only and not LSPP stations)
- ◊ LSPP Station

A) Monitoring of chloride started according to the dates listed except for East Holland, Kettleby and North Schomberg (all 1993).

B) The earliest phosphorus data for any station began in the 1980's. All phosphorus data ended October 31, 2012.

C) Monitoring of nitrates started according to the dates listed except for East Holland, Black, Hawkestone (all 2000), Kettleby, North Schomberg, Whites (all 2002), Talbot – Lock41, and Talbot – Gamebridge (both 2006).

D) Monitoring of TSS started according to the dates listed except for Lovers (1976), Black, Hawkestone (each 2002), Talbot – Lock41, Talbot – Gamebridge, Whites, and Uxbridge (all 2008).

E) Monitoring of iron started according to the dates listed except for West Holland (1968), Lovers (1981), Beaver, Upper Schomberg, Black, East Holland, Hawkestone and Uxbridge (all 2002).

F) Monitoring of zinc and copper started in the early 1980s except for Maskinonge (1985), Black, East Holland, Hawkestone and Uxbridge (all 2002).

G) Daily data was available for the East Holland River station from March 1, 2011 to May 31, 2012 for phosphorus and TSS and part of that period for chloride and nitrates; there was no extra sampling for metals during that period.

H) The data used for the TSS trends for Tannery, Mount Albert, East Holland, Black, Hawkestone and Uxbridge started in 2002.

I) Where trends were not listed, either there were large gaps in the data (>1/3 of time range was missing) or monitoring for those parameters started after 2004.

J) Samples for the PWQMN program are collected during the ice-free period eight times per year and sent to the MOECC Laboratory Services Branch to be analyzed for alkalinity, metals, hardness, total suspended solids, anions such as chlorides, and nutrients including ammonia, nitrites, nitrates, total Kjeldahl nitrogen, total phosphorus and orthophosphates.

Table 4-5: Current water quality conditions for tributaries in the Lake Simcoe watershed.

Monitoring Station	Current Conditions (2010 – 2014) Percentage of samples that meet objective (PWQO or CWQG) Orange = median Concentration ≥objective Green = median Concentration < objective							Current Condition Trend Analysis (2005-2014) Yellow = Increasing Grey = no significant trend Blue = Decreasing			
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	Nitrate	TSS
Tannery Creek	🟩 68	🟧 17	🟩 97	🟧 43	🟧 22	🟩 78	🟩 78	⬜	⬜	⬜	⬜
West Holland River	🟩 93	🟧 7	🟩 95	🟩 90	🟩 65	🟩 100	🟩 91	⬜	🟦	⬜	⬜
Mt. Albert Creek	🟩 100	🟧 13	🟩 97	🟩 84	🟧 43	🟩 97	🟩 92	⬜	⬜	🟦	⬜
Beaver River	🟩 100	🟩 56	🟩 98	🟩 92	🟩 86	🟩 97	🟩 100	⬜	⬜	⬜	🟨
Pefferlaw River	🟩 100	🟧 48	🟩 100	🟩 94	🟩 78	🟩 100	🟩 97	⬜	🟨	⬜	⬜
Lovers Creek	🟩 57	🟩 59	🟩 100	🟩 86	🟩 57	🟩 97	🟩 97	⬜	⬜	🟦	⬜
Schomberg River	🟩 98	🟧 20	🟩 99	🟩 74	🟧 32	🟩 100	🟩 97	🟨	⬜	⬜	⬜
East Holland River	🟧 12	🟧 1	🟩 100	🟩 52	🟧 5	🟩 73	🟩 76	⬜	🟦	⬜	⬜
Kettleby Creek	🟩 100	🟩 58	🟩 100	🟩 74	N/D			⬜	⬜	⬜	⬜
North Schomberg River	🟧 34	🟧 29	🟩 58	🟩 68	N/D			⬜	🟨	⬜	🟨
Maskinonge River	🟩 84	🟧 7	🟩 100	🟩 90	🟧 9	🟩 97	🟩 82	⬜	🟦	⬜	⬜
Black River	🟩 97	🟧 31	🟩 100	🟩 99	🟩 51	🟩 100	🟩 100	⬜	⬜	⬜	⬜

Monitoring Station	Current Conditions (2010 – 2014) Percentage of samples that meet objective (PWQO or CWQG) Orange = median Concentration ≥objective Green = median Concentration < objective							Current Condition Trend Analysis (2005-2014) Yellow = Increasing Grey = no significant trend Blue = Decreasing			
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	Nitrate	TSS
Hawkestone Creek	🟩 100	🟩 86	🟩 100	🟩 96	🟩 86	🟩 100	🟩 97	▒	▒	▒	▒
Talbot River at Lock 41	🟩 100	🟩 97	🟩 100	🟩 100	N/D			🟦	🟦	🟨	▒
Talbot River near Hwy 12	🟩 100	🟩 92	🟩 99	🟩 98	N/D			🟦	▒	▒	▒
Whites Creek	🟩 100	🟩 67	🟩 97	🟩 97	N/D			▒	▒	🟨	🟨
Uxbridge Brook	🟩 100	🟧 13	🟩 97	🟩 76	🟧 46	🟧 86	🟧 100	▒	▒	🟦	🟨
Bluffs Creek	🟩 100	🟩 88	🟩 100	🟩 93	N/D			▒	▒	▒	▒
Hewitts Creek	🟩 71	🟩 53	🟩 71	🟩 86	N/D			🟨	▒	▒	▒
Hotchkiss Creek	🟧 6	🟧 50	🟩 98	🟩 79	N/D			▒	▒	▒	▒
Leonards Creek	🟩 97	🟧 50	🟩 98	🟩 92	N/D			🟨	▒	▒	▒
Ramara Drain	🟩 100	🟧 36	🟩 100	🟩 91	N/D			N/D	N/D	▒	🟦
Objective	120 mg/L	0.030 mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L				

Notes for Table 4-5:

A) All phosphorus data ended October 31, 2012.

B) For the chloride, phosphorus and nitrate trends, Talbot (Lock 41 and Hwy 12) data started in 2006, and Bluffs, Hewitts, Hotchkiss and Leonards data started in 2008.

C) For TSS trends, Kettleby, North Schomberg, Talbot (Lock 41 and Hwy 12), Whites, Bluffs, Hewitts, Hotchkiss and Leonards data started in 2008, and Ramara Drain started in 2009.

As noted above, surface water quality data has been collected since 1993/1994 in the Talbot River subwatershed and Whites Creek. Overall, the median concentrations of the parameters of concerns were all below the objectives in both subwatersheds during the monitoring period.

Looking at the Talbot River subwatershed, there is a long–term decreasing trend in phosphorus at the Highway 12 station (no other trends were available for this station or the Lock 41 station) and a short-term decreasing trend in total phosphorous for the Lock 41 station and no trend for the Highway 12 station. Unlike any other system investigated in the Lake Simcoe watershed, Talbot River is showing a short term decrease in chloride concentrations. Nitrates have increased in the short-term at Lock 41, but show no trend at Highway 12. Neither station has shown an increasing trend in TSS concentrations for this period. These parameters are discussed in more detail in the subsequent sections.

There was no trend in chloride and phosphorus concentrations in Whites Creek over the long-term or in the most recent reportable decade (short-term, 2005-2014). Most other stations in the watershed are showing an increase in chloride over the long-term. Nitrates have increased both over the long- and short-term. Most other stations are showing no trend or a decrease in nitrates in the short-term. TSS has increased in the short-term, which is similar to some other stations in the watershed.

The concentrations of certain metals in Talbot River and Whites Creek (from the spot check samples) were similar to most other stations in the watershed in that zinc and copper were below the objectives. Iron at all four of the Talbot sites was below the objective but one site in Whites exceeded the objective. Levels of iron that exceeded the objective were observed in the Lake Simcoe watershed most often at sampling locations downstream of urban areas (e.g., East Holland River and Uxbridge Brook monitoring stations; Tables 4-4 and 4-5). However, the observed elevated concentrations of iron at the Whites Creek site were from a different source because this site was not located downstream of urban areas.

4.3.5 Phosphorus

Talbot River Subwatershed

Phosphorus is one of the two primary nutrients required for the growth of aquatic plants and algae in streams and lakes. Phosphorus is not considered toxic to plants and animals, but elevated levels of this nutrient in water can cause the process of eutrophication, which results in the excessive growth of algae and aquatic plants, and a corresponding depletion of dissolved oxygen in the water column. The PWQO for total phosphorus (TP) concentrations in watercourses is set at 0.030 mg/L, in order to prevent nuisance algae and aquatic plant growth. The PWQO for TP concentrations in lakes is 0.020 mg/L and it is 0.010 mg/L if those lakes historically have had natural TP levels below this value (MOECC, 1994).

Total phosphorus is a measure of both soluble and insoluble phosphorus within a water sample. The insoluble component is primarily decaying plant and animal matter or soil particles, which either settles to the bottom or remains suspended in the water column as part of the total suspended sediments (solids). This form of phosphorus is not readily available to plants, and does not instantly change the biological productivity of a water body. In contrast, soluble phosphorus (e.g., orthophosphates) can be readily taken up by aquatic plants, causing increased biological productivity and plant growth. Soluble phosphorus has primarily anthropogenic origins and poses a greater threat to the ecosystem than insoluble forms.

The Talbot River is the major watercourse within the study area of 365 km^2 of land that extends far north from Lake Simcoe. As a result of the river headwaters that are located on the Canadian Shield combined with a scarcely populated watershed, the water of the Upper Talbot River has very low concentrations of all chemicals including phosphorus.

The Talbot River is part of the Trent-Severn Waterway and, due to a series of locks and dams, receives surface water from outside of its natural drainage basin. The Gull River watershed contributes a significant amount of water to the Talbot River subwatershed, especially at certain times of the year (i.e., during the fall draw-down). Because both the Gull River and Talbot River watersheds have predominantly natural heritage land uses, the water quality of the Talbot River is very good.

In the Upper Talbot River subwatershed, phosphorus concentrations sometimes exceed the PWQO at the four monitoring locations (MC1, MC3, MC4 and MC7), but TP averages have always been below the provincial objective in the water in all streams (Figure 4-2).

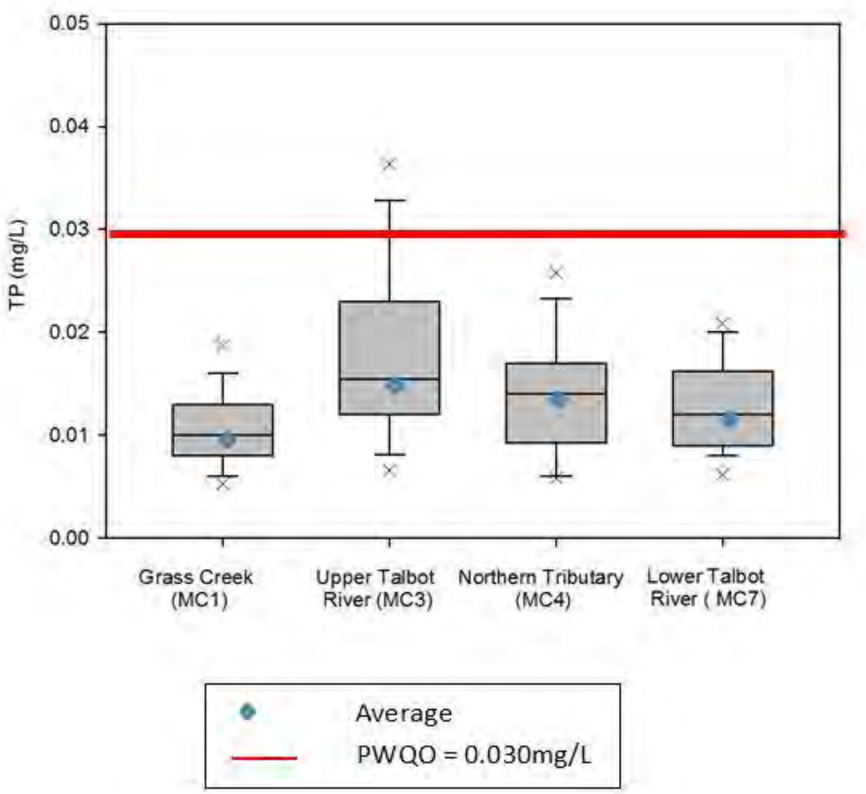


Figure 4-2: Average phosphorus concentrations in the Talbot River subwatershed in 2013-2015

Note: Exceedances for the Lower Talbot station are based on 0.020 mg/L limit

Grass Creek (Station MC1) occupies the south-eastern corner of the Talbot River subwatershed and Mitchell Lake subwatershed. Agricultural lands occupy a considerable portion of this catchment. Phosphorus levels in this creek over the period of monitoring (2013-2015) varied from 0.002 mg/L to 0.022 mg/L and never exceeded the PWQO (Figure 4-2). The average TP concentration in the creek over the two-year period is 0.011 mg/L; well below the PWQO and the lowest among monitored streams in the study area.

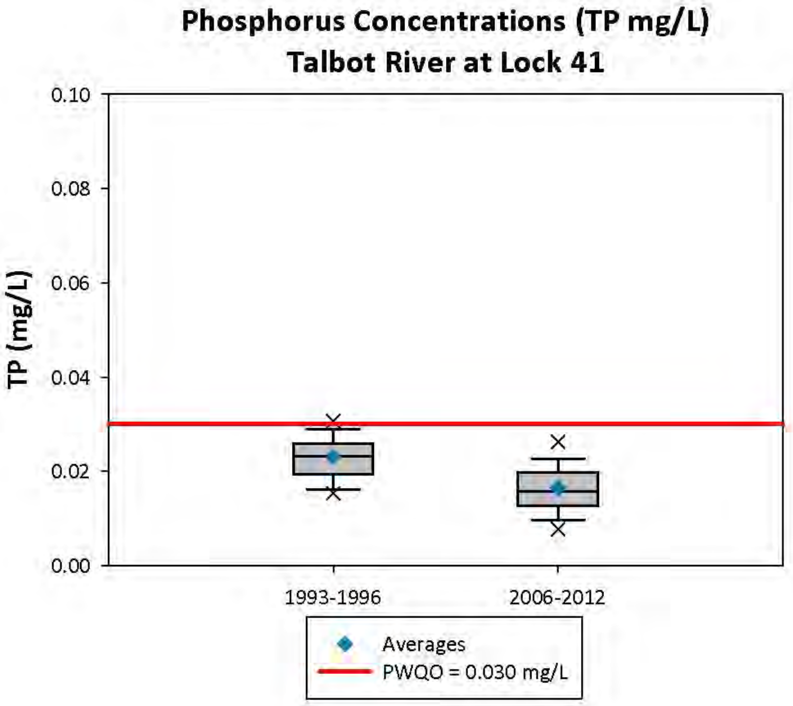
Since the beginning of the intensive monitoring activities in 2013, phosphorus concentrations in the Upper Talbot River (Station MC3) have mostly been below the PWQO for total phosphorus (Figure 4-2). The occurrence of the PWQO exceedance was 11%. The average phosphorus concentration in the river at this monitoring location is 0.018 mg/L with results ranging from 0.004 to 0.042 mg/L (Figure 4-2).

The seasonal distribution of total phosphorus (TP) in the Lower Talbot River site (Station MC7, located at the outlet of Canal Lake) is characterized by the highest concentrations recorded in the late spring and summer during both high and low flow conditions (0.034-0.042 mg/L). In spring time TP concentrations can be also quite high, up to 0.033 mg/L, as a result of snowmelt and corresponding freshet. The lowest TP concentrations in the range of 0.004-0.017 mg/L have usually been observed throughout late autumn to early spring. This can be attributed partly to less input from the surrounding land areas during winter, but also due to direct input of surface water from the Gull River watershed. Phosphorus levels exceeded the PWQO in 17% of all samples (Figure 4-2).

While there have been some exceedances of the PWQO limit for TP at the two LSPP water quality monitoring stations in the Lower Talbot River subwatershed (Table 4-4), median concentrations have decreased over time (Figure 4-3). These two stations are close to the mouth of Talbot River and represent concentrations that would be entering Lake Simcoe. Concentrations at the Lock 41 station (2006-2012 average = 0.017 mg/L, maximum = 0.038 mg/L) are lower than the main river channel at Highway 12 (2006-2012 average = 0.020 mg/L, maximum = 0.137 mg/L) because suspended sediments (containing phosphorus) settle out when the water is not flowing behind the closed gates of the lock. Seasonal patterns are similar to the upstream Canal Lake outlet site (high during parts of the spring freshet, elevated in the summer, lowest in the late fall and winter), but elevated concentrations have been observed in late fall and early winter (using data from a temporary daily sampling program in 2015) which may result from plant senescence in Canal and Mitchell lakes.

Total phosphorus concentrations at the additional four spot-check sites for the spatial study in the Lower Talbot River subwatershed were similar to concentrations observed at the LSPP sites. The range of concentration in low flow conditions was 0.011 to 0.025 mg/L and in high flow was 0.024 to 0.044 mg/L.

The volume of water contributed to Lake Simcoe from the Talbot River is significant due to its size and additional inputs from the Gull River watershed. However, because the concentrations in this subwatershed are low (relative to many other Lake Simcoe subwatersheds), the quantified loads to Lake Simcoe are only moderately high compared to other large subwatersheds such as the West Holland River (see Figure 4-9 in the Stressors section of this chapter). It should be noted that the loads from the Talbot River outlined in this report may not account for large masses of partially degraded macrophytes that are deposited into Lake Simcoe from the Talbot River. It is anticipated that these plants are flushed from Canal and Mitchell Lakes during removal of stop logs from the dams in the fall, and then are transported through the Talbot River and deposited into Lake Simcoe. Eventually they will fully decay and release nutrients to the lake.



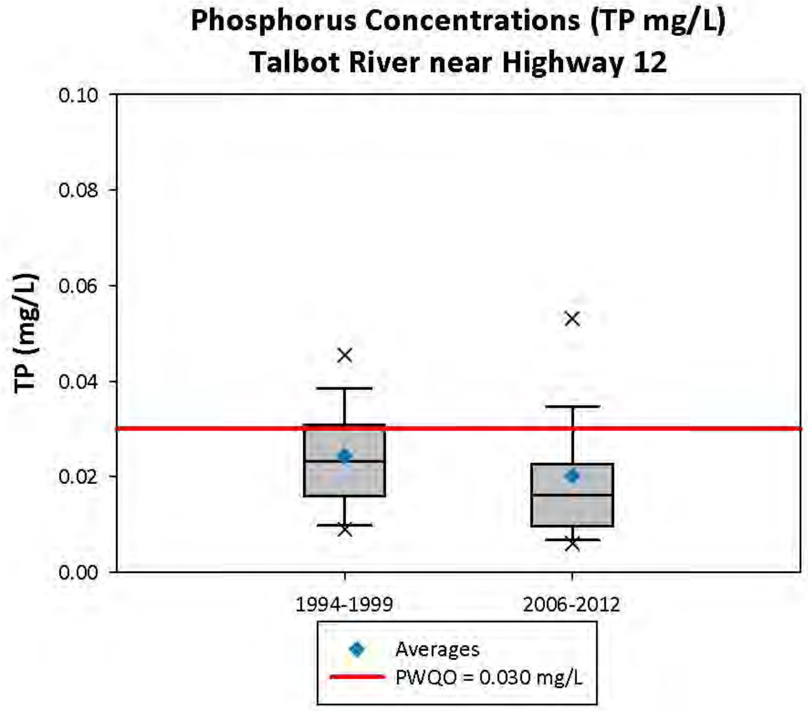


Figure 4-3: Total phosphorous concentrations at the two Talbot River LSPP monitoring sites.

Note: the box encapsulates the middle 50% of the data (with median drawn halfway through each box); the whiskers represent the maximum and minimum values without the more extreme outliers of the dataset; the points above and below the whiskers represent data at the 5th and 95th percentiles.

Whites Creek

Phosphorus is also considered to be the main parameter of concern in Whites Creek. While the median concentration has decreased over time at this station, over 25% of the samples were in exceedance of the PWQO during the most recent sampling period (Figure 4-4). The maximum concentration was 0.273 mg/L overall, and 0.146 mg/L during the most recent sampling period. Spatially across the subwatershed, the concentrations were low with exceedances of the objective only during high flows (maximum = 0.041 mg/L), though concentrations at these sites may be more elevated during other flow events. Given the rural location of this station, the most likely sources of this phosphorus are agriculture or soil erosion. Because the concentrations in this subwatershed are relatively low in comparison with many other Lake Simcoe subwatersheds, the subwatershed only makes up 4% of the phosphorus load going into Lake Simcoe each year (this is discussed further in **Section 4.4 - Stressors**).

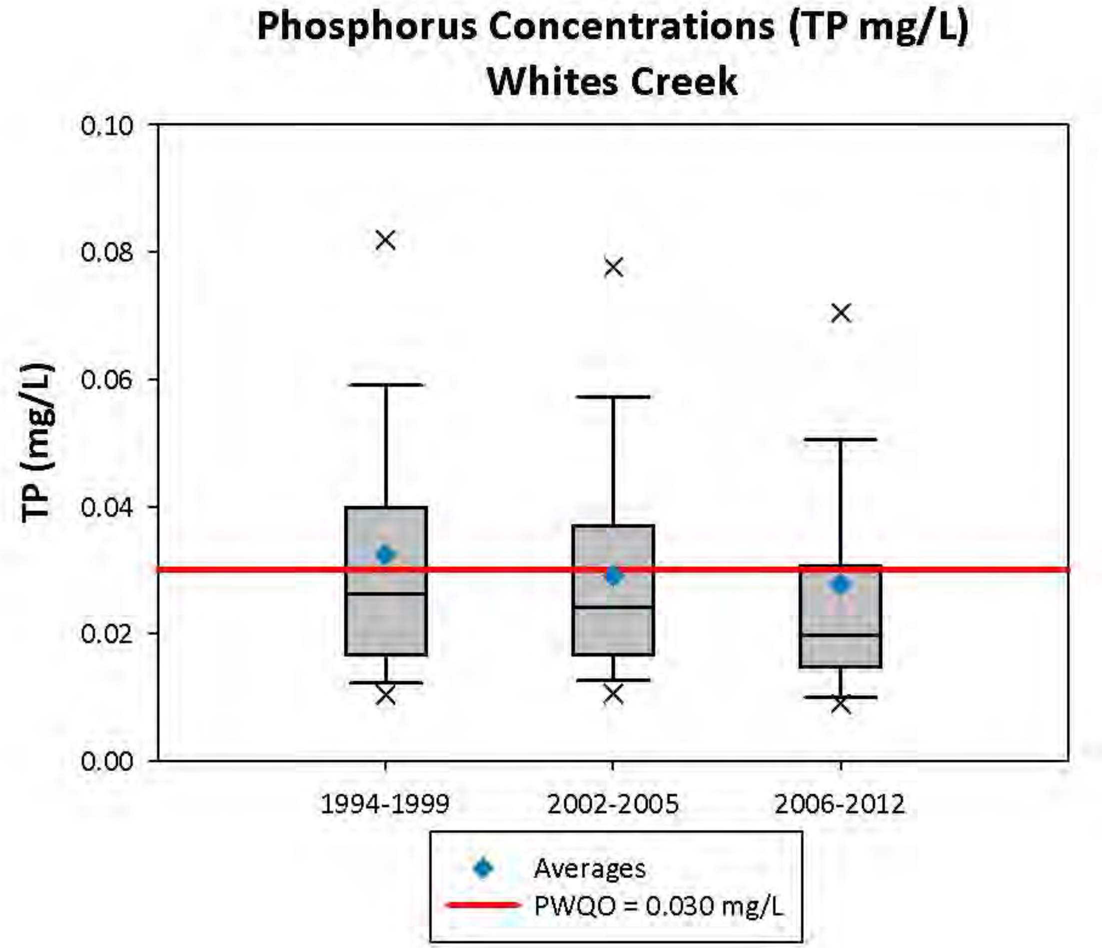


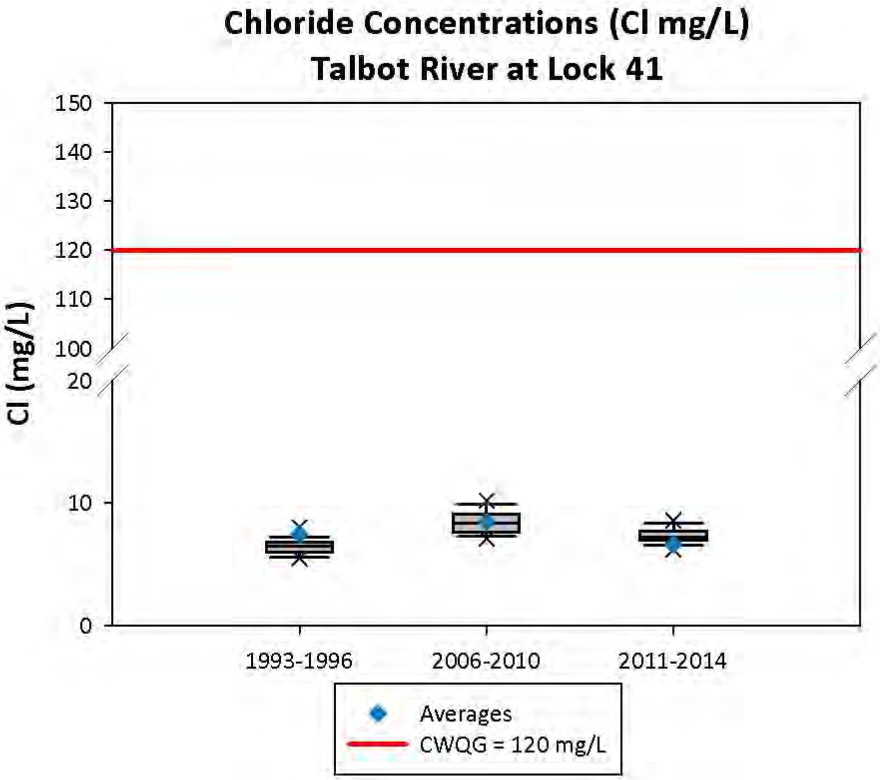
Figure 4-4: Whites Creek phosphorus concentrations (1994-2012).

4.3.6 Chloride

The *Canadian Environmental Protection Act* has defined road salts containing chloride as toxic (2001). This was based on research that found that the large amount of road salts being used can negatively impact ground and surface water, vegetation and wildlife. While elevated chloride levels are primarily found around urban centers, chloride levels have been found to be steadily increasing across the Lake Simcoe watershed and throughout Ontario, including waters that could be considered pristine northern rivers (LSRCA, 2015) as well as in Lake Simcoe itself (Eimers and Winter, 2005). Additionally, some municipalities use calcium chloride as a dust suppressant on gravel roads during the summer months which will also contribute to the chloride levels (CKL, 2014). Within the Kawartha Lakes region approximately 50% of the roads are unpaved and thus management practices call for the use of calcium chloride ($CaCl_2$) to suppress the dust instead of a more expensive paving program (CKL, 2014). However, the quantification of $CaCl_2$ was not within the scope of this study, but a consideration for the future.

Chloride concentrations measured at the two LSPP water quality monitoring stations in the Talbot River subwatershed did not show any exceedances of guidelines for chloride in the period of record (Table 4-4). Median values from the two stations ranged from 7 mg/L to 11 mg/L; well below both the chronic toxicity (120 mg/L) and acute toxicity (640 mg/L) guidelines (Figure 4-5). Chloride concentrations measured at the Whites Creek station were slightly higher (median values ranged from 20-26 mg/L), but still well within the limit (Figure 4-6). These low concentrations are likely attributable to the low urban land use and high groundwater inputs in the subwatersheds. However, this parameter should continue to be monitored as it will likely increase in the tributaries as further development occurs in the area.

The additional spot-check sites for the spatial study in the Lower Talbot River and Whites Creek subwatershed showed that concentrations were elevated in low flow conditions and then decreased during high flow events. This pattern is typical of non-ice seasons, where chloride concentrations become diluted during high flow events. Concentrations of chloride were below the objective at all sites except one in the Talbot River subwatershed. There are not urban areas upstream of this site; elevated chloride may be due to movement of soil in an upstream area that could release chloride that has accumulated, or perhaps from the application of calcium chloride to unpaved roads.



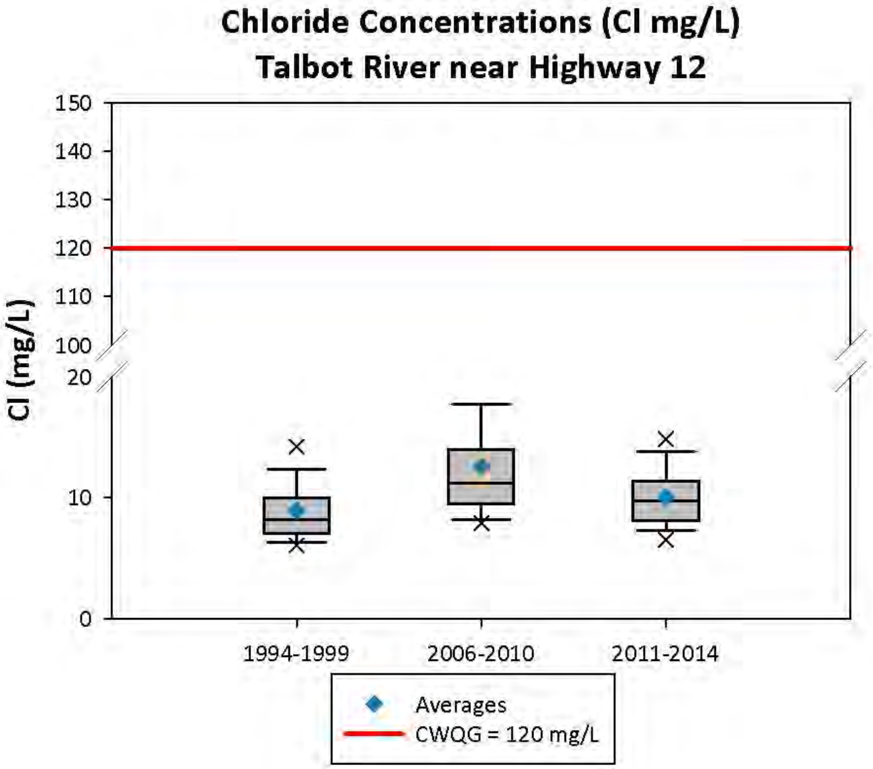


Figure 4-5: Chloride concentrations in the Talbot River subwatershed.

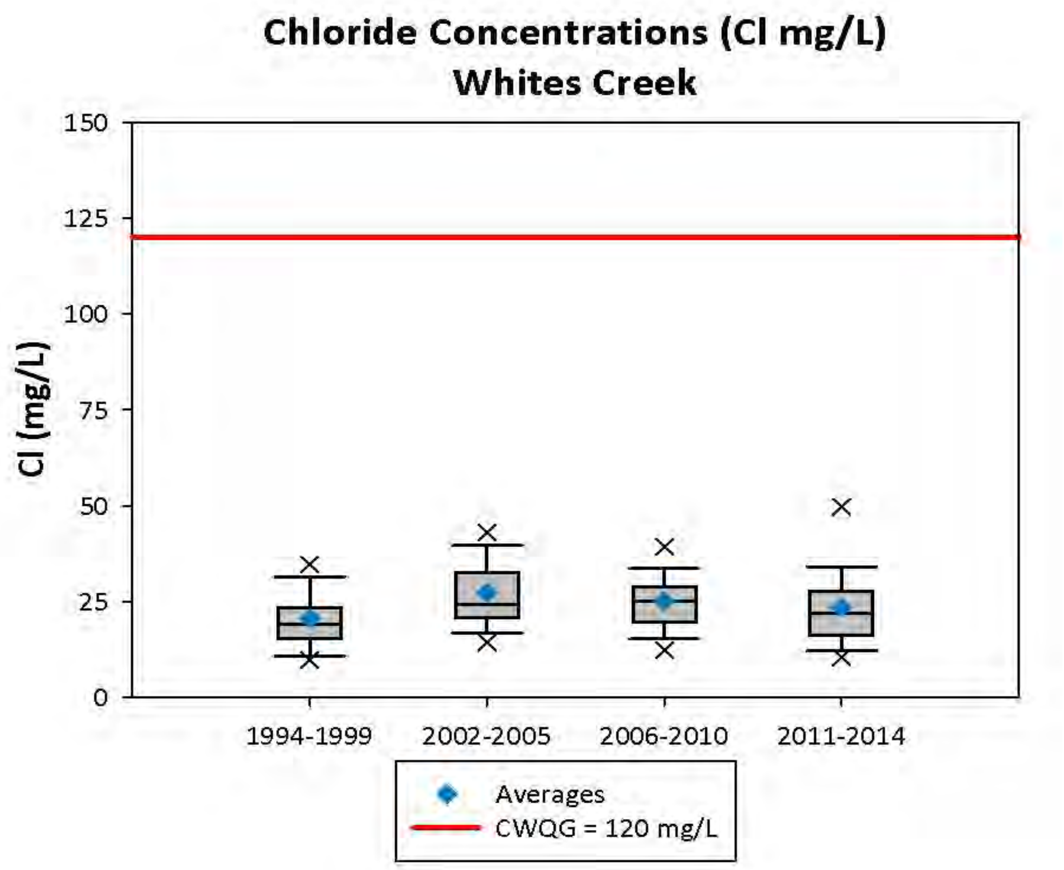


Figure 4-6: Chloride concentrations in the Whites Creek subwatershed.

4.3.7 Total Suspended Solids

Total suspended solids (TSS) are a measure of solid inorganic and organic material suspended within the water column. This is an important measure because, as outlined in Table 4-1, TSS can act as a transport mechanism for a variety of other parameters, some in a benign form such as clay-bound aluminum, while others such as phosphorus can cause excessive nutrient loading downstream.

Excessive amounts of TSS can also have negative impacts on aquatic organisms because of shading, abrasive action, habitat alteration and sedimentation. Suspended solids or sediments have a significant effect on aquatic community dynamics when they interfere with light transmission.

Most flowing waters have considerable variation in suspended solids from day to day, and high TSS concentrations would be expected during and following rain events as soil from pervious areas and accumulated grit and dirt from impervious surfaces are washed into streams. Because this natural variation is so great, it is not desirable to establish a fixed rigid guideline

(CCME, 2001). Water quality sampling conducted during predominantly dry weather conditions will usually indicate a lower occurrence of TSS exceedances. Therefore more flexible guidelines have been established: the concentration of suspended solids in stream water should not be increased by more than 25 mg/L over background levels during any short-term exposure period and no more than 5 mg/L over background levels for long term exposure (30 days and more) (CCME, 2001).

Upper Talbot River Short-term Monitoring Stations

Background concentrations of total suspended solids in streams of the study area are usually 0.5-1 mg/L. After significant rain events, TSS concentrations can increase quite substantially in the Upper Talbot River (station MC3) and Northern Tributary (station MC4) (Figure 4-7). For example, the highest TSS levels have been observed in the Upper Talbot River as a result of a sharp increase in flow volume after storm events. The maximum TSS concentration detected in the river is 27 mg/L, while the average is 5.1 mg/L that is considerably higher than in other streams of the watershed (Table 4-7). Northern Tributary has the second highest maximum and average TSS concentrations subsequent to the Talbot River (Figure 4-7). All average and median TSS concentrations in all monitored streams are well below the CCME guideline.

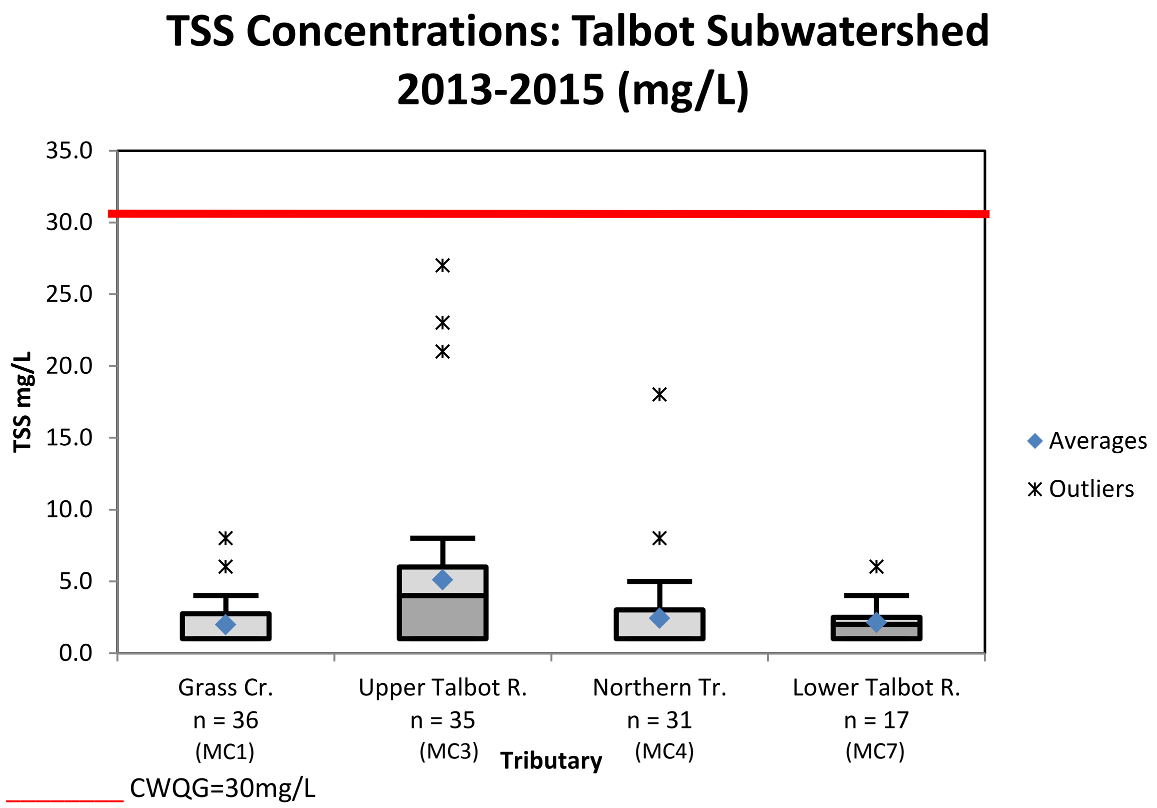


Figure 4-7. Total suspended solids concentrations in the Upper Talbot River Subwatershed for the Period of 2013-2015 (mg/L)

LSPP Long-term Monitoring Stations

There have been no exceedances of the CCME interim guideline for TSS at any of the Talbot River or Whites Creek LSPP stations, and the maximum observed concentration was 18 mg/L (Figure 4-8).

Spot Check Samples (Spatial Study)

Similar to TP, TSS concentrations increase during elevated flows. Even during high flows, the concentrations at all nine sites were well below the interim guideline.

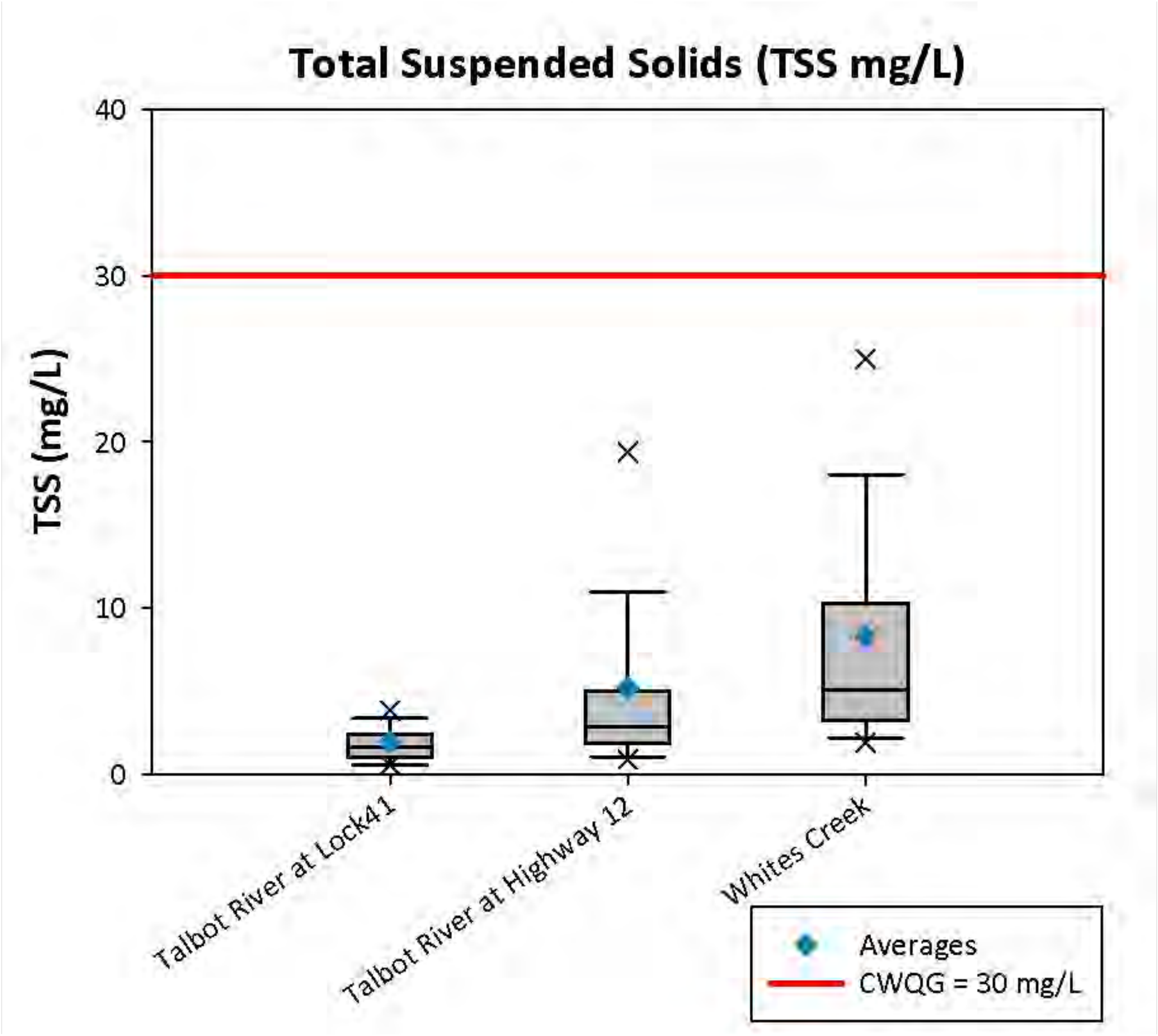


Figure 4-8: Total suspended solids concentrations in the Talbot River and Whites Creek subwatersheds

Key points – Current Water Quality Status:

- There are no Provincial Groundwater Monitoring Wells within the subwatersheds. There are seven stream monitoring sites, as well as three lake monitoring sites in the Talbot River subwatershed; Whites Creek has one stream monitoring station. Additional samples were collected at several spot check sites across the subwatersheds in May 2013 to provide spatial information.
- There are few issues with surface water quality; the majority of water quality samples collected at the monitoring stations meet the relevant water quality objectives.
- Based on available long term monitoring, there is no trend in chloride and phosphorus concentration in the Whites Creek subwatershed but an increasing trend in nitrates, as well as a decreasing trend in phosphorous concentrations in the Talbot River (Hwy 12 station).
- Based on more recent data (2005-2014), there is no trend and a decreasing trend in chloride concentration in the Whites Creek and Talbot River subwatersheds, respectively. Phosphorus either had no trend or a decreasing trend in the subwatersheds. Nitrates and TSS were increasing in Whites Creek. Nitrates and TSS showed no trend for the Talbot River stations, except for nitrates at Lock 41.
- The main parameter of concern for surface water is the nutrient phosphorus. At the Whites Creek LSPP subwatershed monitoring station, 31% of the samples have exceeded the Provincial Water Quality Objective since sampling began in 1994. The highest concentration recorded at the station was 0.273 mg/L, almost 10 times the provincial objective. Of the samples taken at the LSPP Talbot River monitoring stations, 16% have exceeded the PWQO since sampling began in 1993; the highest recorded concentration was 0.137 mg/L.
- In the Upper Talbot River monitoring stations, phosphorus levels exceeded the PWQO in 17% of all samples (2013-2015), and exhibited higher concentrations in the late spring and summer periods.
- Though some trends for nitrates and TSS were increasing in the short-term period, very few of the samples collected at the LSPP stations between 1993 and 2014 exceeded the Canadian Water Quality Guidelines for these parameters.
- Chloride levels in the study area are among the lowest in the Lake Simcoe watershed as no samples from the LSPP monitoring program exceeded the guidelines and there is a decreasing or stable trend in Talbot River and Whites Creek subwatersheds, respectively.

4.4 Factors impacting status - stressors

4.4.1 Groundwater

Because groundwater moves more slowly and is subject to natural filtering as it moves through the soil, the quality of groundwater is most often better than that of surface water. As the water moves through the soil, contaminants are subject to the processes of: adsorption, where they are bound to soil particles; precipitation, where a chemical reaction causes a chemical in solution to become a solid; and degradation, where a chemical breaks down over time. These processes serve to improve the quality of the water.

There are some substances that can easily move through the groundwater system without attenuation by any of the aforementioned processes. The most notable of these is chloride from road salt. Further, if a contaminant source is located near a discharge area, there may not be sufficient time and distance for natural filtering to occur. There are also some parameters, including iron and chloride, which are naturally found within some groundwater aquifers.

Groundwater quality can also be impacted by anthropogenic factors. In rural areas, levels of contaminants including bacteria, phosphorus, nitrates, and chloride (in the form of road salt and dust suppressant) can become elevated where the groundwater is beyond the capacity of the natural filtration capability of the soils. Sources of contaminants in these areas are fertilizers, improperly functioning septic systems, manure storage facilities, road salt and dust suppressant application. In urban areas, groundwater can be subject to contamination by road salt, hydrocarbons, metals, solvents, phosphorus, and other nutrients. Groundwater contamination becomes an issue where it is discharged to the surface and is used by animals or humans. Although we don’t currently have any representative groundwater wells in the study area, these contaminants pose a potential threat to groundwater resources in the Talbot River and Whites Creek subwatersheds.

4.4.2 Surface Water

There are numerous factors that can have an effect on the water quality within the Whites Creek and Talbot River subwatersheds. These include:

- Phosphorus,
- Chloride,
- Sediment,
- Thermal degradation,
- Pesticides,
- Metals,
- Bacteria,
- Emerging contaminants,
- Uncontrolled stormwater and impervious surfaces,

- Recreation, and
- Climate change.

These factors are discussed further in the following sections.

4.4.2.1 Phosphorus

One of the most significant causes of water quality degradation in Lake Simcoe and its tributaries is an excess of phosphorus. Phosphorus promotes the eutrophication of surface waters by stimulating excessive growth of plants and algae. This impairs both the aquatic communities (the decomposition of this extra plant material depletes dissolved oxygen levels, particularly in the deeper parts of the lake where there is critical coldwater species habitat) and recreational opportunities (restricts recreational use of waterways, washes up on beaches, creates a negative aesthetic view along the shoreline, etc.). In the Talbot River and Whites Creek subwatersheds, these issues are particularly prevalent in communities along waterways, such as in Canal and Mitchell Lakes, where the lack of flow tends to exacerbate these issues.

Phosphorus occurs naturally in the environment and is a vital nutrient needed by both plants and animals. However, current land uses have increased the phosphorus loading to Lake Simcoe from an estimated 32 T/yr (prior to settlement and land clearing in the 1800s) to an estimated average load of 86 T/yr for the most recent five-year period (MOECC, 2010; LSRCA and MOECC, 2013). Rural and agricultural land uses make up 59.7% of the Whites Creeks subwatershed and 20.8% of the Talbot River subwatershed. Runoff from pastures and crop land comprises a large proportion of the phosphorus from these areas; another source is the wind erosion of top soil. Urban land use makes up a small proportion (1.1 and 1.4%) of the subwatersheds, but contributes to the phosphorus loading through stormwater runoff (discussed further in Section 4.4.3.7).

As discussed above, phosphorus loads have been calculated for the Lake Simcoe watershed by the LSRCA, in partnership with the Ministry of the Environment and Climate Change. This work takes into account water quality data from sampling stations throughout the watershed, flow data, climate information, and atmospheric sources of phosphorus as found through a number of other sampling stations located around the watershed. The sources estimated through this exercise are the tributaries (which measures sources from urban, agricultural, natural, and other areas within the lake's subwatersheds), sewage treatment plants, atmospheric, septic systems (within 100 metres of the Lake Simcoe shoreline), and the watershed's five vegetable polders. The phosphorus load for each subwatershed is displayed in Figure 4-9 below. The Talbot River subwatershed had the sixth highest loading in the subwatershed, at an average of five tonnes per year, and Whites Creek had the sixth lowest, with an average of 1.4 tonnes per year (LSRCA and MOECC, 2013).

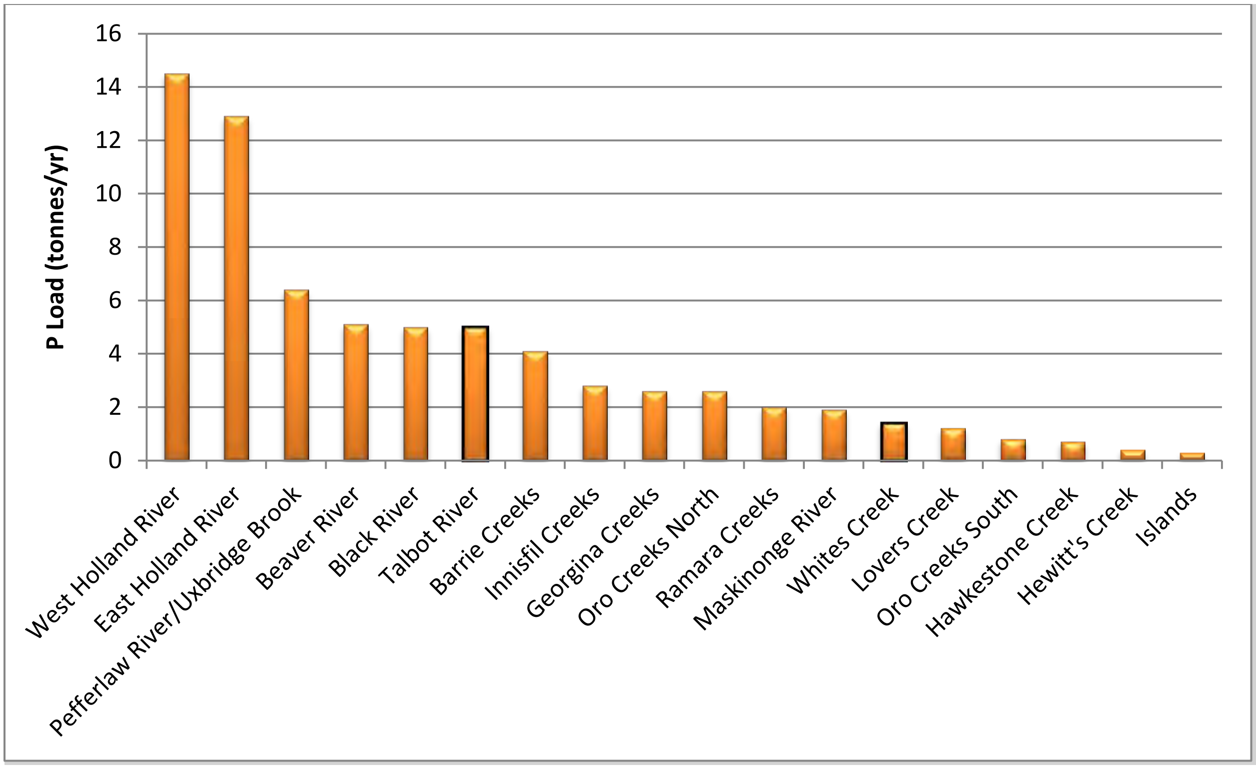


Figure 4-9: Average phosphorus loads (tonnes/year) contributed by each Lake Simcoe subwatershed (data: LSRCA/MOECC, 2013)

Similar work was undertaken using loading estimate models for the Assimilative Capacity Study (Louis Berger Group, 2006), but have since been updated by the original authors in a report completed in September 2010, entitled '*Estimation of the Phosphorus Loadings to Lake Simcoe*' (Louis Berger Group, 2006). A watershed model (CANWET) that estimates nutrient loads based on inputs such as land use, precipitation, and soil type was used for both the ACS and the updated study. This type of exercise is useful for anticipating how the phosphorus load in each subwatershed is influenced by land use, and how the loads will change as land use changes. The following table (Table 4-6) presents the average yearly phosphorus loads (as modeled through the 2010 Louis Berger Group report) derived from each source in the subwatershed under current conditions, the approved growth scenario, and the approved growth scenario with implementation of agricultural best management practices (BMPs). Urban BMPs are not considered in this particular study as the model used did not consider them, but the model is currently being updated and future versions of this subwatershed plan will consider the amount of phosphorus that can be reduced through urban BMPs, which, while they do not make up a significant portion of this subwatershed, could help to alleviate some of the water quality issues that have been noted along the lakeshores.

Talbot River

According to the model, the primary source of phosphorus in the Talbot River subwatershed under existing conditions is derived from hay-pasture (22%), quarries (18%), and stream banks (12%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 22.3% without the implementation of agricultural BMPs (again, urban BMPs are not considered). The projected phosphorus load under the approved growth scenario can be reduced by 3.8% through the implementation of a number of agricultural BMPs (Table 4-6). Under existing conditions, the model ranks the Talbot River subwatershed as the ninth lowest contributor of total phosphorus to Lake Simcoe (Figure 4-10), and is expected to remain the ninth lowest under the committed growth scenario (Figure 4-11) (Louis Berger Group Inc., 2010).

Table 4-6: Phosphorus loads by source for the Talbot River subwatershed associated with agriculture BMP scenarios (Louis Berger Group Inc., 2010).

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Difference (Existing to Growth) (%)	Committed Growth with Agricultural BMPs (kg/year)	Difference (Growth to Agricultural BMP) (%)
Hay/Pasture	634	607	-4.4%	598	-1.4%
Crop Land	269	266	-1.1%	180	-32.3%
Turf-Sod	321	321	0	321	0
Tile Drainage	123	135	9.8%	135	0
Low intensity development	32	32	0	32	0
High intensity development	151	668	343.3%	668	0
Septics	84	84	0	84	0
Polder	0	0	0	0	0
Quarry	524	524	0	524	0
Unpaved road	33	33	0	33	0
Transition	47	44	-7.1%	44	0
Forest	12	12	-2.3%	12	0
Wetland	5	5	0	5	0
Stream bank	350	414	18.4%	377	-9.0%
Groundwater (shallow subsurface flow)	272	349	28.2%	349	0
Point sources	0	0	0	0	0
TOTAL	**2,858**	**3,494**	**22.3%**	**3,362**	**-3.8%**

- Based on Strategic Direction #3 in the Phosphorus Reduction Strategy, future development should be moving to no net increase in phosphorus. Currently our understanding is that the province is working on a phosphorus reduction tool to ensure this.

High phosphorus loads in streams and rivers can also contribute to high rates of growth of aquatic plants and algae, which is commonly seen in the Talbot River as well as Canal and

Mitchell Lakes. While this excessive growth can present issues with respect to boat navigation and aesthetics, algal blooms can also be a public health issue. Of particular concern are blooms of Cyanobacteria, or blue-green algae. In addition to being a nuisance, some species of the bacteria comprising these blooms secrete toxins, which can have a number of effects depending on the species of Cyanobacteria. These effects can include skin irritation, rash or sore, red eyes for persons coming into contact with it; or fever, nausea, vomiting and impacts to the liver or the nervous system for persons ingesting it. Exposure to the water by humans and pets, as well as the consumption of fish from affected areas, should be avoided during periods of algal bloom to prevent potential impacts due to exposure to these toxins.

In fall 2016, there were two confirmed cases of blue-green algae in the Talbot River, in sheltered bays with slow water movement. Factors contributing to this growth are likely the high levels of phosphorus, and warm, slow-moving waters found in these areas. These blooms are typically particularly prevalent in late summer, when temperatures are warmest and there is less rain water and flow to flush the system.

Whites Creek

According to the model, the primary source of phosphorus in the Whites Creek subwatershed under existing conditions is derived from hay-pasture (24%), crop land (21%), and stream banks (19%). Under the approved growth scenario, there is a projected increase in total phosphorus loads of 3.8% without the implementation of agricultural BMPs (again, urban BMPs are not considered). The projected phosphorus load under the approved growth scenario can be reduced by 12% through the implementation of a number of agricultural BMPs (Table 4-6). Under existing conditions, the model ranks the Whites Creek subwatershed as the fifth lowest contributor of total phosphorus to Lake Simcoe (Figure 4-10), and is expected to become the fourth lowest under the committed growth scenario (Figure 4-11) (Louis Berger Group Inc., 2010).

Table 4-7: Phosphorus loads by source for the Whites Creek subwatershed associated with agriculture BMP scenarios (Louis Berger Group Inc., 2010).

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Difference (Existing to Growth) (%)	Committed Growth with Agricultural BMPs (kg/year)	Difference (Growth to Agricultural BMP) (%)
Hay/Pasture	298	294	-1.4%	289	-1.7%
Crop Land	265	263	-0.7%	182	-30.8%
Turf-Sod	6	6	0	6	0
Tile Drainage	99	97	-1.5%	97	0
Low intensity	9	9	0	9	0

Source	**Existing (kg/year)**	**Committed Growth Scenario (kg/year)**	**Difference (Existing to Growth) (%)**	**Committed Growth with Agricultural BMPs (kg/year)**	**Difference (Growth to Agricultural BMP) (%)**
development					
High intensity development	44	98	125.0%	98	0
Septics	24	24	0	24	0
Polder	0	0	0	0	0
Quarry	0	0	0	0	0
Unpaved road	25	25	0	25	0
Transition	10	10	0	10	0
Forest	3	3	0	3	0
Wetland	1	1	0	1	0
Stream bank	235	235	0	167	-29.0%
Groundwater (shallow subsurface flow)	221	220	-0.5%	220	0
Point sources	0	0	0	0	0
TOTAL	**1,241**	**1,288**	**3.8%**	**1,134**	**-12.0%**

- Based on Strategic Direction #3 in the Phosphorus Reduction Strategy, future development should be moving to no net increase in phosphorus. Currently our understanding is that the province is working on a phosphorus reduction tool to ensure this.

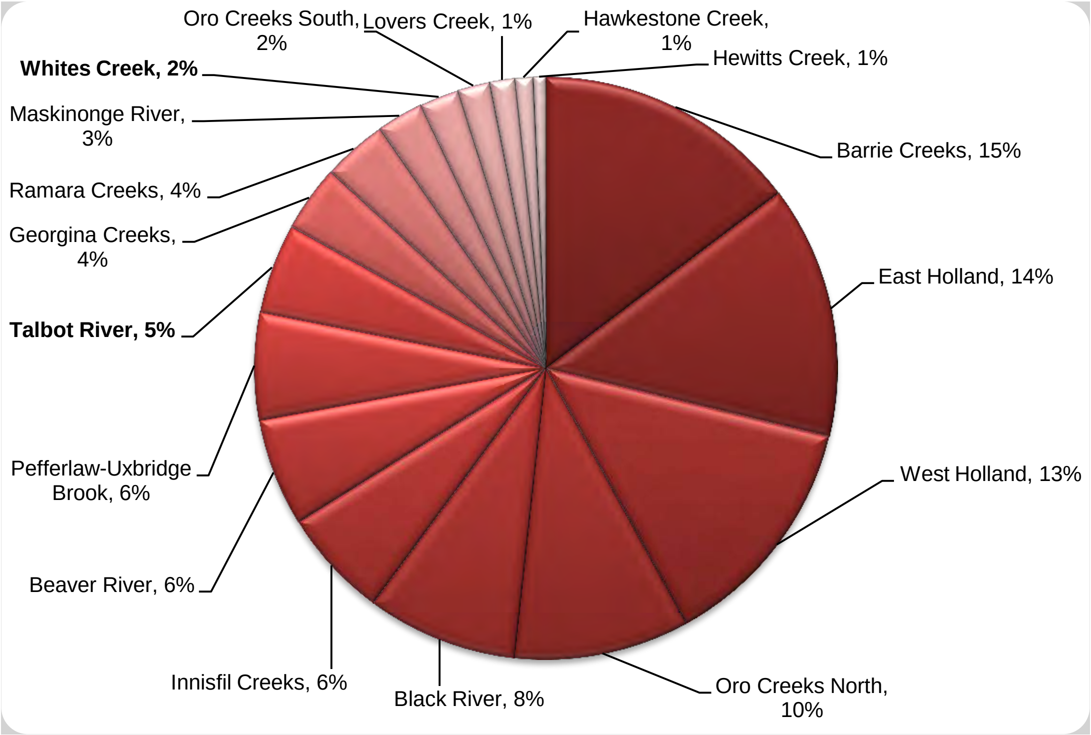


Figure 4-10: Percent phosphorus loads (modelled) to Lake Simcoe per subwatershed under current conditions (data: Louis Berger Group, 2010).

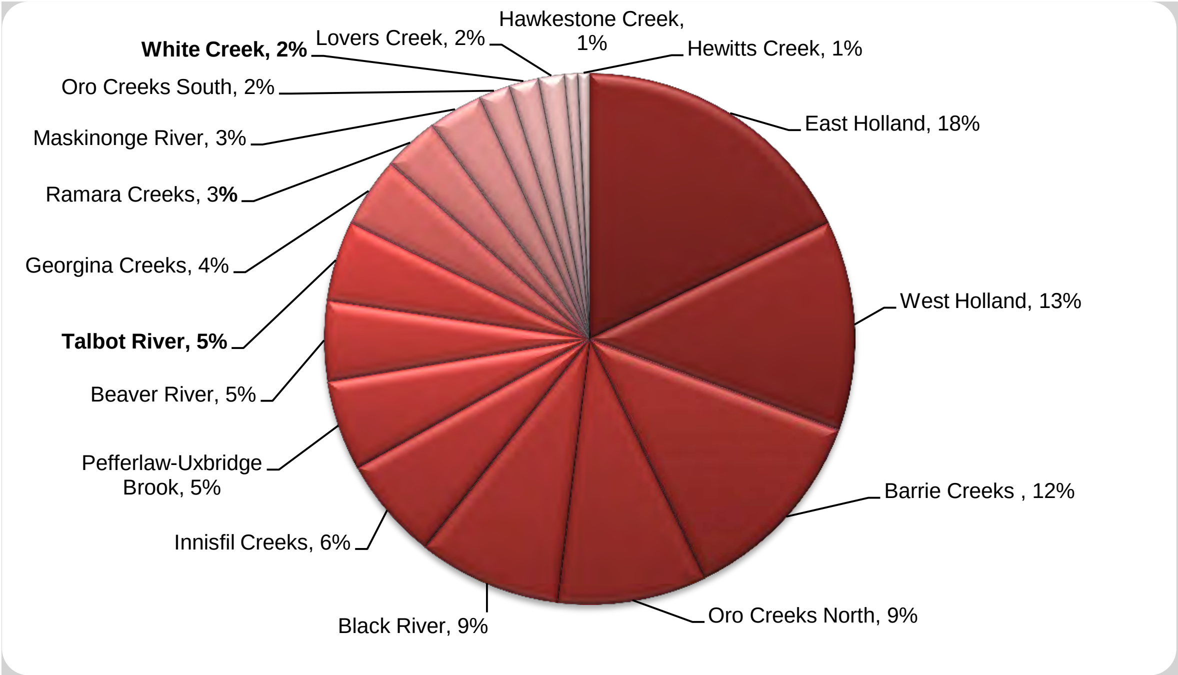


Figure 4-11: Percent phosphorus loads (modelled) to Lake Simcoe per subwatershed under committed growth scenario (data: Louis Berger Group, 2010).

Another way to look at the phosphorus loading of each subwatershed is the amount per year per surface area, or export rate. Figure 4-12 illustrates this, using the loads calculated by LSRCA and MOECC, showing that although the total phosphorus loads to Lake Simcoe from a number of other subwatersheds are much higher than that of Oro Creeks North (Figure 4-9); it contributes the fifth highest amount of phosphorus per square kilometre in the entire Lake Simcoe watershed. The Talbot River and Whites Creek subwatersheds have the third lowest and first lowest export rates, respectively, in the Lake Simcoe watershed. The Talbot River export rate should probably be lower because of the extra load from the Gull River watershed; it is not load from overland runoff in the Talbot River subwatershed. Currently there is no method to quantify the load contributed to the Talbot River subwatershed from the Gull River watershed.

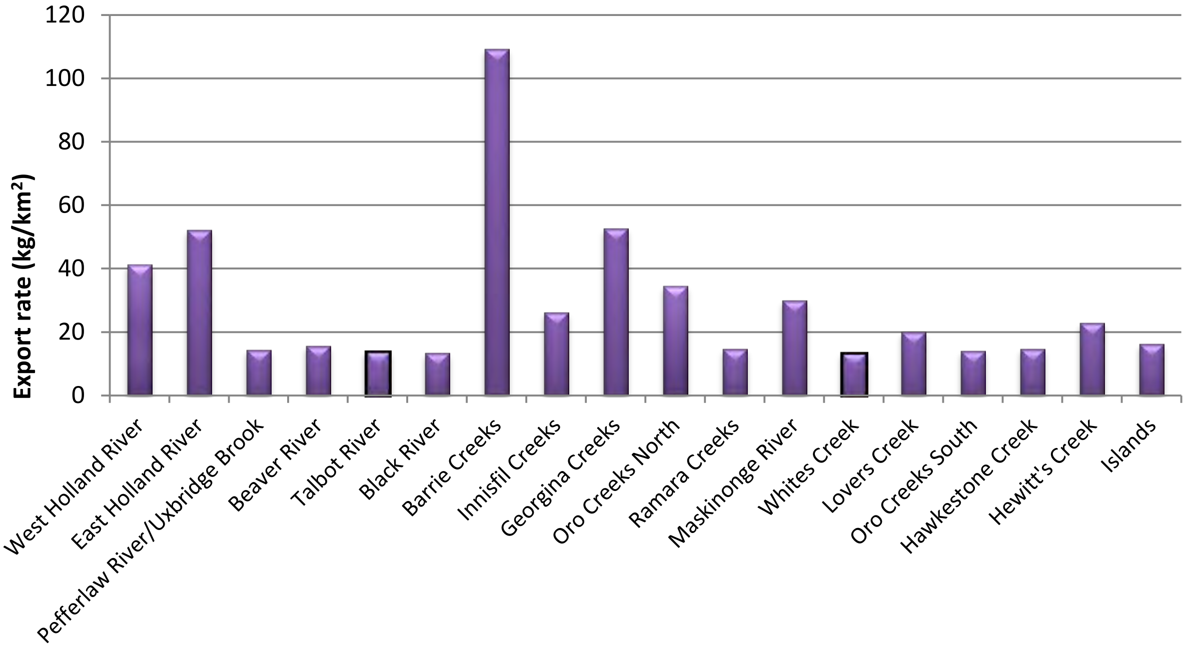


Figure 4-12: Phosphorus loading (kg/yr) per km^2 under current conditions for each Lake Simcoe subwatershed (data: LSRCA/MOECC, 2013).

Catchment Level Best Management Practices Analysis

An additional analysis undertaken for the 2010 report by the Louis Berger Group was to split the subwatersheds up further into catchments, each named by the tributaries they contain. The Talbot River subwatershed has five catchments, ranging in size from 122.9 ha (Talbot River 2) to 2,014.7 ha (Talbot River 1). The Whites Creek subwatershed has eight catchments, ranging in size from 317.9 ha (Whites Creek 2) to 2,607.1 ha (Whites Creek 5).

As already mentioned, an overall potential reduction of 3.8% (Talbot River) and 12% (Whites Creek) can be achieved through the implementation of agricultural BMPs. However, to achieve the basin wide total phosphorus target of 44 T/year, the CANWET watershed model also produced targets for individual subwatersheds. These were further narrowed down to catchment level targets to give a better idea of priority areas for phosphorus reduction. Figure 4-13 and Figure 4-14 illustrate the total phosphorus loads per catchment, based on the agricultural BMP scenario, while

Figure 4-15 and Figure 4-16 illustrate the target total phosphorus loads for each catchment. The difference between the two sets of figures is a further 73.7% and 78.0% reduction from the agricultural BMP scenario to the required (modelled) target loads for the Talbot River and Whites Creek subwatersheds, respectively.

To prioritize areas for phosphorus reduction, each catchment area was assessed based on the amount of phosphorus that needs to be reduced to reach the target, and the associated unit cost ($/kg). For instance, a catchment which contributes relatively high phosphorus loads, but can be reduced at a lower cost, is a higher priority than a catchment that contributes lower phosphorus loads or has a higher unit cost. The Louis Berger Group (2010) prioritized all the catchments in the Lake Simcoe watershed, splitting them into four Tiers (Tier 1 being the highest priority, Tier 4 the lowest) for each subwatershed. Table 4-8 lists each of the catchments in the Talbot River and Whites Creek subwatersheds based on this ranking system.

Table 4-8: Classification of catchments in prioritization tiers (Louis Berger Group Inc., 2010).

Subwatersheds	**Catchments***			
	Tier 1 (highest priority)	**Tier 2**	**Tier 3**	**Tier 4 (lowest priority)**
Talbot River Subwatershed		Talbot River 1	Talbot River 2	
		Talbot River 3		
		Talbot River 4		
		Talbot River 5		
Whites Creek Subwatershed	Whites Creek 5	Whites Creek 3	Alsops Beach Creek	
		Whites Creek 4	Whites Creek 1	
		Whites Creek 6	Whites Creek 2	
		Whites Creek 7		

** Catchments are illustrated in following figures*

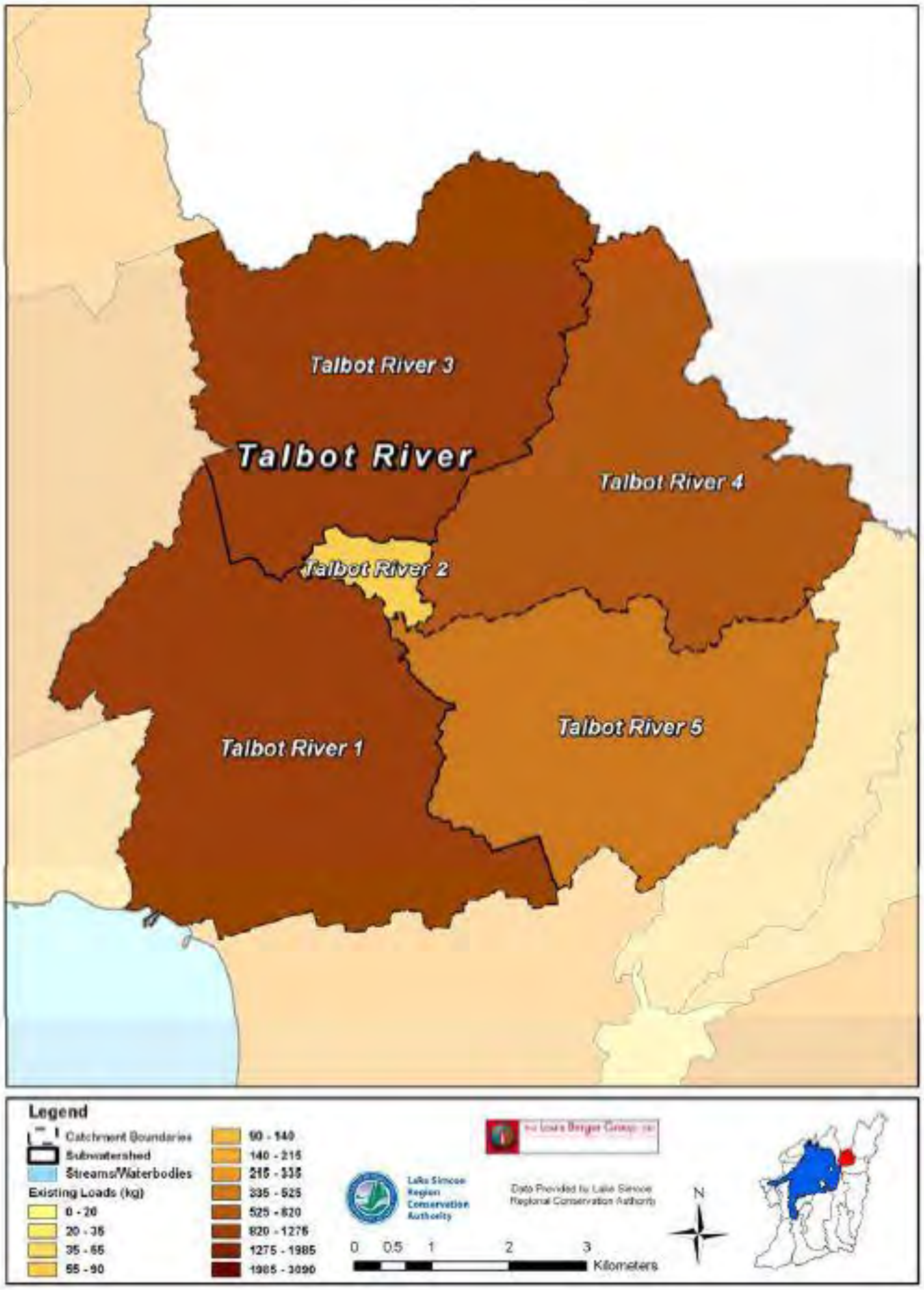


Figure 4-13: Talbot River subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

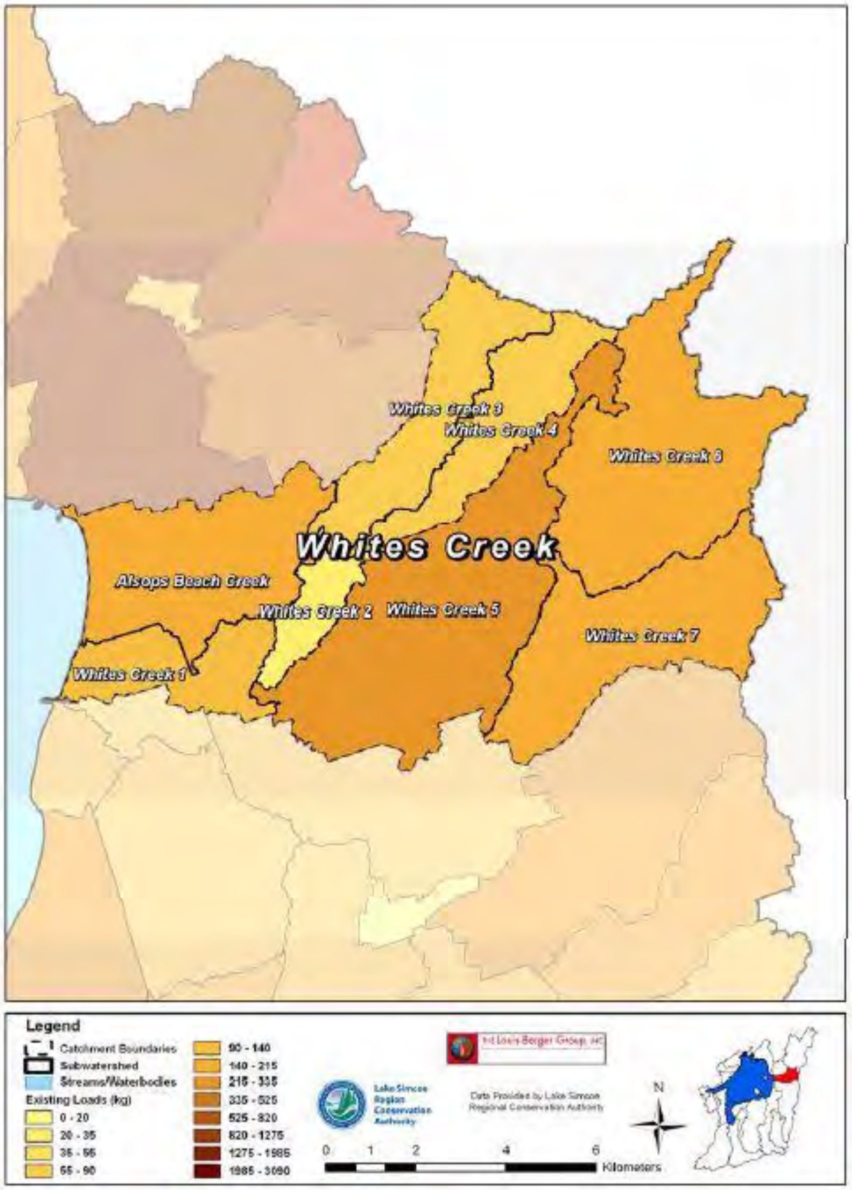


Figure 4-14: Whites Creek subwatershed agricultural BMP scenario total phosphorus loads (Berger, 2010).

Figure 4-15: Talbot River subwatershed target total phosphorus loads (Berger, 2010).

Figure 4-16: Whites Creek subwatershed target total phosphorus loads (Berger, 2010).

4.4.2.2 Chloride

The main source of chloride, in its various compounds, in the environment is from road salt (Environment Canada, 2001). It enters the environment through runoff from roadways as well as through losses from salt storage and snow disposal sites. Due to its high solubility, chloride very easily contaminates both surface and groundwater.

High levels of chloride, such as those found in runoff water draining from roads and salt storage yards, can damage the roots and leaves of aquatic and terrestrial plants, and can also have behavioural and toxicological impacts to animals. Continued exposure to high chloride levels can cause a shift from sensitive communities to those more tolerant of degraded conditions (including a number of invasive species that are able to thrive).

Chloride concentrations fall well below the guideline values at all three monitoring stations, however given the trends currently being seen across the Lake Simcoe watershed it is not unreasonable to think that areas of high chloride concentration might be present in the urban areas of the subwatersheds. Given that there are some areas of growth planned for the subwatershed, it is likely that concentrations will increase over time unless practices are instituted to prevent chloride from reaching area watercourses and the lake. Additionally, the impacts of calcium chloride have not yet been assessed in the study area, and could have additional effects on water quality.

The LSRCA has undertaken a project to model chloride loads for catchments throughout the entire Lake Simcoe watershed, including a breakdown of catchments within the Talbot River and Whites Creek subwatersheds (LSRCA, 2015). These predicted annual average chloride concentrations are based on the land use characteristics in a catchment, and the typical salt application rates (information which has been provided by watershed municipalities). Modelled chloride loads are shown in Figure 4-16. Once the chloride concentrations were modelled, it was possible to identify ‘Salt Vulnerable Areas’ (SVAs) throughout the watershed. SVAs are areas where chloride concentrations may be high enough to affect aquatic biota. The potential impacts are based on the results of previous studies testing the toxicity of chloride at various concentrations on a number of aquatic organisms, including invertebrates, amphibians, fish, and algae. These areas were ranked according to the number of species affected; and, not surprisingly, many of them were found in densely developed areas or along major highways and roads. Because it is still a relatively rural area, there aren’t many SVAs in the subwatersheds; those that are present are located mainly within the denser lakeshore communities (eg. Beaverton) and along some of the major roads, such as Highway 48 around Canal and Mitchell Lake, and Regional Road 15. These are shown in Figure 4-17. Once SVAs have been identified, it is important that the road and property managers in the area seek to implement practices to limit the amount of salt reaching the watercourses within them.

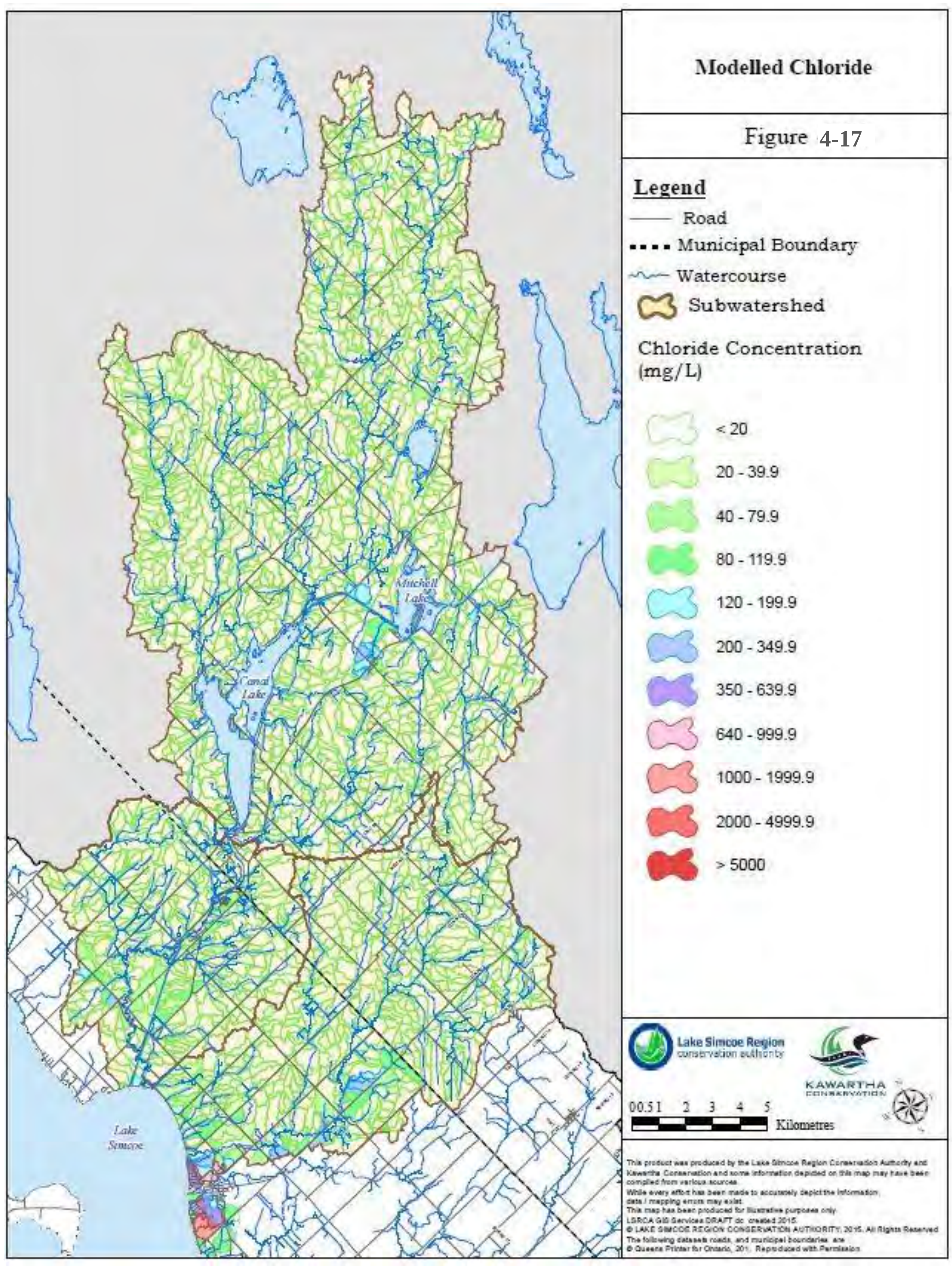


Figure 4-17: Modelled chloride concentrations in the Talbot River and Whites Creek subwatersheds

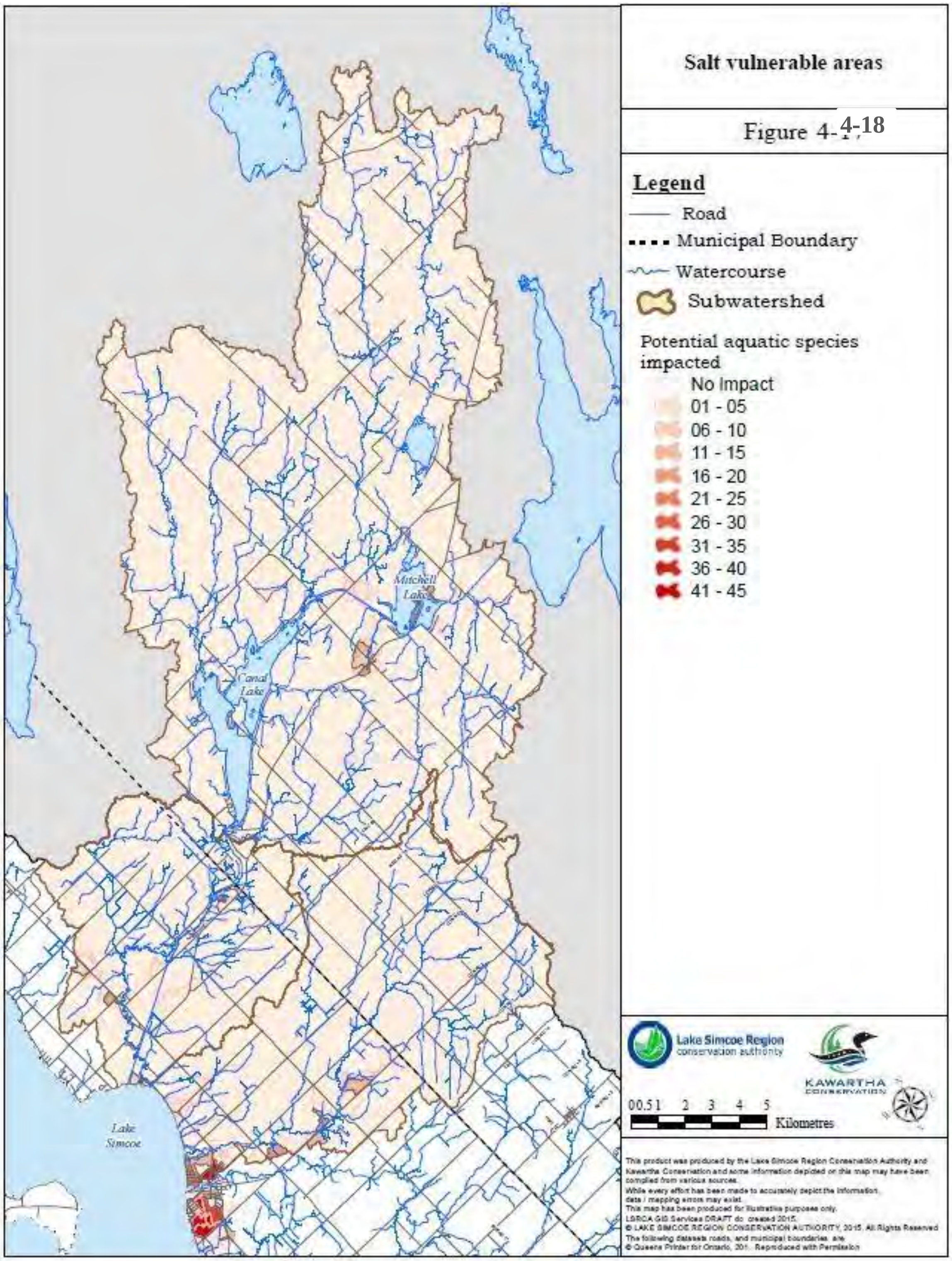


Figure 4-18: Salt vulnerable areas within the Talbot River and Whites Creek subwatersheds

4.4.2.3 Sediment

While a certain amount of sediment input is normal in a natural system, in larger amounts it can cause a number of problems. Many contaminants, including phosphorus, bind themselves to soil particles, and eroding soil acts as a vector for introducing these particles to an aquatic system. There are also impacts to aquatic biota, which are discussed in greater detail in **Chapter 6 - Aquatic Natural Heritage**.

There are a number of sources of sediment in the Talbot River and Whites Creek subwatershed:

Agricultural areas: fields are particularly vulnerable to erosion whenever they are bare (e.g. after tilling and in the spring prior to the establishment of crops). The flow of melt waters and precipitation over the fields during these periods can result in a huge influx of sediment. In addition, some farmers may also remove treed windbreaks and riparian vegetation along watercourses flowing through their properties in order to maximize the cultivable land, both of which help to prevent soil erosion. Practices such as conservation tillage and the use of cover crops, as well as the implementation of appropriate BMPs, will help to reduce soil loss and its associated impacts on watercourses. Another issue is where livestock have access to streams; their trampling of the banks and stream bottoms can cause significant erosion and contribution of sediment. Restricting access and providing alternative water sources are relatively simple solutions to this issue. For more information on the extent of agriculture and riparian buffers in this subwatershed, see **Chapter 2 - Study Area** and **Chapter 8 - Terrestrial Natural Heritage**, respectively.

Urban areas: The use of sand as well as salt for maintaining safe road conditions during the winter is commonplace. However, large quantities of sand remain on the roadsides after all of the snow has melted in the spring, and if it is not removed (e.g. by street sweeping) in a timely manner, much of it will be washed away by surface runoff during rain events. This is of particular concern in areas without stormwater controls, as the sand will be transported directly to local watercourses. For more information on the extent of urban area within this subwatershed, see **Chapter 2 - Study Area**.

Development sites: these sites are often stripped of vegetation well in advance of development in an effort to reduce costs, as many developments are built in phases. These bare soils are then subject to erosion by both wind and water. The proper installation of sediment and erosion controls can prevent some of the soil from reaching watercourses, but it is imperative that these measures are inspected and maintained regularly.

4.4.2.4 Thermal degradation

Surface water tends to warm when it is detained (e.g. in a pond or by a control structure) or flowing slowly through a watercourse, or when it flows over impervious surfaces. During the summer, impervious surfaces such as parking lots and rooftops can become extremely warm. As water flows over these surfaces before discharging to a watercourse, its temperature increases as well. The detention of water in a pond increases the surface area of the water that is exposed to sunlight, and keeps it there for a prolonged period of time, leading to warming.

Similar conditions can occur in municipal drains and lagoons due to the reduced velocity of the flow. The use of practices such as planting vegetation along ponds and watercourses, and the installation of bottom-draw structures in ponds that ensure that the coolest water is being discharged, can help to reduce the heating effect, but ponds and slowly flowing watercourses will still have an impact on the thermal regime of a watercourse. Temperature monitoring in the subwatersheds has indicated that the watercourses surveyed are all considered to be ‘warmwater’ with respect to aquatic habitat (this is discussed in detail in **Chapter 6 – Aquatic Natural Heritage**); however, continued warming without undertaking efforts to reduce temperature will render watercourses in the subwatersheds unsuitable for even the most tolerant fish species. The implementation of some of the practices discussed above could improve thermal conditions in some of the subwatersheds’ streams such that they may be able to support more sensitive ‘cool water’ species. It will, however, be important to take measures to maintain at the very least the current level of health in these subwatersheds.

4.4.2.5 Pesticides

Given the large proportion of agricultural use, pesticide use is a concern in the Talbot River and Whites Creek subwatersheds. While pesticide use for cosmetic purposes has been banned by the Province of Ontario, which is a very positive step, there are a number of exceptions to this law that allows for the use of pesticides for public health or safety (including the protection of public works structures), golf courses, specialty turf, specified sports fields, arboriculture and to protect natural resources, if certain conditions are met. There are also exceptions for agriculture, forestry, research and scientific purposes, and uses of pesticides for structural exterminations (e.g., in and around homes to control insects) and uses of pesticides required by other legislation. Due to the number of uses still allowed for pesticides, there is still the potential for these substances to end up in the surface waters of the subwatersheds. There can be a number of impacts to both terrestrial and aquatic systems due to pesticide contamination, including:

- Cancers, tumours and/or lesions on fish and animals;
- Reproductive inhibition/failure – reduced egg suppression and hatching, sterility;
- Nest and brood abandonment;
- Immune system suppression;
- Endocrine disruption;
- Weight loss;
- Loss of attention;
- Loss of predator avoidance (Ongley, E., 1996, Helfrich *et al*., 2009); and
- Loss of pollinator species (Gill *et al*., 2012).

The use of best management practices for the storage and use of pesticides and integrated pest management practices can limit the amount of pesticide required in a given area, and will also reduce the movement of the pesticides from target areas. These practices should be promoted throughout the subwatershed.

The LSRCA initiated sampling for pesticides, hydrocarbons and heavy metals in the Talbot River and Whites Creek subwatersheds in 2004 with the Toxic Pollutant Screening Program (LSRCA, 2004). Samples were taken from near the mouths of the watercourses and downstream of urban areas. Only surface water samples were collected from these stations (13 other stations around the watershed had sediment samples taken as well). None of the pollutants that were included in the analysis were detected, indicating that these substances, which represent some of the most widespread toxic contaminants found in natural waters, are not an issue in this area of the watershed.

4.4.2.6 Emerging contaminants

As anthropogenic activities increasingly impact our natural areas, the potential for introduction of harmful substances becomes more of a concern. It is for this reason that a Toxic Pollutant Screening Program was initiated by the Lake Simcoe Region Conservation Authority in 2004. The goal of this project was to develop a better understanding of the location and prevalence of certain elements, chemicals, and chemical compounds that have the potential to negatively impact either human or aquatic life in the watershed. Sampling through this program revealed that there are currently some substances with levels exceeding regulatory guidelines in some Lake Simcoe tributaries. In addition, there were some substances, such as pharmaceutical products, that were not included in this monitoring work. Many of these substances have the potential to impact humans and affect aquatic life.

Endocrine Disrupting Chemicals

Endocrine disrupting chemicals (EDCs) are chemicals which adversely affect the endocrine system, which is a set of glands and the hormones which guide development, growth, reproduction, and behaviour. Harmful effects have been observed on wildlife and humans including reproductive disorders, impacts on growth and development, as well as the incidence of some cancers. EDCs can come from both natural and man-made sources including pesticides and hormones (both natural and synthetic which are used in oral contraceptives and in livestock farming), and can be the product of industrial processes such as incineration. In nature, EDCs including polychlorinated biphenyls (PCBs) and other man-made chemicals have caused, among other issues, severe reproductive problems in fish and birds, swelling of the thyroid glands in numerous animal species, reduction in frog populations, and, in birds, the thinning of eggshells.

Pharmaceuticals and Personal Care Products

The presence of pharmaceuticals and personal care products (PPCPs) in the natural environment has been a growing concern over the past two decades, and will become more prevalent with the growing population and increasing use of these products. The effects of pharmaceuticals on humans, during the course of treatment are very well studied, however, the impacts of their by-products after use and persistence within the aquatic ecosystem is not.

Although some of the products and their by-products can be broken down incidentally at Waste Pollution Control Plants, the plants are generally not equipped to remove PPCPs from waste water. Studies have shown hormones, antibiotics, anti-inflammatory drugs, fragrances, antiseptics, sunscreen agents, and a host of other PPCPs in varying amounts in the environment, though they are mostly seen within 100 metres of a waste water treatment plant discharge. In general, the levels in the environment are quite low; however, the effects of prolonged exposure to low levels are not well known. Some studies have shown that PPCPs have the potential to alter physiology, behaviour, and reproductive capacity. Concerns in the environment related to PPCPs include endocrine disruption in aquatic life and antibiotic resistance. Further understanding of these and other concerns is required in order to determine potential steps.

Polybrominated Diphenyl Ethers

Polybrominated Diphenyl Ethers (PBDEs) are emerging as a chemical of concern to both human and environmental health due to their persistence and ability to bioaccumulate in the environment. PBDEs are a group of chemicals used as flame retardants in a number of manufactured products, particularly in plastics. They are found in most homes and businesses in products such as electronics, TVs, textiles, cars, aircrafts, construction products, adhesives, sealants, and rubber products. They have become an increasingly common pollutant and have been found in samples taken in air, water, and land. PBDEs have also been detected in a number of species (including humans) worldwide, and studies are finding that levels of PBDEs have been increasing steadily and substantially over time. In the Canadian environment the greatest potential risk from PBDEs is secondary contamination in wildlife from the consumption of prey with elevated PBDE levels as well as effects on benthic organisms through exposure to PBDEs in sediments.

Due to the environmental persistence and bioaccumulation of PBDEs they are considered toxic to the environment as defined under the Canadian Environmental Protection Act (CEPA). Currently, Canada is proposing a ban on the import and manufacture of a number of forms of PBDEs. This ban, however, does not include the decaBDE form, the most commonly used form. Efforts to control the release of decaBDE would involve working with industry and stakeholders to minimize the impact of PBDEs in the environment. Through the federal government, environmental objectives are also being proposed for virtual elimination of a number of forms of PBDEs detectable in the environment.

4.4.2.7 Uncontrolled stormwater and impervious surfaces

Urban land use comprises approximately 1.3% of the subwatershed area in Whites Creek and Talbot River. Runoff in urban areas, particularly those built prior to the requirement for stormwater management, can carry a host of pollutants to local watercourses. These pollutants build up on roads, driveways and parking lots, and even lawns, and are washed to watercourses during precipitation events. The pollutants that can be carried by urban stormwater runoff include nutrients and pesticides from lawns, parks and golf courses; road salts; tire residue; oil and gas; sediment; and nutrients and bacteria from pet and wild animal faeces. Generally, concentrations of pollutants such as bacteria (e.g. *Escherichia coli* and other fecal coliforms, *Pseudomonas aeruginosa* and fecal streptococci), nutrients (e.g. phosphorus, nitrogen), phenolics, metals and organic compounds are higher in urban stormwater runoff than the acceptable limits established in the PWQO (MOECC, 1994).

In the past it was common practice to route stormwater directly to streams, rivers or lakes in the most efficient manner possible. This practice typically has negative impacts on the receiving watercourse. Over the last two decades this has changed and efforts are made to intercept and treat stormwater prior to its entering watercourses or waterbodies. However, in many older urban areas stormwater typically still reaches watercourses untreated.

Paved surfaces increase the volume and velocity of surface runoff, which leads to streambank erosion, contributing more sediment to watercourses. Subwatersheds with less than 10% imperviousness[1] (hardened surfaces) should maintain surface water quality and quantity and preserve aquatic species density and biodiversity, as recommended in Environment Canada's Areas of Concern (AOC) Guidelines (EC, 2004). The AOC Guidelines further recommend an upper limit of 30% as a threshold for degraded systems that have already exceeded the 10% impervious guidelines. The impervious area in the study area is currently 3.8% (Lower Talbot River), 1.8% (Upper Talbot River), and 2.5% (Whites Creek); these values are all below the AOC guidelines. It will be important to maintain this low level of imperviousness and to implement practices that will promote infiltration in paved areas as growth proceeds in the subwatersheds into the future in order to avoid its associated impacts.

The increase in impervious surface area associated with urban growth and the resultant increases in stormwater runoff can have significant effects on water quality and quantity and aquatic habitat in a subwatershed. While it will obviously not be possible to eliminate impervious surfaces and their impacts, there are activities that can be undertaken to reduce these impacts.

The requirement for stormwater management facilities in all new developments will help to mitigate these issues in urban areas; however, the ongoing maintenance of these facilities is crucial to ensuring that they continue to reduce sediment and nutrient loads as designed. Additional best management practices should also be implemented in conjunction with stormwater management wherever possible to reduce the amount of these pollutants, as even a stormwater facility with the highest level of control does not achieve 100% removal. Another input of sediment and nutrients from urban areas is the wind erosion of soils stripped bare for development. These areas can be without vegetated cover for prolonged periods of time, and can be a significant source of windborne pollution.

Based on the Stormwater Practices Manual (MOECC, 1994, 2003), there are various levels of stormwater control established to ensure the protection of receiving waters (i.e. watercourse, ditch, lake). Four levels of protection were established focusing on the ability of stormwater management ponds to control and remove suspended solids. The four levels are:

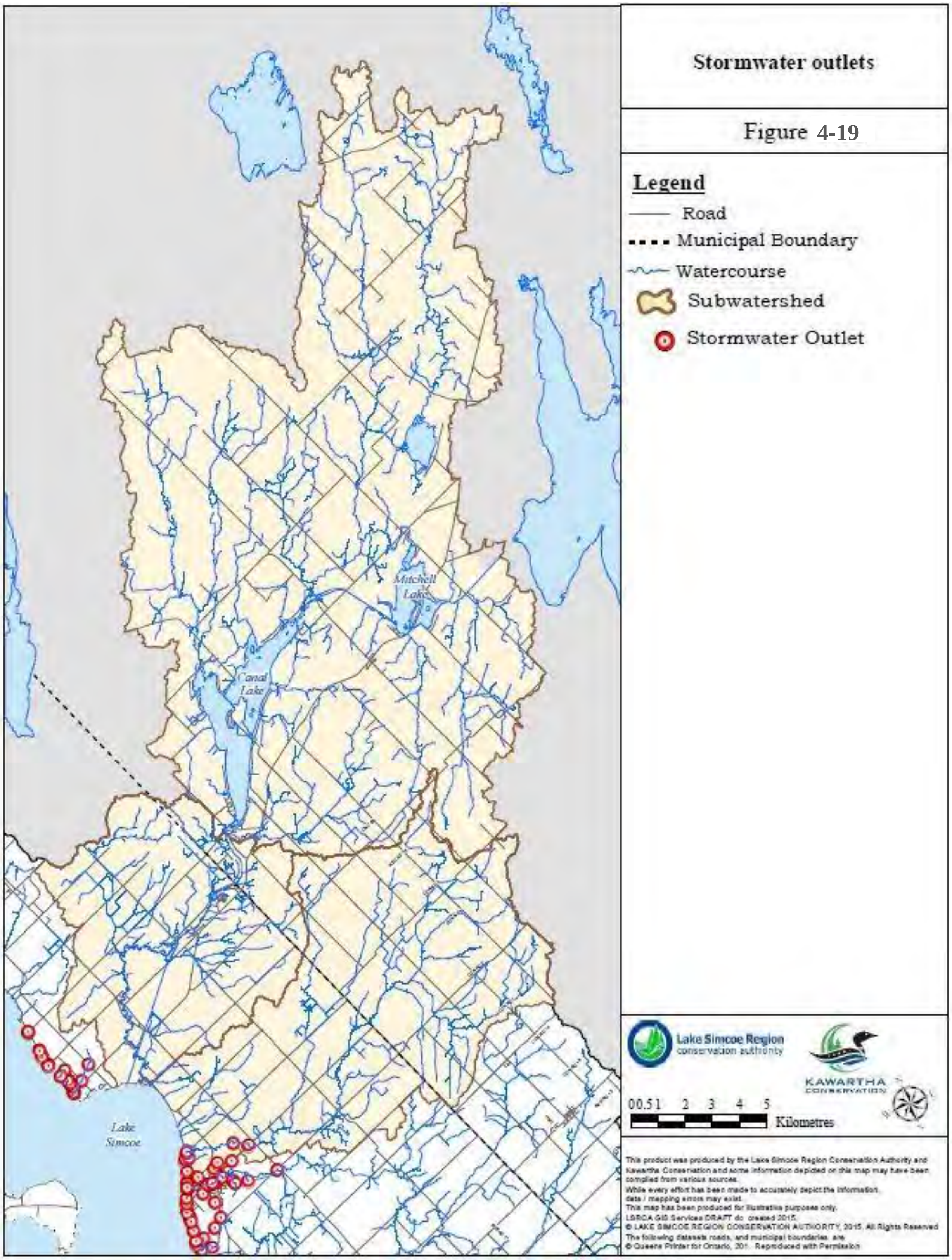
---

[1] Impervious surfaces refer to any hardened surface, but do not include features such as wetlands that are sometimes considered impervious in hydrogeological models

> **Level 1** is the most stringent level of protection designed to protect habitat which is essential to the fisheries productivity (such as spawning, rearing, and feeding areas) and requires 80% removal of suspended solids.
>
> **Level 2** protection calls for a 70% removal of suspended solids. In this instance the receiving water can sustain the increased loading without a decrease in fisheries productivity.
>
> **Level 3** controls are relaxed further, requiring a 60% sediment removal rate again reflecting the lower quality of the receiving water for fish production.
>
> **Level 4** controls exclusively address retrofit situations where, due to site constraints, the other levels of control cannot be achieved. Level 4 protection is not considered for any new development, only for instances where uncontrolled urban areas can implement some stormwater management facilities to improve the environmental health.

While there are no urban areas in the Talbot River subwatershed, the urban area of Beaverton falls within the Whites Creek subwatershed. As indicated by the Lake Simcoe Basin Stormwater Management and Retrofit Opportunities Report (2007), there are no stormwater controls in Beaverton, with most of the runoff discharging via grassed swales, ditches, and storm sewers into the Beaver River or directly into Lake Simcoe. Stormwater outlets for this area are shown in Figure 4-19.

The Draft Stormwater Management Master Plan identifies a number of new stormwater pond locations, as well as retrofit opportunities for dealing with stormwater from new and existing developments. Where appropriate and feasible, the use of a number of different Low Impact Development practices is recommended to reduce the amount of stormwater directly reaching watercourses and the lake via storm drains and ditches.



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While every effort has been made to accurately depict the information, data / mapping errors may exist.
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Figure 4-19: Stormwater outlets in the Talbot River and Whites Creek subwatersheds

4.4.2.8 Recreation

Natural areas such as streams and rivers are a popular location for recreational activities such as hiking, boating and snowmobiling. These activities, if not managed correctly and undertaken in a responsible manner, can negatively impact the surface water quality in the area. Impacts from recreational activities can include increased bank erosion and instability, loss of riparian area resulting in an increase in input of total suspended solids (TSS) and pollution. Stresses on these sensitive areas may be increasing as a result of increasing population and diminishing natural heritage lands.

4.4.2.9 Climate Change

While it is difficult to predict direct impacts of climate change to water quality within the Lake Simcoe watershed, it is likely that it will exacerbate the many of the previously mentioned water quality stressors, creating cumulative, long-term impacts.

Warmer temperatures will lead to further thermal degradation of watercourses and create ideal habitat for bacteria and pathogens. An increase in the frequency and intensity of weather events can also have an impact on contaminants, including:

- Causing the release of contaminants through damage to storage facilities, overflow of retention areas and mobilization of surface contaminants that are normally immobile;
- Transporting contaminants greater distances; and
- Increasing the quantity of contaminants (such as road salt) that are required to deal with weather events (such as snowfall).

Figure 4-20 and 4-21 shows two different climate scenarios (based on different models) and how they will impact the total phosphorus loads in the coming years for each of the subwatersheds. The climate change scenario outputs were initially reporting the base case phosphorus load (2004-2007). However, it was felt that using the 2004-2007 loads in light of the other longer term scenarios does not provide a meaningful comparison and could be misleading given the small snap-shot of time. The rationale behind this reasoning is that the climate change scenarios use a much greater modelling period of 30 years (1961-1990) to develop the climate change precipitation and temperature projections. Thus, to have a meaningful comparison, model runs were performed using the original precipitation and temperature data spanning the period 1961-1990, comparing existing loads and future climate change loads using the same modelling period of 30 years. Figure 4-20 illustrates the current 'baseline' value for Talbot River. For this area, both scenarios show phosphorus loads increasing, with a more pronounced increase after 2070. Figure 4-21 shows the baseline for Whites Creek and in this case, both models predict a decrease until 2017 followed by an increase in phosphorous loading.

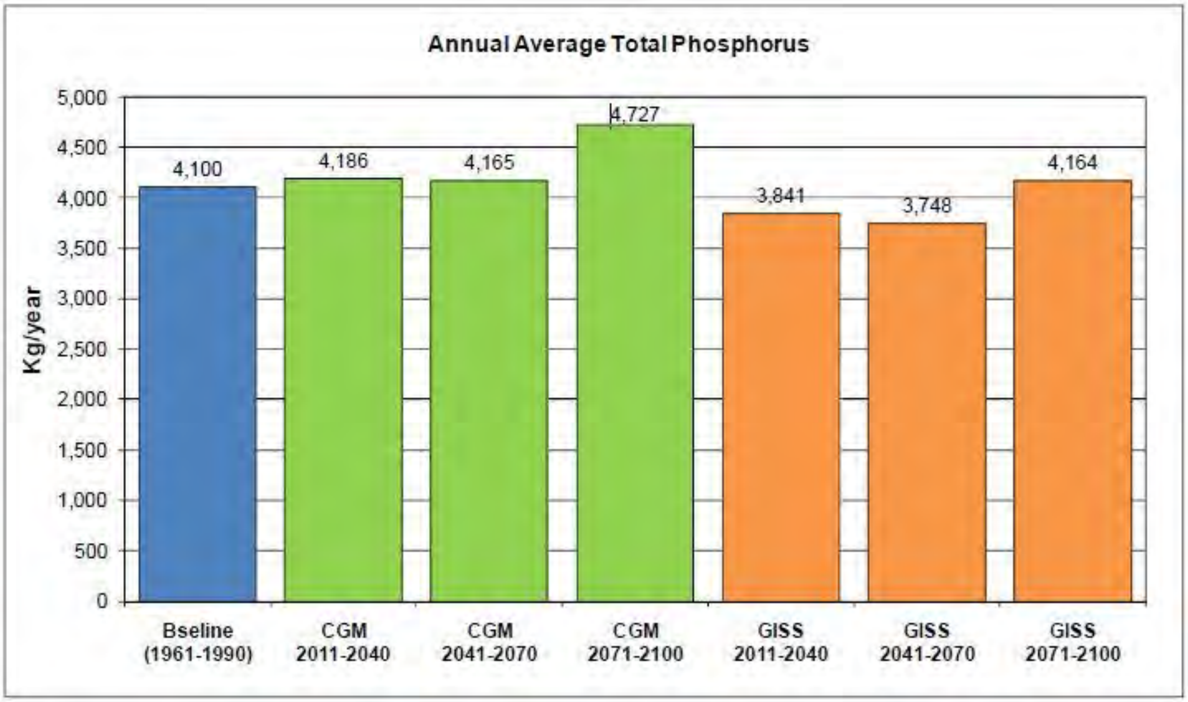


Figure 4-20: Base case land use applied to climate change scenarios for total phosphorus loads in the Talbot River subwatershed (Louis Berger Group Inc., 2011).

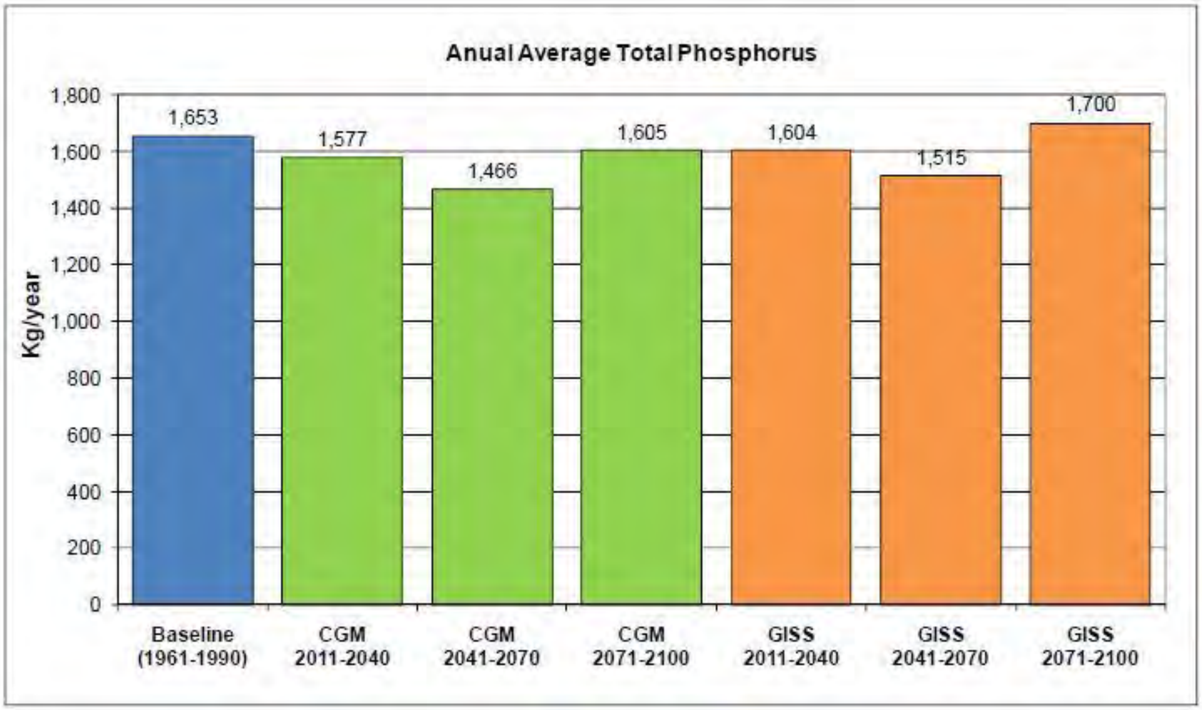


Figure 4-21: Base case land use applied to climate change scenarios for total phosphorus loads in the Whites Creek subwatershed (Louis Berger Group Inc., 2011).

Further information on how climate change will affect aquatic and terrestrial natural heritage can be found in **Chapter 6 – Aquatic Natural Heritage** and **Chapter 7 – Terrestrial Natural Heritage**, respectively.

***Key points – Factors Impacting Water Quality - Stressors*:**

- According to modelled load estimates, the primary source of total phosphorus in the Talbot River and Whites Creek subwatersheds are hay pastures (22% and 24%, respectively). Under the approved growth scenario in the modelling done for the Assimilative Capacity Studies, there is a projected increase in total phosphorus loads of 22.3% (TR) and 3.8% (WC) if agricultural BMPs are not implemented.
- When comparing the phosphorus loads (kg/yr) per square kilometer of the subwatersheds in the Lake Simcoe watershed, Whites Creek is the fifth lowest contributor per hectare, and Talbot River is the ninth lowest.
- A blue-green algae bloom was confirmed at two locations in the Talbot River in fall 2016.
- Sediment sources include agricultural areas, sites stripped for development, and sand used on roads in the winter. Sediment itself is a pollutant, and also acts as a vector for other pollutants, such as phosphorus.
- Increasing surface water temperatures can be attributed to overland flow across impervious surfaces and discharge from ponds. Stream temperature issues can be expected to increase in the coming years as the amount of impervious area increases.
- Chloride concentrations are well within guideline values at the water quality station; however, concentrations may be much higher in the subwatersheds' urban areas, particularly around commercial and industrial areas. Given the trends across much of the Lake Simcoe watershed, it can be expected that concentrations will increase in the subwatershed as growth occurs.
- Salt Vulnerable Areas have been identified in dense lakeshore communities and along some major roads, including Highway 48 near Canal and Mitchell Lakes.
- The emerging threat of climate change will interact with all of these stressors, creating additive long-term impacts that, based on climate change scenarios, will increase phosphorus in both the Talbot River and Whites Creek subwatersheds.

4.5 Current Management Framework

Various programs exist to protect and restore the water quality in the Lake Simcoe watershed, ranging from regulatory mechanisms, to funding and technical support provided to private landowners, to ongoing research and monitoring.

Many of these programs already address some of the stresses to water quality in the Talbot River and Whites Creek subwatersheds, as outlined in the following sections.

4.5.1 Protection and Policy

There are numerous acts, regulations, policies and plans aimed at maintaining or improving water quality. These include the Lake Simcoe Protection Plan, the Provincial Policy Statement, the *Clean Water Act* and municipal official plans. This management framework addresses many of the stresses identified in these subwatersheds. In Table 4-9 we categorize nine such stressors, recognizing that many of these overlap and that the list is by no mean complete. The legal effects of the various Acts, policies, and plans on the stressors are categorized as 'existing policies in place' (shown in green), or 'no applicable policies' (shown in red). The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Chapter 1 - Introduction**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 4-9: Summary of the current management framework as it relates to the protection and restoration of water quality.

Stressor affecting water quality	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Nutrient Management Act (2002)	Ontario Water Resources Act (1990)	Environmental Protection Act (1990)	Clean Water Act (2006) – Source Water Protection	LSRCA Watershed Development Policies (2008)	Comprehensive Stormwater Management Master Plan Guidelines (2011)	Simcoe County Official Plan (2007)	Township of Ramara Official Plan (2003)	Durham Regional Official Plan (2015)	City or Kawartha Lakes Official Plan (2012)
Development and site alteration	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Application of road salt	🟥	🟩	🟥	🟥	🟩 3	🟥	🟥	🟥	🟥	🟥 7	🟥	🟩 13	🟥
Loss of natural heritage features	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩 14	🟩
Uncontrolled Stormwater	🟩 1	🟩	🟩	🟥	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Impervious surface	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟩	🟩	🟥 8	🟩 9	🟩 15	🟩 16
Discharge of material	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩 10	🟩	🟩
Agricultural runoff	🟩	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟥 11	🟩	🟩
Septic systems	🟩	🟥	🟩 2	🟥	🟩 4	🟥	🟥	🟩 5	🟥	🟩	🟥 12	🟩	🟩
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩 6	🟥	🟥	🟩	🟩

🟩 **Existing Policies**	🟥 **No applicable policies**

[1] Gives specifics of what stormwater management plans are to include, but these are very general (e.g. 'protect water quality')

[2] PPS specifies where private septic systems would be allowed, does not give details around inspections/restrictions

[3] General policy regarding the discharge of any material that may impair the quality of water (not specific to road salt)

[4] Septic systems >10,000 L/day are regulated under OWRA (smaller systems under building code)

[5] One policy regarding replacement of septic systems that are in wetlands

[6] Refers to the Climate Change Adaptation Strategy in the LSPP – Policy 7.11

[7] Road salt prohibited within Oak Ridges Moraine Conservation Plan areas, but not subject area

[8] Targets for impervious cover provided for the Oak Ridges Moraine Conservation Plan areas, but not subject area

[9] In Shoreline Residential areas

[10] Within or adjacent to the Natural Areas features and functions identified in the Official Plan

[11] There are no policies in the OP; however, one of the Objectives is to 'encourage best farm management practices including opportunities for sound disposal of animal wastes on farmland'

[12] The preferred treatment for hamlets is identified as private or communal (not municipal). Municipal is preferred in Villages

[13] ROP has provisions to prohibit/restrict storage of road salt within municipal wellhead protection areas and areas of high aquifer vulnerability as identified in the ROP.

[14] Policies apply within Greenbelt Natural System, key natural heritage features, woodlands and key hydrologic features and their associated vegetation protection zones.

[15] Applies in Major Open Space Areas (including key natural heritage and hydrologic features) and in the Oak Ridges Moraine planning area (outside of the Settlement Area)

[16] Referenced in relation with stormwater treatment facilities for application to establish or expand major recreational uses.

Legislation and policy restrictions are the primary source of protection for water quality in the Lake Simcoe watershed, guided by the fundamental provincial planning policies as articulated in the Provincial Policy Statement (PPS) and Lake Simcoe Protection Plan (LSPP). However, some stressors are better suited to policy and regulation than others. For example, a water quality stressor such as climate change is hard to regulate; however, stressors associated with site alterations and stormwater are much easier to control and regulate.

Policy tools to deal with these stressors can be found in Provincial Policy (such as PPS or LSPP), municipal official plans and zoning bylaws, and Conservation Authority Regulations. Together these documents are intended to provide protection to features that are significant both locally and provincially, while providing clarity to private landowners, and accountability to the electorate.

Further to the guidelines provided by the PPS, the LSPP identifies additional targets to improve existing water quality in the Lake Simcoe watershed. These targets call for the reduction of phosphorus, pathogens (such as *E. coli*), and contaminants (i.e. heavy metals, organic chemicals, sediments, and chlorides). To assist in achieving these targets, policies established under the Lake Simcoe Protection Plan place firmer controls on sewage treatment plants (Policies 4.1-4.4), stormwater management (Policies 4.-5-4.12), septic systems (Policies 4.13-4.15), and construction activities (Policies 4.16-4.21), as well as promoting better management practices throughout the various communities in the watershed (LSPP, 2009).

Within the Lake Simcoe watershed and its tributaries, excessive phosphorus is considered the most significant cause of water quality impairment. Because of this, Policy 4.24-SA of the LSPP committed the Province, LSRCA, local stakeholders, municipalities and other partners to develop a comprehensive Phosphorus Reduction Strategy within the first year of the Plan. In June 2010, the Lake Simcoe Phosphorus Reduction Strategy (PRS) was completed. The PRS is an adaptive management tool that takes a watershed-based approach to managing the phosphorus levels in Lake Simcoe. By looking at the problems and researching solutions for the lake and its tributaries, the PRS provides direction to achieve proportional reductions from each major contributing source of phosphorus to reduce the current total load of 72 T/yr down to 44 T/yr in the future. The goal of 44 T/yr is the annual phosphorus load required to achieve the

LSPP deep water dissolved oxygen target of 7 mg/L, that research proposes is needed to support a naturally reproducing and self-sustaining cold water fishery in Lake Simcoe.

The PRS is broken down into six key concepts, derived from the LSPP, to address the major sources or sectors contributing phosphorus to the Lake Simcoe watershed. These include:

- Adaptive Management;
- Watershed Approach;
- Stewardship and Community Action;
- Source-specific Actions;
- Monitoring and Compliance; and
- Research, Modelling and Innovation.

Each of these sections includes the ways in which that concept can address the stressors and how they contribute to the overall function of the PRS tool. Additionally, “strategic directions” have been incorporated into the PRS to set out actions to be taken to reach the goal of 44 T/yr. Many of the gaps, related mostly to insufficient information available, are addressed in the “strategic directions” to continue research efforts and link to the appropriate actions (such as stewardship efforts, work with aggregate and development industries, etc). Related policies from the LSPP have also been included in the source-specific actions to further the connection between the PRS and LSPP documents.

The watershed-based approach for protecting drinking water was first adopted in Ontario in 2006, with the *Clean Water Act* to protect drinking water at its source, as part of the Province’s overall commitment to safeguard human health and the environment, by using a multi-barrier approach. The protection of sources of drinking water in the lakes, rivers, and underground aquifers of Ontario comprises the first barrier. Source Protection complements the other components, which include effective water treatment, secure distribution systems, monitoring programs and responses to adverse test results, by reducing the risk that water is contaminated in the first place. Participants in the Source Protection program include the Ministry of the Environment and Climate Change, Source Protection Authorities, Source Protection committees, municipalities, First Nations, consultants, and the public.

A key component of the Source Protection Program is the creation of a Source Protection Plan. A Source Protection Plan is a document that focuses on preventing the overuse and contamination of drinking water supplies across the Source Protection Region. The South Georgian Bay Lake Simcoe Source Protection Plan includes policies and strategies to protect drinking water by allowing municipalities to take a proactive approach in preventing, reducing or eliminating significant threats to water resources (for example: chloride from road salt).

The Source Protection program was approved in 2015. In October 2012, the proposed Source Protection Plan was submitted to the Ministry of the Environment and Climate Change for review. A year later, the Ministry of the Environment and Climate Change completed their review of the proposed plan and provided recommendations to ensure the policies contained in the plan were implementable as written. The Source Protection Committee acknowledged the recommendations and worked to amend the proposed policies before re-consulting the public on the amendments through a series of open houses and consultations. On July 3rd, 2014 the revised proposed Source Protection Plan was submitted to the Ministry of Environment and Climate Change for a second round of review and approval was received on January 26, 2015. The plan took effect on July 1, 2015 and moving forward, municipalities in the South Georgian Bay Lake Simcoe Source Protection Region will implement and enforce the policies in order to protect local drinking water sources.

Under the *Clean Water Act* and the LSPP, The Ministry of Environment and Climate Change has implemented a mandatory on-site sewage (septic system) maintenance inspection program to ensure that septic systems are properly maintained in order to decrease the risk of sewage effluent impacting water quality and human health. Within this framework, septic systems located in vulnerable areas (CWA) and/or within 100m of the Lake Simcoe shoreline or any pond or tributary of the Lake (LSPP) must be inspected at least every five years.

In addition to the PPS, the LSPP, the *Clean Water Act* and the other acts and policies in Table 4-9, municipal Official Plans (OPs) are key to preserving and improving water quality within the subwatersheds. Official Plans from Simcoe County, Durham Region, City of Kawartha Lakes and Township of Ramara apply to the study area, and all contain goals and policies set around the protection of water quality in the area’s watercourses and waterbodies. The OPs address, at least to some extent, the majority of the stressors listed in Table 4-9, with the exception of road salt application, agricultural runoff, septic systems, and climate change. Summaries of the relevant policies and goals in each OP are outlined in the following subsections.

Simcoe County

One of the four themes of the OP’s growth management study is the Protection and enhancement of the County's natural heritage system and cultural features and heritage resources, including water resources, and the plan contains policies to protect the hydrologic functions such as groundwater recharge and baseflow. Development and site alteration are not permitted in significant wetlands or fish habitat. New development or site alteration should have no negative effects on key hydrologic features, and removal of other hydrologic features should be avoided. The OP encourages local municipalities to establish stormwater management policies, and required that stormwater runoff volume and pollutants be reduced. In terms of impervious surfaces, the OP sets goals to maintain overall impervious cover in a subwatershed below 10%, and in an individual site below 10% of the total developable area. A policy relating to discharge of material is included in the requirement for stormwater management reports for new developments: post development runoff water quality must be maintained to meet applicable provincial/federal guidelines and standards for stormwater quality. The OP also contains restrictions on animal agriculture and the storage of animal manure and agricultural equipment within well head protection areas within the Oak Ridges Moraine Conservation Plan Area. New subsurface sewage works are not permitted within 100m of Lake Simcoe, other Lakes or any permanent stream (with some exceptions).

Regional Municipality of Durham

The regional OP does not permit development or site alteration within key hydrologic features and encourages the region to cooperate with provincial governments and conservation authorities to protect against impacts of development on water quality. In areas where development could impact groundwater discharge, applicants must conduct a study to demonstrate that groundwater quality will be protected, improved or restored. The OP does not contain specific policies in regards to road salt or agricultural runoff, but does recognize the storage of road salt and use of agricultural pesticides, herbicides, fungicides and chemicals as high risks to groundwater resources. Uncontrolled stormwater is addressed in policies to promote groundwater infiltration through improved stormwater management design, and the requirement for a servicing and infrastructure study as part of a development or site alteration proposal. The regional OP contains policies requiring a hydrological and servicing report for development proposals requiring septic systems. In regards to climate change, there is a policy in the OP that the Regional council will recognize the potential implications of climate change and will continue to investigate and implement mitigation measures.

Township of Ramara

The goal for ‘Water’ under the OP’s Natural Resources section is to protect the quantity and quality of surface water and groundwater for their benefit as fishery habitat, and for domestic and agricultural uses. The objectives include carefully utilizing water resources for recreational purposes, and protecting surface and ground water resource areas from contamination. The objectives for ‘Agriculture’ under the Natural Resources heading includes encouraging best farm management practices, including opportunities for sound disposal of animal wastes on farmland. The Natural Areas and Physical Environment goal includes protecting, conserving, and enhancing natural areas, features, and functions, including good community planning and design to prevent contamination of air, water and land resources. Under its Natural Areas policies, the OP states that development or site alteration proposed in or adjacent to natural areas including watercourses, lakes, and discharge areas are required to demonstrate that the natural condition will be maintained; that unreasonable soil erosion will not cause increased siltation, and that waste materials or harmful or toxic substances will not be discharged into or impair surface water quality. In its policies around recharge areas, the OP notes that once these areas are defined, they should be protected from contaminants likely to move toward and reach a well or series of wells supplying water. In its Water Resources policies, the OP states that because groundwater aquifers are the primary source of water taking supplies for agricultural, industrial, and domestic uses, quality and quantity need to be protected. In looking at options for waste water servicing, potential impacts on groundwater and surface water quality resources are to be considered. The OP also requires stormwater controls for developments of greater than five residential lots, and in commercial and industrial designations.

City of Kawartha Lakes

Development and site alteration policies in the OP include the adoption of a site alteration by-law be adopted in conformity with the LSPP, and that development be encouraged in areas that are not environmentally sensitive. Under the OP’s Environment section, two of the goals are to support water conservation and to protect and where possible, enhance the ground and surface water resources throughout the city. Within the Water Resources section, the OP supports reducing stormwater runoff volume and pollutant loadings through various stormwater management initiatives, and requires stormwater management plans as part of development applications. In regards to agricultural runoff, under the Environmental Protection Designation, agriculture is permitted in these areas but should not contribute to erosion, pollution or deterioration of the environment. The OP also contains policies regarding setbacks of septic systems from waterbodies and restrictions in source water areas

Lastly, on a smaller scale than the LSPP, the Subwatershed Plans themselves are also an important vehicle for highlighting the current conditions of the water quality, what the stressors are, where the gaps are in current acts, regulations, policies, and plans, and to provide recommendations that count on the involvement of various partners, as well as encouraging the incorporation of applicable recommendations into municipal Official Plans.

4.5.2 Restoration and Remediation

There is a range of programs operating in these subwatersheds to assist private landowners improve the environmental health of their land.

The Landowner Environmental Assistance Program (LEAP) is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which have traditionally been funded by the LEAP program include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Between 2005 and 2015, the LSRCA, through the LEAP as well as through funding partnerships such as the federal Lake Simcoe Cleanup Fund and through Source Water Protection, supported a number of projects specifically aimed at improving water quality in the Talbot River and Whites Creek subwatersheds, including 8 septic system upgrades, 4 well decommissionings, improvements to manure storage (3) and milk house waste (1), stream bank erosion projects (5), clean water diversion (2), and the installation of fencing to restrict livestock (2).

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, wetlands, and woodlands. Through this program, numerous projects to improve water quality have been completed between 2005 and 2011, including 264 in the City of Kawartha Lakes, 42 in the Township of Ramara, and 60 in Brock Township; these include improved cropping systems, upland and riparian area habitat management, manure storage and handling, improved pest management, and runoff control.

Kawartha Conservation also administers the Kawartha Lakes Farmland Stewardship Fund (KLFSF), a grant program initiated in 2015 and available to agricultural landowners in the City of Kawartha Lakes. Through this program, funded by OMAFRA, Kawartha Conservation provides support to agricultural landowners who implement projects minimizing sediment and nutrient input into waterbodies within the City of Kawartha Lakes. KLFSF supports a number of project types, including exclusion fencing, manure and contaminant management, native species plantings, well upgrades and decommissions, clean water diversion, and cropland erosion controls. Staff undertook a GIS exercise in early 2015 that identified 19 priority areas within the Kawartha part of the Talbot watershed lacking riparian cover in order to better direct stewardship activity within the Fund. Sixty-one additional properties with known agricultural land use were identified in the fall of 2015 and were sent informational packages about the Fund and other farmland stewardship opportunities in the area.

In addition, the Kawartha Farm Stewardship Collaborative network of non-profit farm and stewardship organizations and projects, conservation authorities and government partners was formed to work together to acquire funding and provide technical support for on-farm stewardship throughout the greater Kawartha region, including this watershed. Since 2010, they have contributed funding and technical expertise to stewardship projects on almost 100 farms across the Kawartha Lakes. The most common types of projects supported include livestock fencing, streambank/shoreline erosion control, wetland or stream crossings, wetland restoration and buffer and pollinator plantings.

With respect to the lake shoreline community Kawartha Conservation staff, with support from the City of Kawartha Lakes, the Municipality of Trent Lakes, the RBC Blue Water Project (2012-2014), the OMAFRA Rural Economic Development Program (2014-2015), the World Wildlife Foundation (2016) and on the ground actions from Trent Matters, have been out on a number of the Kawartha Lakes (including Canal and Mitchell Lakes) since 2012 with their Blue Canoe program. The Blue Canoe program consists of Kawartha Conservation staff speaking with shoreline landowners in a dock talk format about how they can affect water quality in the lakes. Through this program, conservation authority staff canoe around the shorelines of the lakes and offer information and advice to educate and encourage landowners to undertake the necessary steps to improve and maintain a healthy shoreline property.

In 2008, 2009, and 2014, LSRCA field staff surveyed the majority of the watercourses in the subwatershed, as well as the shorelines of Canal and Mitchell Lakes, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found 920 sites in Talbot River and 135 in Whites Creek where runoff was entering creeks or lakes, potentially impacting water quality.

4.5.3 Science and Research

An ongoing commitment to applied science and research is necessary to improve our understanding of the water quality within the Lake Simcoe watershed. Ongoing monitoring programs led by the MOECC and the LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

Since the 1980s, efforts have been made through the Lake Simcoe Environmental Management Strategy (LSEMS) to identify and measure sources of phosphorus in the watershed and recommend remedial measures. As set out in the Lake Simcoe Protection Act (passed December 2008), objectives of the LSPP include reduction of phosphorus loads. Estimates of total phosphorus (TP) loads to the tributaries and lake are used to evaluate the progress towards achieving the water quality-related objectives of LSEMS and the LSPP. Research projects aimed at understanding the links between phosphorus loading and biotic impairment also require estimates of phosphorus loading to the lake. Since the 1990s, annual TP loads have been estimated from atmospheric deposition, tributary discharge, urban runoff, water pollution control plants (WPCPs), septic systems, and vegetable polders. Total phosphorus loss from the lake through the outflow is also quantified. Quantitative hydrological data and lake water balances are evaluated and used for the calculation and validation of the loads.

The Ontario Ministry of the Environment and Climate Change, Environment Canada, Parks Canada, and LSRCA operate monitoring sites throughout the watershed and information from these programs is used for load estimations. Ongoing research and monitoring will aid in detecting changes in watershed conditions that affect phosphorus loads. As the effectiveness of management efforts and understanding of issues such as climate change and atmospheric deposition improves through research and monitoring, we will be better prepared to deal with future impacts.

In addition to these ongoing monitoring programs, numerous scientific and technical reports have been published based on research conducted in the Lake Simcoe watershed. As a result of this combined focus, Lake Simcoe is one of the most intensively studied bodies of water in Ontario. The results of this research have been summarized, in part, in LSEMS (2008) and Philpot *et al*. (2010), and have informed the development of this subwatershed plan.

The Lake Simcoe Protection Plan also commits the MOECC, MNRF, MAFRA, and LSRCA to research and monitoring related to water quality in Lake Simcoe and its tributaries. An enhanced scientific water quality monitoring program is proposed to continue and build upon routine monitoring of key parameters and of biological indicators linked to water quality, as well as monitoring and reporting upon the effectiveness of measures put forth to improve water quality (Policy 4.22). Additionally, scientific research projects that build on existing research and monitoring programs for identifying emerging issues are to be promoted (Policy 4.23).

4.6 Management Gaps and Recommendations

As described in the previous sections, many regulations and municipal requirements aimed at protecting water quality of the Talbot River and Whites Creek subwatersheds already exist. Similarly these subwatersheds have been the focus of numerous restoration and remediation efforts, such as those coordinated through the Landowners Environmental Assistance Program (LEAP) and the Environmental Farm Plan. Despite this strong foundation, there are a number of gaps in the management framework that need to be considered. This section identifies some of the gaps in existing protection and restoration of the water quality in the Talbot River and Whites Creek subwatersheds, and outlines recommendations to help fill these gaps.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase

4.6.1 Groundwater (Hydrogeologic and Hydrologic)

There is a need to maintain and, in some locations, promote groundwater infiltration to enhance water volume and temperature in the tributaries that are dependent on baseflow contributions for the ecological requirements of those systems, within the Whites Creek and Talbot River subwatersheds.

> **Recommendation 4-1** - That the LSRCA provide training to municipal staff and stormwater engineering consultants on the design, construction, operation, and maintenance of Low Impact Development technologies.
>
> **Recommendation 4-2** – That the LSRCA assist subwatershed municipalities in developing a funding model to support the construction and maintenance of Low Impact Development approaches to stormwater management.

4.6.2 Surface Water

4.6.2.1 Urban - improving stormwater

The urban areas in the Whites Creek and Talbot River subwatersheds are lacking stormwater controls. While this can cause issues in any watercourse, as well as in the lake nearshore, these issues have become particularly acute in Canal and Mitchell Lake, where poor water quality and excessive growth of plants and algae are regular occurrences. This general lack of stormwater control within the subwatershed provides many opportunities for retrofits and/or more innovative Low Impact Design (LID) solutions. Significant reductions in phosphorus loads to Lake Simcoe, in addition to improvements to the tributaries, would result from improved stormwater control. New developments will present an opportunity to implement innovative solutions to stormwater control.

The LSPP already includes a number of polices related stormwater management, leading off with the requirement for municipalities to prepare and implement comprehensive stormwater management master plans. The following recommendations build on the LSPP stormwater management policies

> **Recommendation 4-3 -** That the Townships of Brock and Ramara, and City of Kawartha Lakes, in cooperation with the LSRCA, promote the increased use of innovative solutions to address stormwater management and retrofits. This could include an assessment of potential retrofit opportunities, as well as the promotion of practices including requiring enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls; improving or restoring vegetation in riparian areas; rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways; enhance urban tree cover; where conditions permit, the use of soakaway pits, infiltration galleries, permeable pavement and other LID solutions; the on-going inventory, installation and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where this is appropriate; and where practical and feasible, enhance measures to control TSS.
>
> **Recommendation 4-4 -** That the MOECC approve the Lake Simcoe Phosphorus Offsetting Program, to provide a private-sector source of funding for the maintenance, construction and /or retrofit of stormwater facilities and/or Low Impact Development practices as identified in Stormwater Management Master Plan relevant to the subwatersheds.
>
> **Recommendation 4-5 -** That the Townships of Brock and Ramara and the City of Kawartha Lakes promote Low Impact Development (LID) approaches to stormwater management for private landowners within their jurisdictions, where sites are suitable.
>
> **Recommendation 4-6 -** That the LSRCA and its partners recognize that while the construction and/or retrofit of quality control facilities is extremely important, quantity control may be a consideration in some areas of the Talbot River and Whites Creek subwatersheds; therefore, quantity control facilities should be constructed in those areas where geographical space is limited or other LID options are not feasible. In these situations, federal and provincial governments should provide financial incentives to allow the Township to complement quantity control storm water ponds with an enhanced street sweeping program.

4.6.2.2 Urban – construction practices

While the rate is not as high as in some areas of the Lake Simcoe watershed, there is some growth projected for the Talbot River and Whites Creek subwatersheds. Significant deterioration to tributary water quality can occur during construction phase as exposed soils are very susceptible to run-off and wind erosion if codes of practices are not followed. While site alteration by-laws, and policies in the LSPP (e.g. 4.20-DP) aim to minimize construction phase impacts, further improvements could be made through use of current BMP and improved enforcement.

Recommendation 4-7 - That the LSRCA and Kawartha Conservation, the Townships of Brock and Ramara, and the City of Kawartha Lakes promote and encourage the adoption of best management practices to address sedimentation and erosion controls during construction and road development. This may include, but will not be limited to, more explicit wording in subdivision agreements detailing what is required in this regard.

Recommendation 4-8 – That the Townships of Brock and Ramara, City of Kawartha Lakes and LSRCA review and, where necessary, revise current monitoring, enforcement, and reporting on site alteration and tree cutting by: 1) undertaking a review of the current programs and actions, 2) encouraging the allocation of adequate resources for the improvements, and 3) monitoring and reporting on results.

4.6.2.3 Urban – reducing salt (chloride)

Chloride concentrations have been increasing across the Lake Simcoe watershed over the past number of years. While the water quality stations in the Whites Creek and Talbot River subwatersheds have not shown issues with respect to chloride, it is reasonable to assume that this is due to the rural nature of the stations' location. Recently completed mapping shows a number of chloride 'hot spots', areas anticipated to have higher concentration, mainly located around county roads, this in spite of Salt Management Plans that are already in place. It is in these areas that impacts to the health of aquatic and riparian biota are anticipated, and where actions can be undertaken to minimize these impacts.

Recommendation 4-9 - The LSRCA has recently undertaken an exercise to identify areas in the Lake Simcoe watershed, including watercourses within the Whites Creek and Talbot River subwatersheds, which are vulnerable to road salt (as outlined by Environment Canada). This assessment may be refined through further examination of relative salt tolerance of local biota. As outlined in Environment Canada's Code of Practice for the Environmental Management of Road Salt, municipalities should examine alternate methods of protecting public safety while reducing environmental impacts in these areas. These methods should be utilized in the salt vulnerable areas identified through the LSRCA exercise in addition to those areas identified in the municipalities' Salt Management Plans.

Recommendation 4-10 - That the LSRCA, in coordination with the municipalities, develop and undertake a program to raise the awareness of property owners, property managers and snow removal contractors on salt application and its environmental impacts. Particular emphasis may be given to those who own or manage property in salt vulnerable areas. The program should reflect BMPs for salt storage and application, as well as appropriate snow disposal.

Recommendation 4-11 – That the LSRCA and Kawartha Conservation investigate the inputs of calcium chloride into the study area waterbodies, given the amount of rural area and unpaved roads.

4.6.3 Agriculture and rural areas

Subwatershed modelling (that excludes atmospheric) indicates that 47% of the phosphorus load in the Talbot River subwatershed, and 54% in the Whites Creek subwatershed, can be attributed to agriculture. Recent water quality monitoring (2010 to 2014) within these two subwatershed has shown that phosphorus concentrations regularly exceed the provincial standards. Considering the current concentrations of phosphorus in Whites Creek and the Talbot River, and the high proportion that can be attributed to agricultural sources, actions leading to reduction in agricultural phosphorus loads to the subwatersheds is a priority.

Within the current management framework, the Nutrient Management Act contains the most stringent policies related to agriculture, as it requires plans for the management of nutrients created and/or stored on farms. Other policies relate to the protection of agricultural resources, but few relate to the management of nutrients from agricultural areas, with only ‘have regard to’ statements encouraging the use of agricultural BMPs.

Although there are currently no requirements for farmers to undertake BMPs such as cover crops, conservation tillage, the planting of windrows, and leaving riparian buffers intact, there are a number of available programs to assist farmers to implement these programs. In particular, the Environmental Farm Plan program and LSRCA’s Landowner Environmental Assistance Program (LEAP) provides guidance and funding for a number of types of projects. Other gaps in current management include policies requiring livestock to be fenced and kept out of watercourses, an activity that causes numerous water quality issues as well as causing bank instability.

> **Recommendation 4-12 -** That the LSRCA and Kawartha Conservation continue to participate in the Kawartha Farm Stewardship Collaborative, and continue to pursue new and innovative ways of engaging the agricultural community in undertaking voluntary projects focused on protecting and enhancing watershed health.
>
> **Recommendation 4-13 -** That the recently developed spatially-explicit prioritization tool be used to properly allocate stewardship resources, so that funds are provided in locations where maximum phosphorus reduction can be achieved. These tools should be updated continually to reflect updated information and the completion of projects.
>
> **Recommendation 4-14** - Given the anticipated lack of offset opportunities in using stormwater pond retrofits to offset phosphorus loading from projected growth areas in the Whites Creek and Talbot River subwatersheds, that the LSRCA assess the feasibility of expanding the Lake Simcoe Phosphorus Offsetting Program (LSPOP) to support phosphorus-reduction projects on agricultural land in these subwatersheds.

Note that unrestricted livestock access and its related impacts were reported on and remedial actions are recommended as part of the implementation of agricultural BMPs in **Chapter 5 - Aquatic Natural Heritage**. Recommendation 5-7 is most relevant to the concern.

4.6.4 Water Temperature – thermal degradation

Increases in stream temperature in the subwatersheds, whether they are due to impervious surfaces, lack of riparian vegetation, reduction of groundwater contributions, or climate change negatively affect the distribution and existence of a number of sensitive species. The watercourses in the Whites Creek and Talbot River subwatersheds are all considered to be warm water, and therefore do not contain the most sensitive cold water species; however, they do support some cool water species. Measures should therefore be taken to ensure that conditions continue to support these species.

> **Recommendation 4-15**– As new or retrofit stormwater facilities are constructed, LSRCA will work with municipalities to reduce potential thermal impacts of those stormwater ponds and to recognize the importance of LID uptake in relation to maintaining stream temperature.
>
> **Recommendation 4-16** -That LSRCA and Kawartha Conservation work with their federal, provincial and municipal partners to refine the anticipated impacts of climate change in the Lake Simcoe watershed. This information can then be used to develop management strategies to address these impacts. Emphasis at this time should be placed on building ecological resilience in vulnerable subwatersheds through stream rehabilitation, streambank planting, barrier removal, and the implementation of other BMPs, in conjunction with the protection of current hydrologic functions.

Note that thermal issues associated with dams are also reported on and remedial actions are recommended as part of the implementation of BMPs in **Chapter 5 - Aquatic Natural Heritage**. Recommendation 5-7 and 5-9 assist in dealing with this specific concern.

4.6.5 Monitoring and Assessment

Currently there are only three long-term and eight short-term surface water quality stations to represent the many watercourses and lakes in the Whites Creek and Talbot River subwatersheds. To enhance our understanding of the conditions in the subwatersheds, there is a need to provide improved and expanded information on temporal and spatial change in water quality. The existing monitoring networks are not comprehensive enough and a review of the expectations of the program is required. More extensive and frequent sampling will be required to meet future needs. In addition, potential issues related to new water quality contaminants such as pharmaceuticals will require further investigation.

> **Recommendation 4-17**- That the LSRCA and Kawartha Conservation develop an environmental monitoring strategy for Canal Lake, Mitchell Lake and the Talbot River subwatershed. This strategy should identify parameters of watershed health to be monitored, frequency of monitoring, lead agencies, and potential funding sources. The strategy should also address identified limitations and gaps of the current monitoring program, which could include:
>
> - Undertaking periodic monitoring of toxicants such as pesticides and pharmaceuticals;

- Spatial coverage of monitoring stations relative to addressing key monitoring questions such as the relationship between changes in land use cover and changes in water quality and quantity;
- Monitoring additional parameters that are key indicators of ecosystem health and restoration progress;
- Monitoring the Carden alvar; and
- Monitoring additional lakes within the subwatersheds, including Talbot and Raven Lakes.

Recommendation 4-18 –That the MNRF, LSRCA, Kawartha Conservation, and MOECC follow the data management recommendations in the Comprehensive Monitoring Strategy to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program

Recommendation 4-19 – That the LSRCA, Kawartha Conservation, MNRF, and MOECC analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs regularly, and further that the LSRCA use the information to update the LSRCA Watershed Report Card and Key Performance Indicators website. Further, stakeholders should be made aware when updates are available, and be provided access to the monitoring data collected via a web portal, to increase distribution and communication of this data.

Recommendation 4-20 That the LSRCA and Kawartha Conservation, in collaboration with MNRF, MOECC, and OMAFRA, develop a program for assessing efficacy of new stormwater facilities, stewardship best management practices, and restoration projects, to improve understanding of the effectiveness of stewardship efforts.

5 Water Quantity – Surface and Groundwater

5.1 Introduction and Background

The effective management of water resources requires the accounting of the total quantity of water and its distribution within a watershed, known as a water budget. The input into the budget is the total amount of precipitation within a watershed and the outputs include evaporation, transpiration, infiltration (movement of water into the subsurface), and runoff (or overland flow) into rivers and streams, which all make up components of the hydrologic cycle.

An assessment of surface water quantity looks at components of the hydrologic cycle that move overland and are within lakes, streams, and wetlands. Surface flow is comprised of groundwater discharge into rivers and streams, overland flow from rain, snow melt, and precipitation that falls directly into lakes, rivers, streams and wetlands.

Groundwater quantity assessments include components of the hydrologic cycle that are present below the earth's surface, in the spaces between rocks and soil particles. The discharge of groundwater to lakes and streams remains relatively constant from season to season; it therefore forms an important part of the surface water flow system, and is particularly important when surface runoff is at its lowest levels, when it can be the only source of water to streams.

Many natural systems rely on a consistent supply of groundwater. For instance, a large number of fish species are dependent on specific ratios of groundwater to total streamflow for their survival. Ponds and wetlands are also often maintained by groundwater flow during the dry summer months. In many areas of the subwatershed, humans are extremely dependent on a reliable supply of groundwater for a variety of purposes including irrigation of fields, potable water, industry, and recreation.

Targets set for water quantity under the Lake Simcoe Protection Plan include:

- Maintenance of instream flow regimes that are protective of aquatic ecosystem needs, and;
- Effective water conservation and efficiency plans.

The physical properties of a watershed, such as drainage area, slope, geology, and land use can influence the distribution of the water and the processes that function within it. This chapter quantifies the surface and groundwater components within the hydrologic cycle for the study area and also identifies how the rural and urban land uses in the Whites Creek and Talbot River subwatersheds have altered the hydrologic cycle (Figure 5 - 1), including changes to the surface flow volumes, recharge, and annual flow patterns.

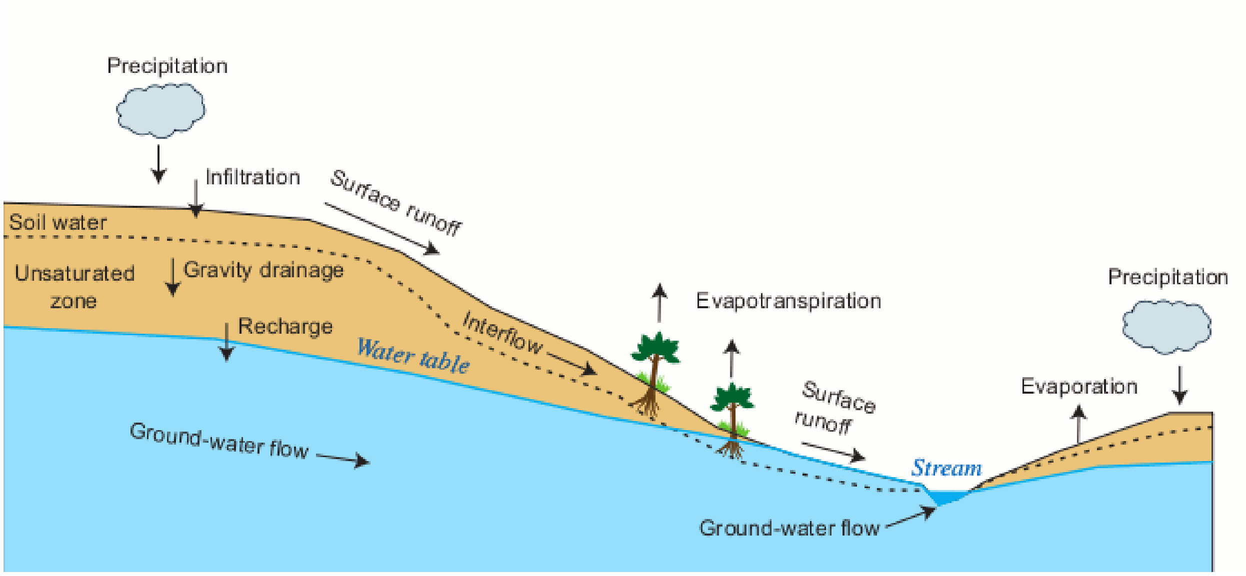


Figure 5 - 1: Hydrologic Cycle (USGS, 2008)

5.1.1 Understanding the Factors that Affect Water Quantity

There are several factors that influence the quantity of surface and groundwater available within a subwatershed. They are climate, geology, land use, and water use. All four of these factors are further explained below.

Climate

Both surface and groundwater quantity can be influenced by a number of climatic factors including precipitation, evaporation, and evapotranspiration. Precipitation is the main climate variable that has a direct influence on the quantity of water available, since it is the main input into the system. The amount of precipitation that falls, particularly in one event, will have a significant influence on how much infiltrates into the soil, and how much will run off. In much of Southern Ontario, relatively little precipitation runs over the land to watercourses, as a high percentage of the precipitation is either cycled back into the atmosphere through evapotranspiration, or infiltrates into the soil. An intense storm event, where a large quantity of precipitation falls over a short time, will direct most of the precipitation overland, as will a significant snowmelt event. This type of event is typically observed during March or April snowmelts or at the onset of spring rains in April or May.

In addition to precipitation, many other variables associated with climate will also influence water quantity. In particular, evapotranspiration is strongly influenced by climate and, unlike precipitation, it is considered an output or loss to the system. Evapotranspiration is the water lost to the atmosphere by two processes, evaporation and transpiration. Evaporation is the loss of water from open water bodies, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other than the physical characteristics of water, soil, snow, and plant surfaces also affect the evapotranspiration process including net solar radiation, surface area of open bodies of water, wind speed, density and type of vegetative cover, availability of soil moisture, root depth, reflective land-surface characteristics, and season.

An assessment of the climate in the Whites Creek and Talbot River subwatersheds was undertaken as part of a broader Tier 2 Water Budget study completed by Earthfx (2014) for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds. There are three active climate stations found in and around the Whites Creek and Talbot River subwatersheds. Two of the stations are operated by the LSRCA; the first is located on the Talbot River near Gamebridge (LS0109), while the second is on Whites Creek near Regional Road (LS0109). The third active station is Environment Canada's Lagoon City station (6114295) which is located just outside of study area boundaries, in the adjacent Ramara Creeks subwatershed. In addition, there are four inactive stations with varied periods of record that have historic information within the study area subwatersheds.

Geology

Geology also has a significant influence on groundwater quantity. The underlying geology and the type of soil present at the surface will determine how much water will infiltrate during a precipitation event. For example, coarse-grained and loosely packed soils, such as sands and gravels, will promote groundwater recharge, whereas fine-grained or hard packed soils, such as clay, will allow less water to infiltrate to recharge the groundwater system. The surficial geology is an important factor in determining the amount of water that flows to and within a watercourse.

Land Use and Land Cover

Land cover is an important factor that can strongly influence both surface and groundwater quantity because it will affect several aspects of the water budget including surface water runoff, evaporation, and infiltration. Developed land will often have a higher proportion of impervious or hardened surfaces, such as roadways, parking lots, and buildings roofs. Increased runoff rates result in erosion and reduced infiltration to recharge groundwater reserves. In addition, groundwater pathways may also be affected because of development, which can result in decreased discharge to wetlands and streams.

The land types present in the study area subwatersheds will influence how much water remains at the surface and how fast it will be flowing. As discussed in Chapter 2, a large number of land use categories are found across the Whites Creek and Talbot River subwatersheds. Agriculture is the predominant land use in the Whites Creek subwatershed, with agricultural land uses covering 59% of the subwatershed area. Natural areas, including forests and wetlands cover approximately 38% of this rural subwatershed, while developed/settled areas (including urban and rural development, residential, institutional, transportation, parks, industrial, and commercial land uses) cover only 2.5% of the subwatershed.

Across the Talbot River subwatershed, natural areas (including forests and wetlands) cover 76% of the landscape, and therefore account for the greatest distribution of land use in the subwatershed. Agricultural land uses cover 20% of the area, while developed/settled areas (including urban, rural, residential, transportation, industrial, institutional, and commercial land uses) cover only 2.5%. Aggregate pits and quarries are an important land use in this subwatershed, with eight quarry operations currently covering just less than 1% of the landscape.

Some notable natural features in the study area subwatersheds include three prominent lakes located in and around the upper portion of the Upper Talbot subwatershed. Two of the lakes, Canal Lake and Mitchell Lake are located within subwatershed boundaries, while the third, Balsam Lake, is situated just outside of the eastern subwatershed boundary. All three of the lakes are connected through the Trent Severn Waterway, a 386 km navigable chain of interconnected rivers and lakes that runs from Lake Ontario at Trenton to Port Severn in Georgian Bay. The canal serves thousands of recreational boaters during its May to October operating season. Water levels are maintained by a series of dams, and navigation is accomplished through locks which raise and lower boats between adjacent sections of the waterway. There are six such structures between Lake Simcoe and Balsam Lake, all of which run through the Talbot River subwatershed (Earthfx, 2014).

Other features of note in the subwatershed include a number of scattered wetlands in the northern portion of the study area. The Grass Creek wetland is an extensive stretch of swampland that runs from the southern portion of the upper Talbot subwatershed into the northern portion of the Whites Creek subwatershed. A prominent scattering of wetland areas can also found in the vicinity of Raven Lake in the northern portion of the upper Talbot subwatershed. Many of the lakes and wetlands mentioned above are situated in unique northeast to southwest trending geologic features called “tunnel valleys.” These tunnel valleys were formed by the sub-glacial processes that worked to erode deep into the bedrock. Following erosion, tunnel valleys were in-filled with sediments (Earthfx, 2014). Today the lowland portions of these valleys are now the wetlands and lakes (e.g. Canal Lake) that characterize the landscape of the study area subwatersheds.

As Ontario’s population continues to grow, urban and development areas in the Whites Creek and Talbot River subwatersheds may expand, resulting in an increase in impervious surfaces. These impervious surfaces lead to a decrease in the time it takes a watercourse to reach peak flow following a rain event, as the ability of the surrounding lands to store and slowly release water has been eliminated. Watercourses in the undeveloped areas of the subwatershed exist under natural conditions making them less vulnerable to extreme changes in climatic events; for example, time to peak flow will not occur as rapidly. As impervious surfaces increase in area, the maximum height of peak flow can also increase as water cannot infiltrate into the ground, and therefore runs off into surface water bodies, increasing the risk of flooding, particularly during the spring freshet. At this time, the Whites Creek and Talbot River subwatersheds have a low percentage of hardened surfaces, and few development pressures.

Water Use

In the Whites Creek and Talbot River subwatersheds both surface and groundwater are used for a variety of purposes, including municipal water supply, agriculture, golf course irrigation, aggregate operations, private water supplies, and by the native plants and animals. Many of these users may withdraw large amounts of water and could potentially be putting stress on the system. Therefore, it is important to be able to identify the large water users by location, source of water (surface or groundwater), type of water use, and amount of water takings to ensure the water within the subwatershed is managed in a sustainable manner. An effort to quantify these water withdrawals has been undertaken as part of the Tier 2 Water Budget study completed for the Ramara Creeks, Whites Creek, and Talbot River subwatershed, as well as the Source Water Protection initiatives required under the Clean Water Act, 2006 (discussed in Section 4.4.1).

5.1.2 Previous Studies

Information from several groundwater and water budget studies was used to assess the hydrogeology of the Whites Creek and Talbot River subwatersheds. The following are a list of key studies and reports that have influenced the information provided in this chapter.

Source Water Protection Water Budget Studies

A number of Source Water Protection water budget studies were completed for the Whites Creek and Talbot River subwatersheds.

- South Georgian Bay-Lake Simcoe Watershed Preliminary Conceptual Water Budget Report (SGBLS,2007);
- Lake Simcoe Watershed Tier One Water Budget and Water Quantity Stress Assessment Report (LSRCA, 2009);
- Water Balance Analysis of the Lake Simcoe Basin using the Precipitation-Runoff Modelling System (PRMS) (Earthfx, 2010).

A complete summary of the Source Water Protection work in the study area is included in Part 1 and Part 2 of the “Approved Assessment Report: Lake Simcoe and Couchiching-Black River Source Protection Area” (SGBLS, 2015).

Lake Simcoe Protection Plan Studies

As required under the Lake Simcoe Protection Plan Policy 5.2-SA, a Tier 2 Water Budget & Water Quantity Stress Assessment was completed for the Whites Creek and Talbot River subwatersheds, as part of a broader Tier 2 Water Budget study that also incorporated the Ramara Creeks subwatershed. The Tier 2 analysis undertaken for the three subwatersheds was completed by Earthfx (2014) by means of an integrated surface water and groundwater flow model that was used to quantify water budget elements by subwatershed, and to undertake the stress assessment scenarios outlined by the Clean Water Act, 2006 Technical Rules (MOE, 2011).

In addition to the completion of a Tier 2 Water Budget study, the Lake Simcoe Protection Plan Policy 6.37-SA also requires that ecologically significant groundwater recharge areas be identified. Ecologically significant groundwater recharge areas within the Whites Creek and Talbot River subwatersheds were also delineated as part of the Earthfx (2014) Tier 2 Water Budget study. The results of ecologically significant groundwater recharge area assessment are further discussed in Section 4.2.6.

Lake Simcoe Region Conservation Authority Water Monitoring Program

Information about water quantity is required by a wide audience, including research scientists, policy-makers, design engineers and the general public. Water level and flow data are used by decision makers to resolve issues related to sustainable use, infrastructure planning, and water apportionment. Hydrological models use the data to improve the forecasting of floods and water supplies, and to predict the impacts of changes to flow regimes on human and aquatic health and economic activity.

The Lake Simcoe Region Conservation Authority, in co-operation with Environment Canada and the Ministry of the Environment and Climate Change, operate and maintain 16 hydrometric stations on the major tributaries of Lake Simcoe. Data is collected, catalogued, and interpreted by the Lake Simcoe Region Conservation Authority using Kisters WISKI hydrologic software. This data is essential for flood-forecasting, planning, and nutrient budget estimation for Lake Simcoe, and to support the water quantity information needs of our municipal partners. The Lake Simcoe Region Conservation Authority also manages an extensive field program to monitor the general health of streams and tributaries across the Lake Simcoe watershed. Lake Simcoe monitoring staff collect and analyze a variety of data through a number of monitoring programs including: precipitation data, continuous groundwater level and stream flow monitoring, surface water and groundwater quality monitoring, spot flow measurements, and snow surveys.

5.2 Current Status

5.2.1 Hydrogeologic Setting

The hydrogeology of the Whites Creek and Talbot River subwatersheds is shaped by the stratigraphic framework discussed in **Chapter 2 – Study Area and Physical Setting**. In order to understand the hydrogeological conditions across the subwatersheds, Earthfx (2014) developed an integrated groundwater and surface water model for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds using modelling software called GSFLOW. GSFLOW integrates two submodels (PRMS and MODFLOW) in order to simulate groundwater/surface water flow and interactions. The MODFLOW submodel represents groundwater flow in the study area by simulating the physical characteristics of the study area including the stratigraphy, hydrostratigaphy, aquifer and aquitard properties, and anthropogenic inputs and outputs. Using the MODFLOW groundwater sub-model, researchers are able to determine groundwater levels in the study area, provide estimates of the rates of groundwater discharge to streams and wetlands, and identify the exchange of water between shallow and deep aquifers and lateral groundwater inflow and outflow across catchment boundaries (Earthfx, 2014). The PRMS surface water submodel, on the other hand, represents surface water and hydrological process in the study area by simulating the impacts of precipitation, climate, topography, soil type, and landuse on streamflow and groundwater recharge. The two submodels are coupled together in GSFLOW to create a fully integrated model that works simulate to groundwater/surface flow and interactions across the study area subwatersheds. The model boundaries are shown in Figure 5-2. For the remainder of the chapter, this integrated GSFLOW model will be referred to as the “Tier 2” model. In addition to the Whites Creek and Talbot River subwatersheds, the model area also incorporates the adjacent Ramara Creeks subwatershed, as well as portions of catchments located to the north, east, and south of the three core study subwatersheds. Although the model area covers additional subwatersheds, the focus of this chapter will be on the trends and patterns specifically observed within the Whites Creek and Talbot River region of the model area.

In order to understand the hydrogeology of an area, it is important to first understand the stratigraphy. The conceptual model of stratigraphic units within the subwatershed was presented in Figure 2-14, **Chapter 2 – Study Area and Physical Setting**.

As a result of the stratigraphic model the cross sectional profile of the study area was created, and is representative of the hydrogeology across the Whites Creek and Talbot River subwatersheds (Figure 2-14, **Chapter 2 – Study Area and Physical Setting**). The profile demonstrates how the thickness and depth of the aquifer complexes vary throughout the model area.

A critical first step in developing the groundwater flow model was the interpretation and creation of the hydrostratigraphic layers (i.e. the aquifer and aquitard layers). The hydrostratigraphic model layers are a simplification of the conceptual geologic interpretation described in **Chapter 2 – Study Area and Physical Setting**. A listing of the final seven integrated hydrostratigraphic units represented in the integrated Tier 2 Model are described in Table 5 - 1 below. Although the seven primary model layers are a good conceptualization of the overall regional hydrostratigraphy, they do not adequately represent the unique hydrostratigraphy of the Carden Plain physiographic region found in the northern portion of the study area.

As a result of its unique geologic characteristics, the Carden Plain was represented in the model using a separate and distinct conceptualization from the regional model (Earthfx, 2014). The Carden Plain is predominantly found along the northern portion of the Upper Talbot subwatershed, and is characterized by a unique limestone plain geology known as “alvar”. Alvar plains are often characterized by distinctive landscape features such as large fractures and underground drainage systems that form through the dissolution of rock by rainwater containing dissolved carbon dioxide. Many of these unique features have significant impacts on the hydrogeology of the area.

In the primary regional model unweathered bedrock and silty sand till formations are generally associated with aquitards, while weathered/fractured bedrock and sandy channel sediment units generally behave as aquifers. The top two layers in the model are assigned properties of overburden materials, except in the Carden Plain conceptual submodel, where the top two layers are used to represent the solutionally enhanced bedrock referred to as Alvar. The remainder of the layers in both the regional model and the Carden Plain conceptual submodel represent the aquifers and aquitards present in the bedrock units.

Table 5 - 1: MODFLOW layer structure (Earthfx, 2014).

GEOLOGIC LAYERS (Earthfx, 2013)		HYDROSTRATIGRAPHIC LAYERS	
		Regional Conceptual Model	Carden Plains (Alvar Conceptual Model)
OVERBURDEN	Post-Glacial Deposits	**Layer 1 and Layer 2** - Surficial Deposits	(PRMS Soil Zone Representation)
	Glaciofluvial Sediments		
	Dummer till		
	Newmarket Till		
	Thorncliffe / Channel Sediments	**Layer 3** (aquifer) - Thorncliffe/Channel Sediments/Weathered Bedrock	
PALEOZOIC BEDROCK	Lindsay Formation	**Layer 4** (aquitard) - Interbedded Limestone and Shale of Verulam and Lindsay Formations/ Unweathered limestone of Bobcaygeon Formation and Upper Gull River	(Formations Not Present)
	Verulam Formation		
	Bobcaygeon Formation		**Layer 1 and Layer 2** - Alvar Fracture Network **Layer 3** (aquifer) - Weathered Bedrock **Layer 4** (aquitard)
	Upper Gull River		
	Green Marker Bed	**Layer 5** (aquifer) - Green Marker Bed	**Layer 5** (aquifer) - Green Marker Bed
	Lower Gull River	**Layer 6** (aquitard)	**Layer 6** (aquitard)
	Shadow Lake Formation	**Layer 7** (aquifer) - Shadow Lake/Fractured Precambrian	**Layer 7** (aquifer) - Shadow Lake/Fractured Precambrian
PRECAM BEDROCK	Precambrian	(model base)	(model base)

The groundwater system within the study area is complex. In the regional conceptual model, the uppermost model layers in the model characterize the regionally variable surficial deposits found across the study area. Layer 1 is representative of the glacio-lacustrine and glacial-fluvial overburden deposits found intermittently across the model area. In the model, these surficial deposits are formally referred to as the Mackinaw Interstadial Sediments (MIS) and function as a regionally discontinuous aquifer (Earthfx, 2014). Generally the material associated with this unit consists of glaciofluvial sand and gravel deposits. These sand and gravel deposits are found discontinuously across the Whites Creek and Lower Talbot subwatersheds, as well as along the eastern boundary of the Upper Talbot. Post-glacial deposits such as fine grained silts and clays interpreted to have originated from post-glacial lakes are also represented in the first layer of the model. Where present, the post-glacial materials in this unit are the shallowest of the overburden units. In the study subwatersheds, these fine grained silts and clays are predominantly found in the south-western portion of the Whites Creek subwatershed, and in the lower Talbot subwatershed.

Layer 2 of the model represents two till units formally known as the Newmarket Till and Dummer Till. The stoney Dummer Till predominantly appears to the extreme east of the Tier 2 model boundary, while the Newmarket Till is present across much of the southern portion of the study area. The higher density sandy silt to silty sand materials that characterize the Newmarket Till form a protective barrier for the deeper aquifers.

As mentioned above, layers 1 and 2 in the Carden Plain conceptual submodel area are different from those in the regional hydrostratigraphic model. In the Carden Plain submodel, layers 1 and 2 represent the solutionally weathered Paleozoic Alvar bedrock. As previously mentioned, The Carden Plain Alvar is a unique physiographic region characterized by Karst topography formed through the solutional weathering of Palezoic limestone pavement. In the study area, the dissolution of Alvar has resulted in formation of solutionally enlarged joints that have created an extensive network of fractures across alvar region.

Layer 3 of the regional model is representative of the interface between the bedrock and the permeable overburden materials present across the model area. This hydrostratigraphic unit incorporates both the weathered shale bedrock of the Lindsay formation and the permeable overlying glaciofluvial and gravel overburden materials. The permeable glaciofluvial sand and gravel materials are generally associated with channel tunnel features formed as a result of high –energy sub-glacial drainage events that worked to erode earlier deposits. As flow waned, and the erosional processes subsided, these tunnel channels were infilled with the glacial sand and gravel sediments represented by Layer 3 in the model. The interface between the shale beds of the Lindsay/Verulam formations and the permeable overlying tunnel channel sediments serve as a regional shallow aquifer used by a number of private wells in the model area. Layer 3 in the Carden Plain submodel is also classified as an aquifer and representative of the interface between the weathered Alvar bedrock and the deeper bedrock units in the region. The remainder of the underlying layers in the submodel were kept conceptually consistent with those of the regional model.

Layer 4 of the model consists of the upper member of the Gull River Formation, as well as the overlying Bobcaygeon, Verulam, and Lindsay Formations where present. These units are all considered to represent regional aquitards where they are intact and unweathered (Earthfx, 2014). Although the clay rich limestones and interbedded shales of the Verulam and Lindsay Formations are geologically distinct from the thickly bedded limestones of the underlying Bobcaygeon and upper Gull River Formations, these units all have similarly low hydraulic conductivity and are generally not exploited by water wells in the area (Earthfx, 2014). Together these low hydraulic conductivity units are referred to as the Upper Bedrock Aquitard and are assumed to form the bedrock surface across the regional model area.

The Green Marker Bed Formation is represented by layer 5 in the model and characterizes the zone between the upper and lower members of the Gull River formation. This zone consists of fractured argillaceous limestones (i.e. limestone with a significant clay mineral component) of generally higher hydraulic conductivity. The Formation is a productive aquifer for the domestic water supply, despite the Formation’s limited thickness of less than 1.5 m.

Layer 6 of the model is characterized by the Lower Gull River formation and serves as a regional aquitard. The composition of the unit varies from fine grained dolostone to argillaceous limestone with typically low hydraulic conductivity values. The hydrostratigraphic unit is formally referred to as the Lower Bedrock Aquitard.

The last hydrostratigraphic unit represented in the model consists of the Shadow Lake Formation and the weathered Precambrian basement rocks. The composition of the Shadow Lake Formation is highly variable but can generally be associated with coarse grained sandstones, while the weathered Precambrian basement rocks are representative of a zone of increased permeability at the Paleozoic- Precambrian contact. This final model layer serves as a regional aquifer and overlies the base of the model which is characterized by unweathered Precambrian age bedrock found extensively throughout the model area. This low permeability basement is not explicitly represented in the model.

5.2.2 Hydraulic Properties

Hydraulic properties, such as hydraulic conductivity, specific storage (S_s), specific yield (S_y), hydraulic gradients, and porosity characterize the amount, rate, and direction of groundwater flow through soil and rock.

Hydraulic conductivity is the primary variable that controls the calculated hydraulic head (also referred to as observed groundwater levels). Within the model, reasonable estimates of hydraulic conductivity were assigned to each material based on published literature (Freeze and Cherry, 1979), estimates from aquifer testing, and calibration values from previous modelling studies undertaken in the area. For a full list of the modelling studies that were consulted refer to the Earthfx (2014) report. Coarse grained materials (sands and gravels) were assigned a higher hydraulic conductivity than finer grained materials (silts and clay). Initial estimates of hydraulic conductivity of the aquifers and aquitards were made based on the typical values and reported ranges presented in Table 5 - 2. Estimates were then refined through model calibration.

Table 5 - 2: Reported Hydraulic Conductivity Values from previous studies (Earthfx, 2014).

Material	Geometric Mean Hydraulic Conductivity (m/s)	Range in Values (m/s)	Sources*
Overburden (undifferentiated)	$2x10^{-5}$	$4x10^{-7}$ - $3x10^{-3}$	1,3,5
Newmarket Till	$1x10^{-7}$	$2x10^{-8}$ - $6x10^{-7}$	1
Weathered Lindsay/Verulam	$5x10^{-6}$	$4x10^{-7}$ - $5x10^{-5}$	1,3,4
Weathered Bobcaygeon/Gull River	$6x10^{-6}$	$6x10^{-8}$ - $4x10^{-4}$	1,4
Verulam	$4x10^{-7}$	$1x10^{-10}$ - $6x10^{-4}$	1,2,3
Bobcaygeon (undifferentiated)	$4x10^{-7}$	$1x10^{-9}$ - $2x10^{-4}$	1
Upper Bobcaygeon	$1x10^{-7}$	$5x10^{-10}$ - $6x10^{-3}$	1,2,3,7,8,9
Lower Bobcaygeon	$1x10^{-8}$	$1x10^{-11}$ - $1x10^{-5}$	1,3,6,7,8,9
Gull River (undifferentiated)	$1x10^{-8}$	$2x10^{-11}$ - $2x10^{-5}$	1,8,9
Upper Gull River	$6x10^{-7}$	$5x10^{-11}$ - $2x10^{-3}$	1,3,6,7,8
Green Marker Bed	$7x10^{-6}$	$4x10^{-9}$ - $2x10^{-3}$	1,3
Lower Gull River	$6x10^{-7}$	$2x10^{-11}$ - $1x10^{-4}$	1,3,6,7,8
Shadow Lake / Precambrian Contact	$5x10^{-8}$	$1x10^{-11}$ - $6x10^{-4}$	1,3,6,7,8,9
Precambrian	$1x10^{-9}$	$1x10^{-10}$ - $6x10^{-8}$	7

* Numbers refer to source listed in the Tier 2 Water Budget, Climate Change, and Ecologically Significant Groundwater Recharge Area Assessment for the Ramara Creeks, Whites Creek, and Talbot River Subwatersheds (Earthfx, 2014).

Figure 5 - 3 to Figure 5 - 9 display the spatial distribution of hydraulic conductivities within each aquifer and aquitard in the subwatershed. In the Whites Creek and Lower Talbot portions of the study area, the hydraulic conductivities assigned to Layer 1 correlate with the glacial overburden deposits whose permeable sand and gravel materials are associated with higher recharge rates (Figure 5 - 3). In the Carden Plain Alvar region, where the overburden deposits are absent, hydraulic conductivity rates are even higher due to the extensive fracture network that allows for the rapid conveyance of groundwater across the landscape. Contrary to Layer 1 in the regional model, the extensive Newmarket Till aquitard unit (Layer 2) exhibits lower hydraulic conductivity values due to its silt-dominated character (Figure 5 - 4). The weathered Lindsay/ Verulam Bedrock interface and overlying permeable tunnel channel infill sediments (Layer 3) act as a regional shallow aquifer and are therefore characterized by higher hydraulic conductivity values (Figure 5 - 5), while the unweathered, thickly bedded limestones of Layer 4 (Upper Bedrock Aquitard) are characteristic of lower conductivities (Figure 5 - 6). The Green Marker Bed (Layer 5), an argillaceous limestone formation, exhibits higher conductivities due to its increased fracture occurrences (Figure 5 - 7), while Layer 6 (the Lower Bed Aquitard) is characterized by low hydraulic conductivities due to its fine grained dolostone and argillaceous limestone composition (Figure 5 - 8). Finally, the Shadow Lake –Precambrian unit (Layer 7) generally exhibits higher conductivity rates due to its composition of basal coarse grained sandstones and weathered Precambrian bedrock (Figure 5 - 9), however in the northern portion of the study area, where the Paleozoic bedrock layers gradually “pinch-out”, and the igneous and metamorphic rocks of the Canadian Shield outcrop, the hydraulic conductivity is significantly reduced. The lowest hydraulic conductivity in the model layer sequence occurs at the model base, where the surface of the unweathered Precambrian Formation is found. This unweathered Precambrian basement is not explicitly represented in the model except in a few areas (i.e south of Head Lake) where overlying Paleozoic and overburden units are absent (Earthfx, 2014). Figure 5 - 10 provides a cross sectional profile that summarizes the hydraulic conductivity of the hydrostratigraphic units simulated by the groundwater model.

Specific storage and porosity are closely related hydraulic properties. Porosity refers to the volume of void space per unit volume of geologic materials, where specific storage refers to volume of water stored within the geologic materials. Storage in a confined aquifer is derived from two sources. Water is slightly compressible and will expand slightly as the pressures in the aquifer drop. The soil matrix is also slightly compressible and water can be squeezed from the pore space when pressures in the aquifer decrease. This occurs when the fluid pressure decreases, the inter-granular stresses increase to balance the constant overburden stress and the aquifer matrix is compressed. In an unconfined aquifer, the water yielded by gravity drainage as the water table declines is also considered to be a form of release of water from groundwater storage. The amount of water yielded from unconfined storage is generally orders of magnitude larger than that from compressive storage (Earthfx, 2011a). The following section (4.2.3) will discuss how these properties influence groundwater flow.

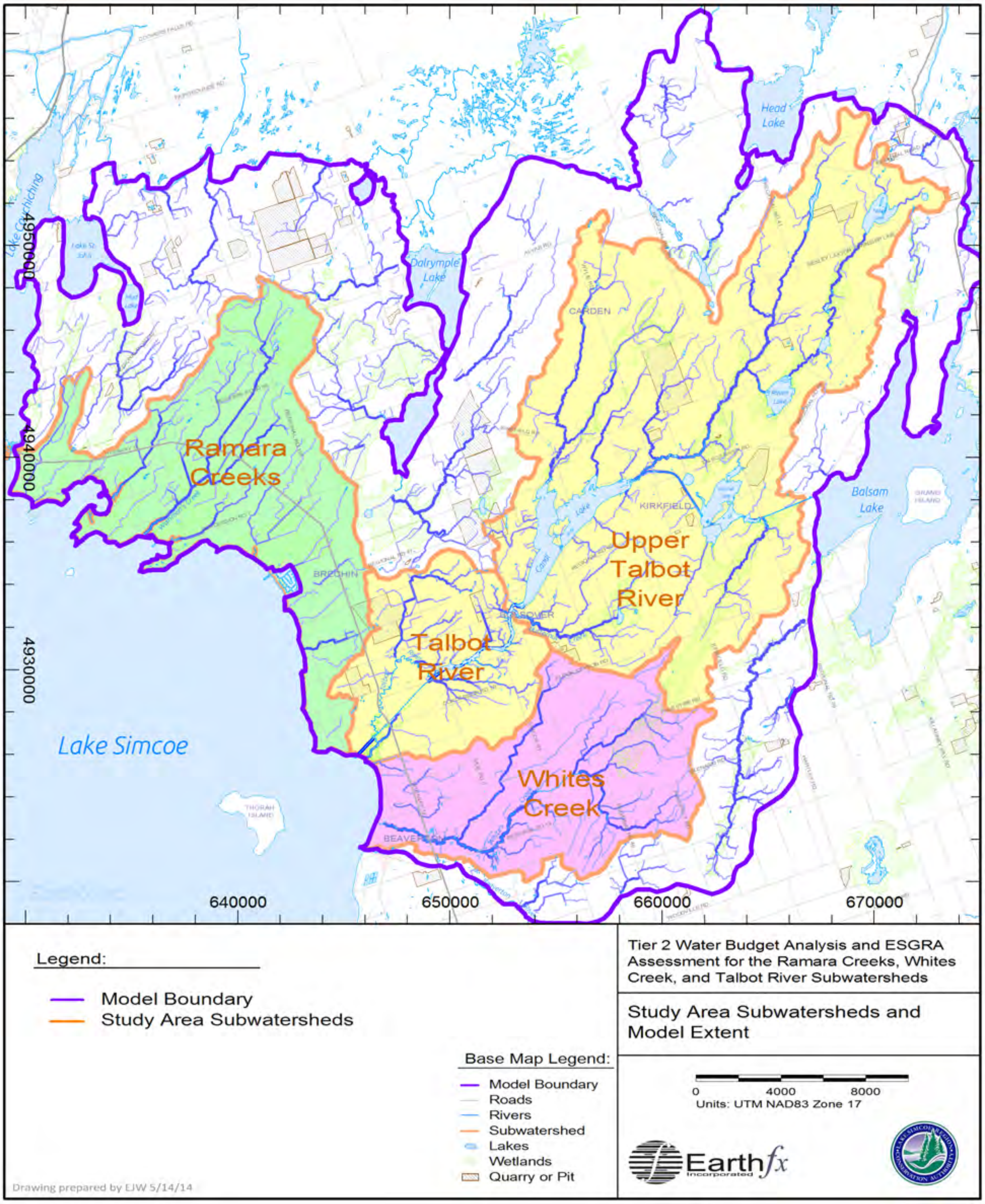


Figure 5 - 2: Model Area Boundaries (Earthfx, 2014).

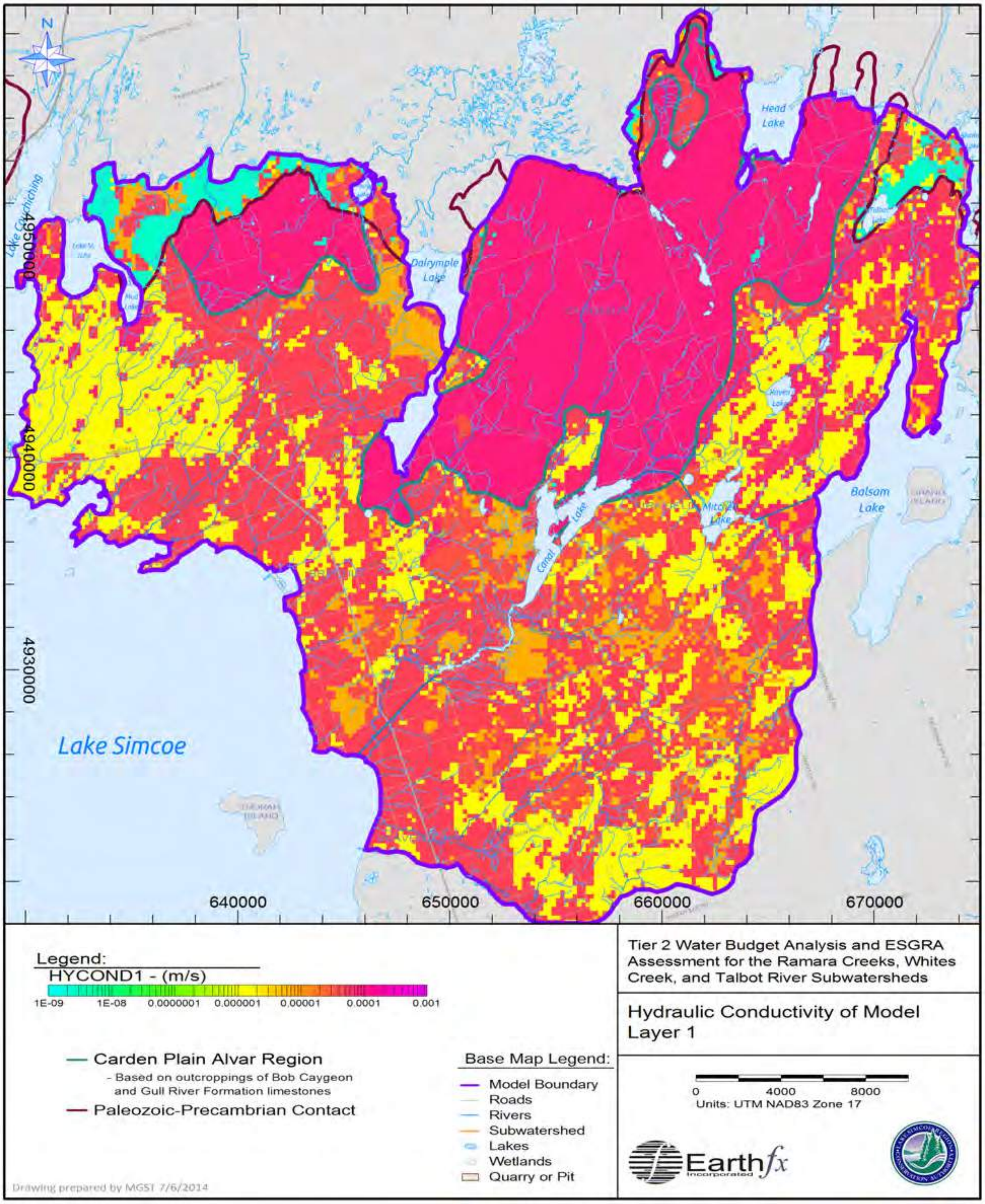


Figure 5 - 3: Hydraulic conductivity, in m/s, for Layer 1 (surficial deposits/highly weathered Alvar) (Earthfx, 2014).

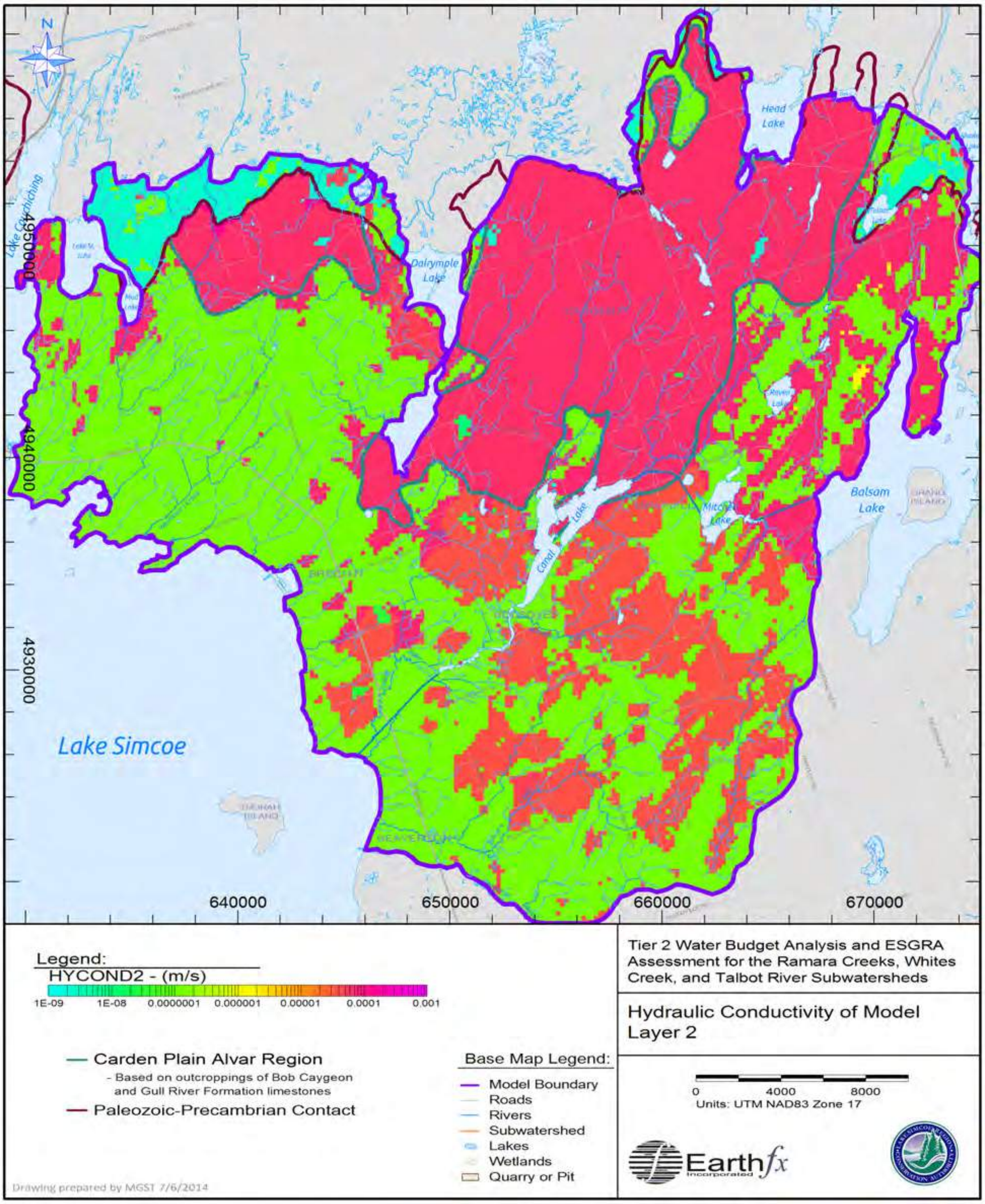


Figure 5 - 4: Hydraulic conductivity, in m/s, for Layer 2 (Newmarket Till and highly weathered Alvar) (Earthfx, 2014).

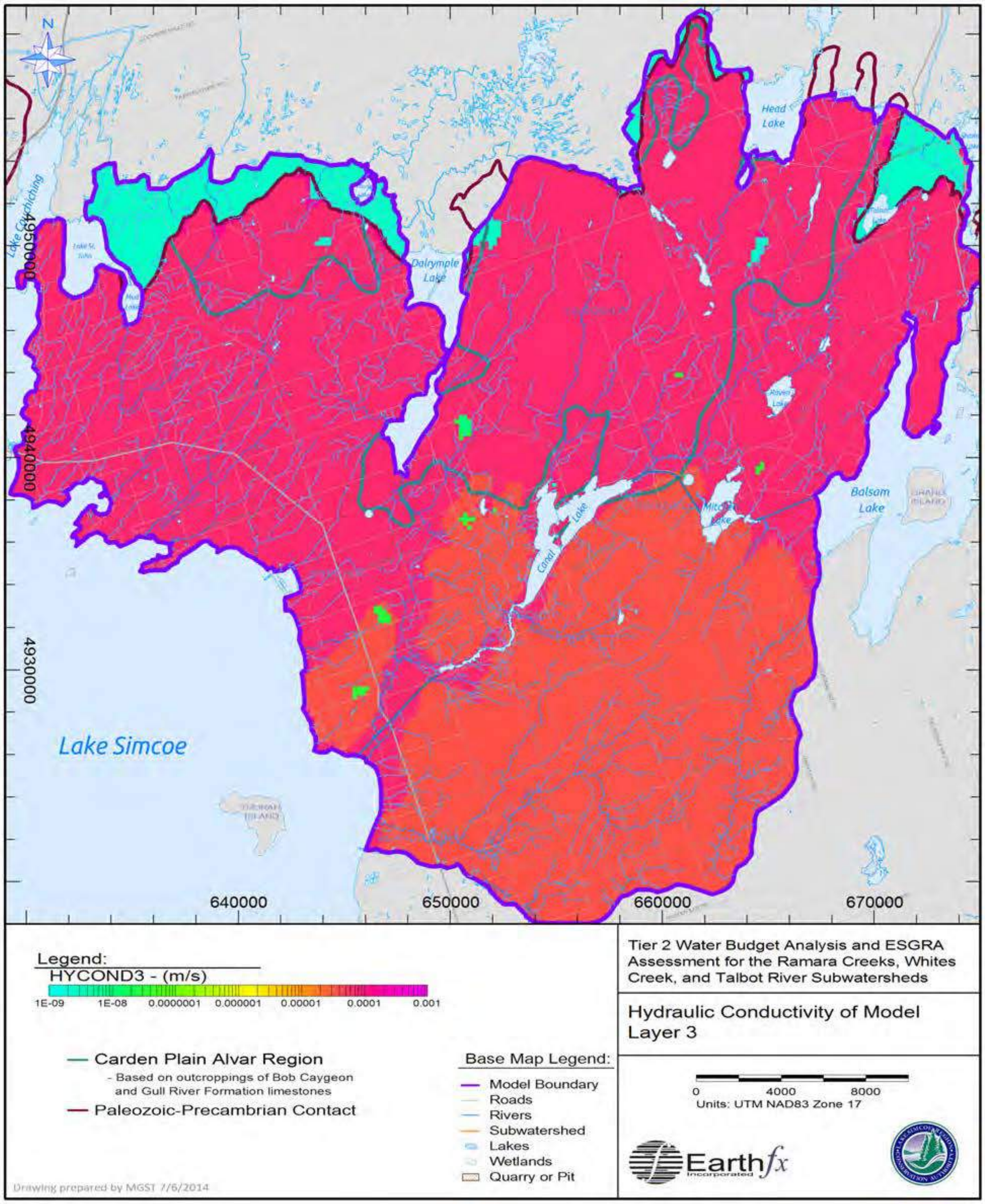


Figure 5 - 5: Hydraulic conductivity, in m/s, for Layer 3 (weathered bedrock interface aquifer) (Earthfx, 2014).

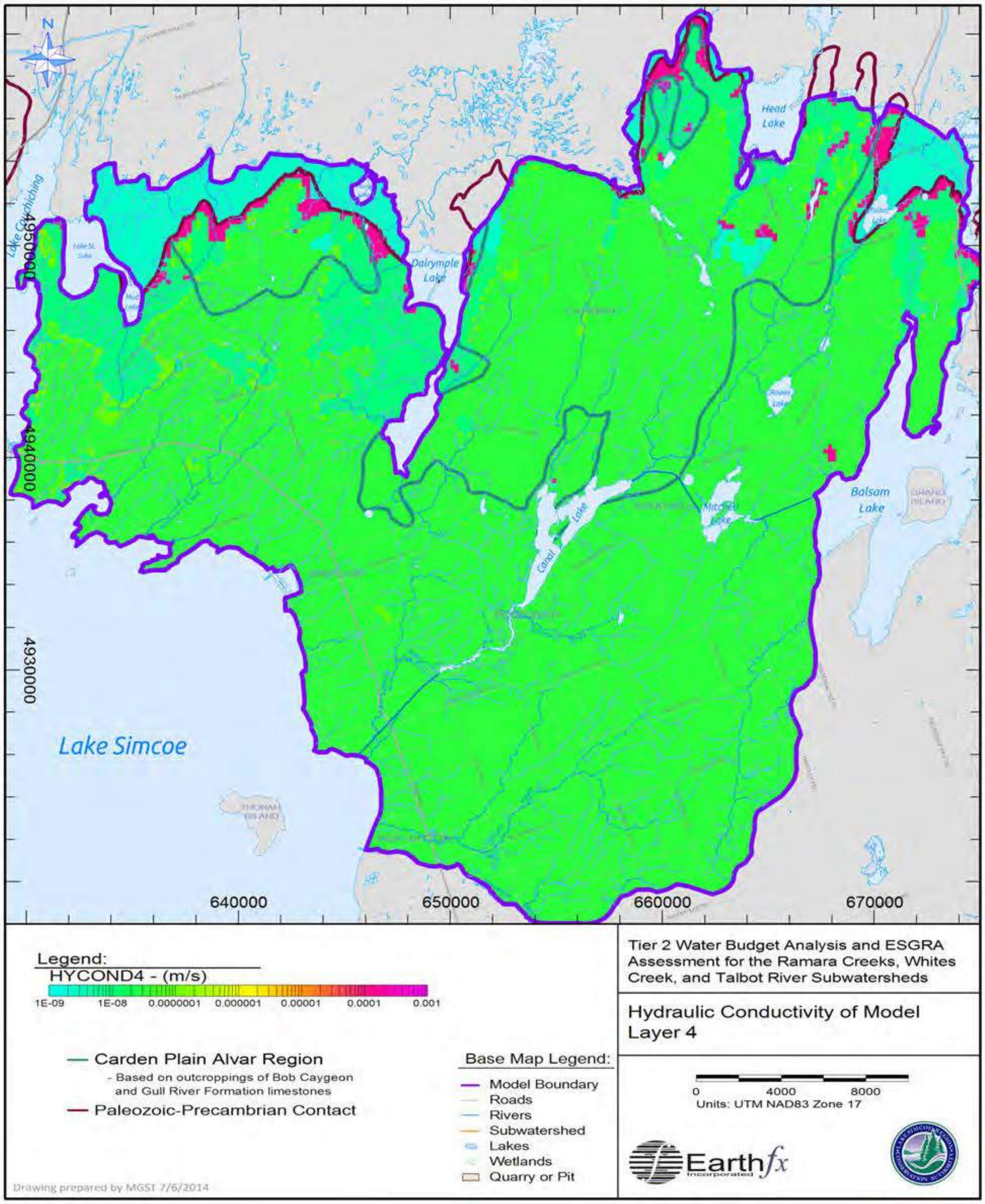


Figure 5 - 6: Hydraulic conductivity, in m/s, for Layer 4 (upper bedrock aquifer) (Earthfx, 2014).

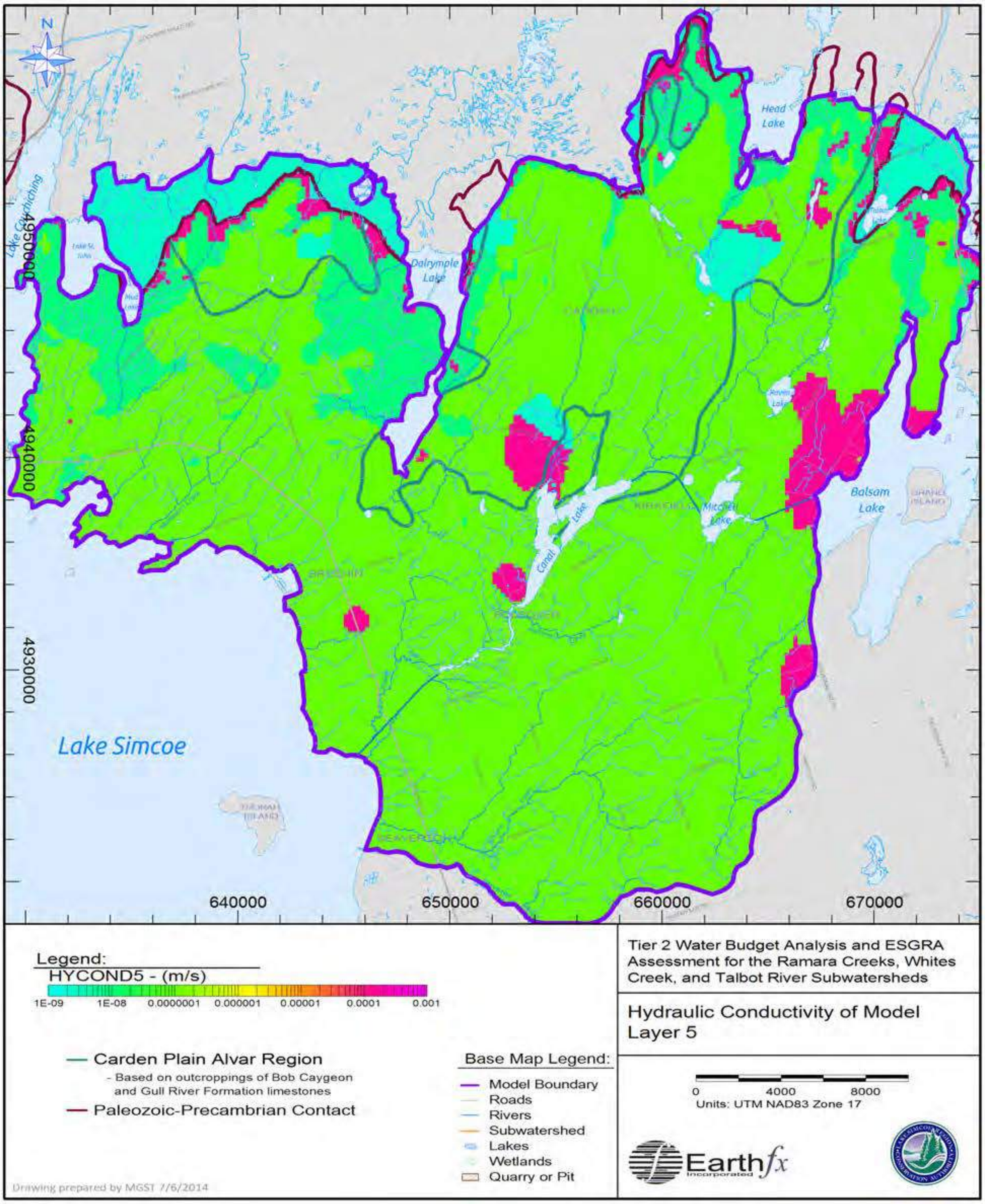


Figure 5 - 7: Hydraulic conductivity, in m/s, for Layer 5 (Green Marker Bed) (Earthfx, 2014).

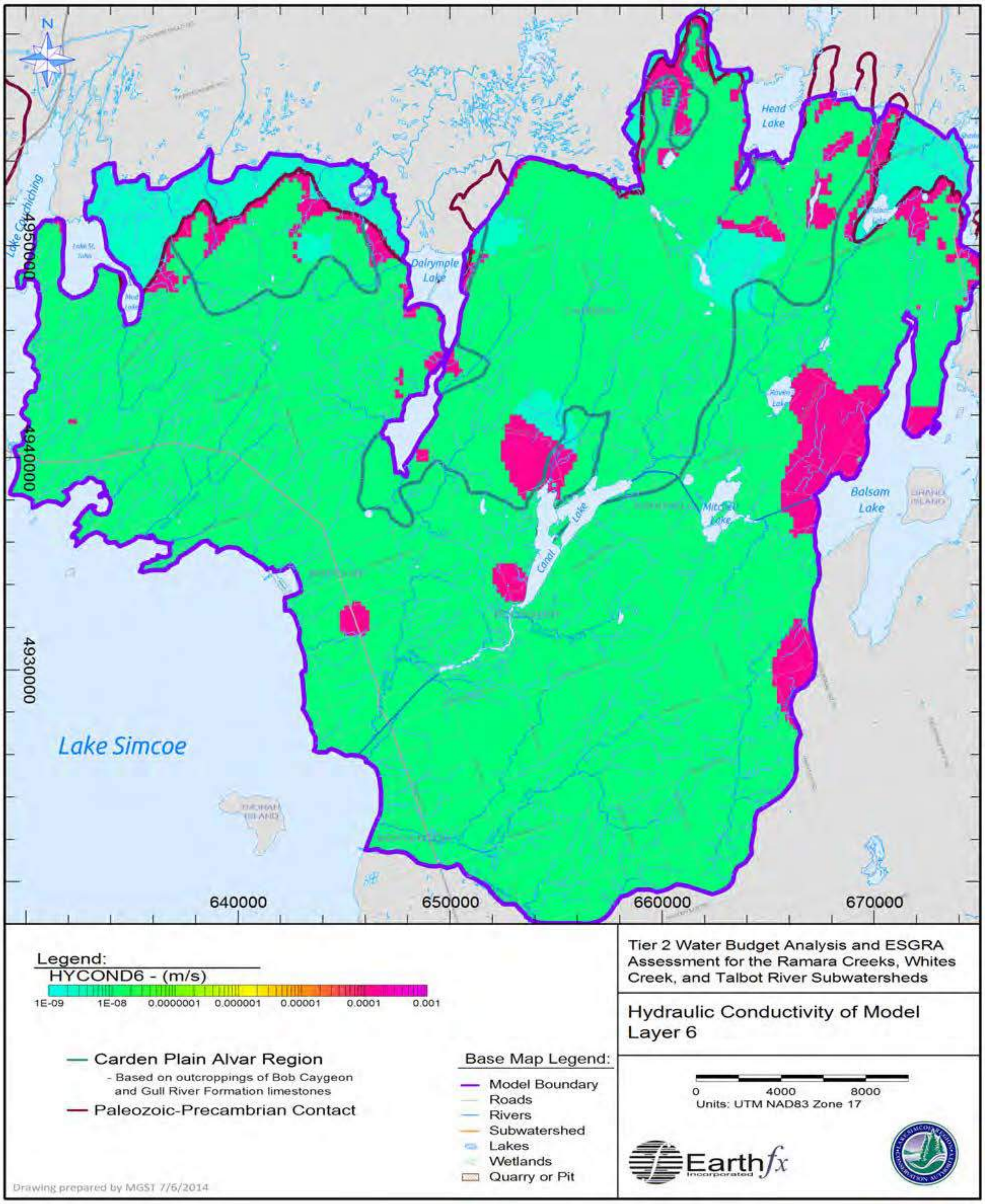


Figure 5 - 8: Hydraulic conductivity, in m/s, for Layer 6 (Lower Bedrock Aquifer) (Earthfx, 2014).

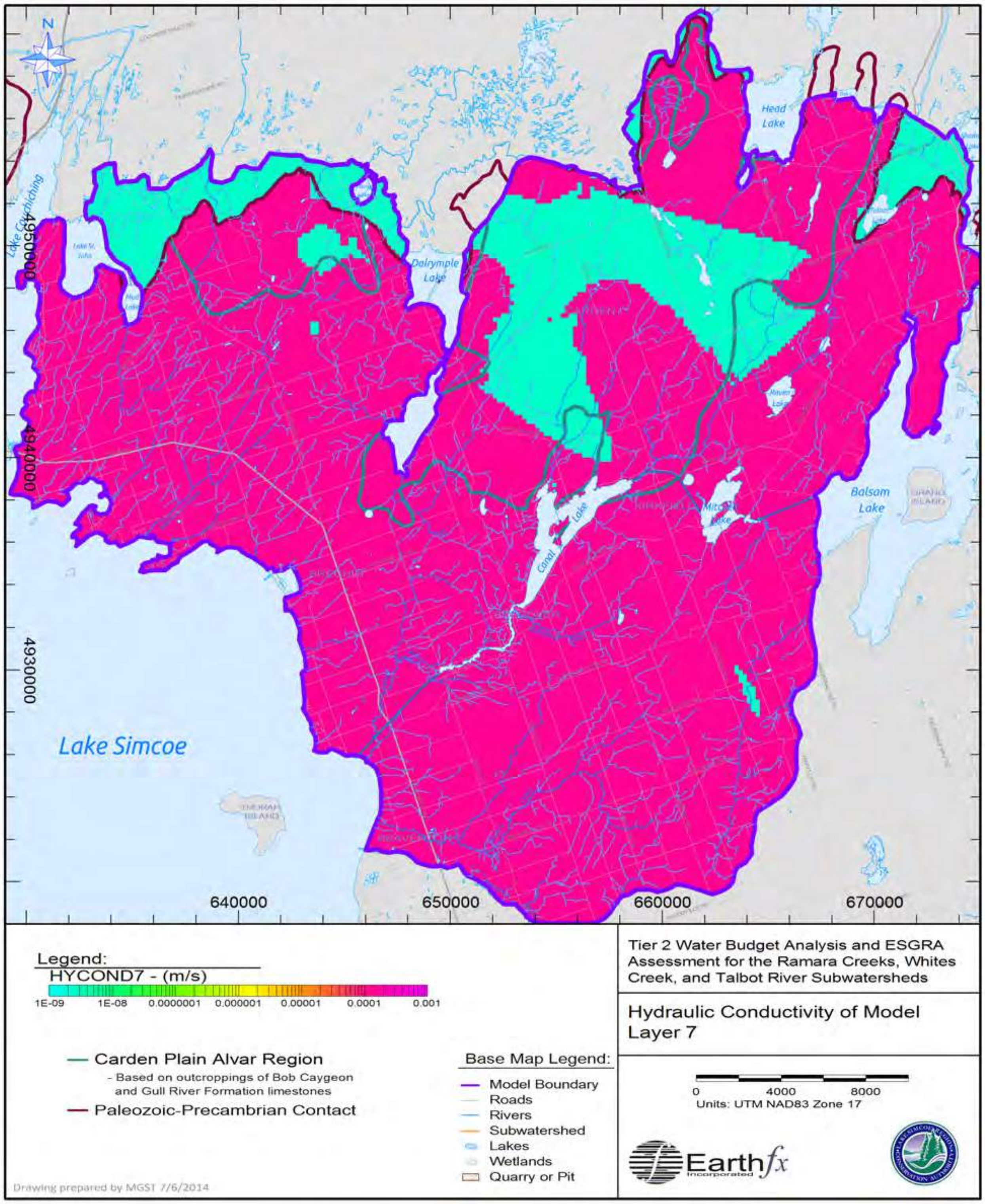


Figure 5 - 9: Hydraulic conductivity, in m/s, for Layer 7 (Shadow Lake-Precambrian contact aquifer) (Earthfx, 2014).

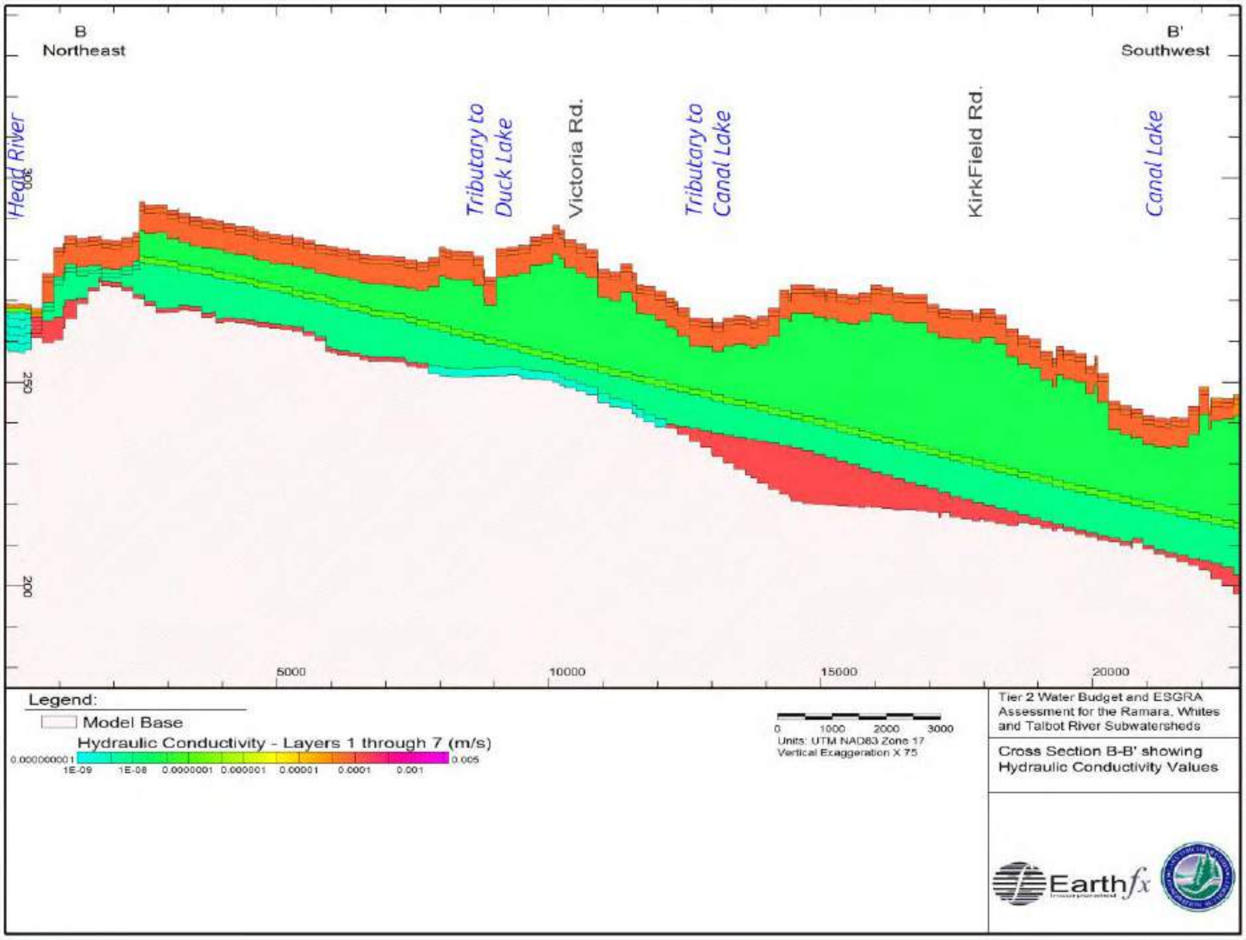


Figure 5 - 10: Regional north-south cross section showing hydraulic conductivity distribution in numerical model layers (Earthfx, 2014)

5.2.3 Groundwater Flow

Groundwater flow is controlled by the variation in aquifer transmissivity (i.e. hydraulic conductivity multiplied by aquifer thickness) taking into consideration hydraulic gradients. Groundwater moves continuously but at different rates based on the hydraulic properties of the geologic formations mentioned in Section 4.2.2. Groundwater will flow down a hydraulic gradient from points of higher to lower hydraulic heads. The direction of movement at any point within the system is dependent on the distribution of hydraulic potential (Funk, 1997). Within each formation, groundwater can move in both the horizontal and vertical directions. Since the shallow water table commonly follows the ground surface topography, horizontal flow can be topographically mapped using water table data obtained from shallow wells.

Regional water level patterns in the Whites Creek and Talbot River subwatersheds were interpreted using static water level data from wells documented in the MOE Water Well Information System (WWIS). The available static water level data were analysed, and measurements were assigned to one of the 14 hydrogeologic units identified in the study area based on the reported depth of the well screen for each well (Earthfx, 2014). Analysis of the water level data indicated that the majority of the well screens are located in the shallow overburden and weathered bedrock interface aquifer (Layer 3), while only a small number of the wells are screened in the deeper bedrock units (Earthfx, 2014).

Due to the availability and spatial distribution of WWIS data, it was possible to reliably interpolate the water levels in the shallow groundwater system. Data for the deeper system was too sparse to interpolate, however individual measurements were still used during the calibration of the model. As illustrated in Figure 5 - 11, interpolated water levels (hydraulic heads) indicate that the shallow groundwater system tends to be a subdued replica of the land surface topography (Earthfx, 2014).

The interpolation of water levels also allowed for the development of a reasonable representation of regional groundwater flow patterns across the study area. The direction of groundwater flow is interpreted as moving perpendicular to the contours delineated in Figure 5 - 11. In the Whites Creek and Talbot River subwatersheds, a general westward to south-westward trend in regional groundwater flow toward the eastern shores of Lake Simcoe can be observed across most of the study area. Radial flow occurs from three large groundwater recharge mounds in the area; two are associated with the higher elevations in the Upper Talbot subwatershed, and the third is at the southeast end of the Whites Creek subwatershed (Figure 5 - 11). Groundwater flow patterns also indicate that the major surface water bodies in the study area, including Balsam Lake, Canal Lake, Mitchell Lake, Head River, and Lake Simcoe, represent areas of groundwater discharge. Along the lower reaches of the Talbot River, below Canal Lake, “v-shaped” groundwater contours can be seen pointing upstream, suggesting significant groundwater discharge to the Talbot River (Earthfx, 2014).

Figure 5 - 12 illustrates that groundwater in the Whites Creek and Lower Talbot subwatersheds can generally be found less than 10 m below ground surface. In the Upper Talbot, particularly within the Carden Plain Alvar region, water levels are found more consistently below the bedrock surface. This is to be expected since the highly weathered Paleozoic bedrock in this area generally occurs at or near the ground surface (Earthfx, 2014). In these Alvar areas, the water table likely rises only to the base of this highly fractured bedrock zone most of the year (Earthfx, 2014).

Groundwater levels across the Whites Creek and Talbot River subwatersheds are at their highest elevation of 290 metres above sea level (masl) at the upland recharge areas in the north eastern and south eastern part of the study area. The northeastern water level high is found in the vicinity of Head Lake, where the overburden thickness is minimal and the confining sequences of the Paleozoic bedrock provide topographic control on groundwater levels by limiting downward drainage (Earthfx, 2014). The water level high in the southeast is found in an area where thicker Newmarket Till sequences overlie argillaceous limestone units (i.e limestone with a significant clay mineral component). In both cases, interpolated water levels are located within the upper few metres of the sub-cropping or outcropping bedrock (Earthfx, 2014).

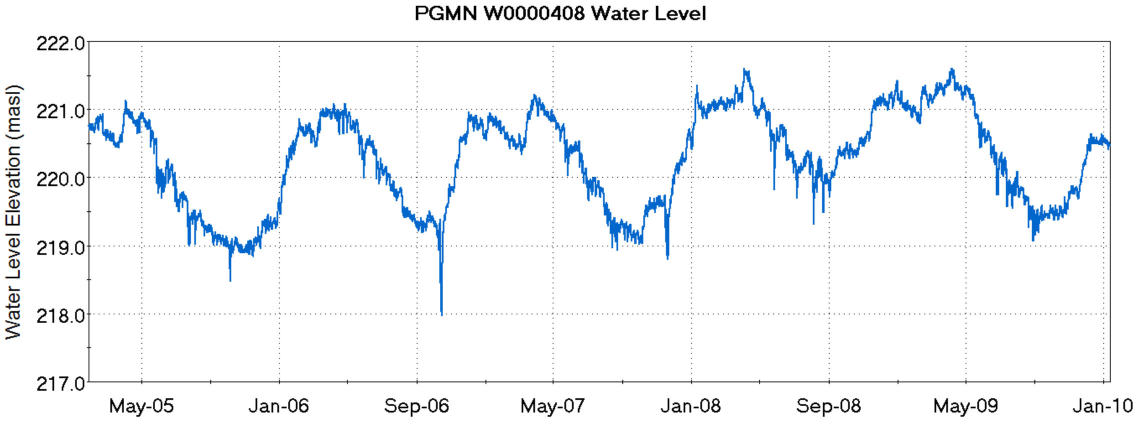
Groundwater levels are at their lowest elevation of 220 masl along the eastern shores of Lake Simcoe. This observation corresponds well with the water level measurements taken at the single Provincial Groundwater Monitoring Network (PGMN) well located just outside the northwestern boundary of the Lower Talbot River subwatershed, on the shores of Lake Simcoe.

The Provincial Groundwater Monitoring Network (PGMN) is a province wide program that aims to gather long term baseline data for groundwater quality and quantity in key aquifers across Ontario. The Ministry of the Environment and Climate Change, in partnership with the Lake Simcoe Region Conservation Authority, manages a number of PGMN wells in the Lake Simcoe watershed, one of which is located on the southern tip of the Ramara Creeks subwatershed, just outside the boundary of the Lower Talbot River subwatershed. The single PGMN well in the subwatershed is located near the outfall of the Trent- Severn Waterway into Lake Simcoe, and has been online since January of 2005. The well is completed to a depth of 13.7 metres below ground surface and screened in the overburden/weathered bedrock interface aquifer unit associated with layer 3 of the regional groundwater submodel. A review of the available long-term water level data from the PGMN well was conducted to quantify seasonal fluctuations in groundwater levels. Water levels in the PGMN well are presented in Table 5 - 1, and show a seasonal fluctuation of approximately 2 m (between 219 masl and 221 masl). Water levels generally increase in late winter/spring until they peak between April and May, after which they experience gradual declines into late fall/early winter(Earthfx, 2014). These fluctuations are slightly offset from the seasonal patterns at Lake Simcoe, where stage fluctuates approximately 0.5 m seasonally, with an increase from mid-March to April, a plateau until July, followed by a water level decline into the winter months (Earthfx, 2014). Due to the well's proximity to Lake Simcoe, measured water levels at the PGMN well were not considered a reflection of seasonal trends across the study area subwatersheds.

Groundwater Monitoring

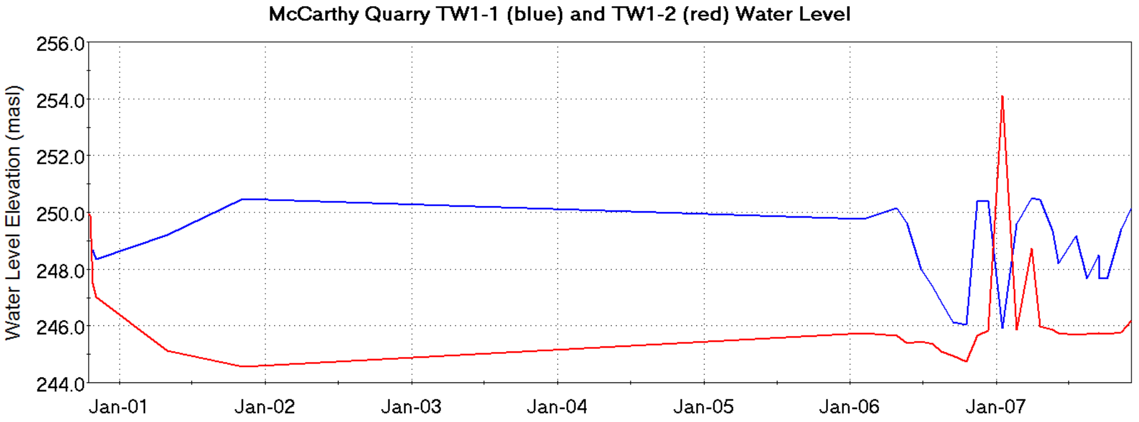
- The static water levels measured in monitoring wells characterize the amount of water stored in an aquifer, aquifer complex or saturated portion of the subsurface system. Groundwater levels can fluctuate due to precipitation, barometric pressure, temperature, and water withdrawal.
- Monitoring groundwater levels can help researchers understand baseline conditions and assess how groundwater is affected by climate change, seasonal fluctuation, land and water use. Monitoring helps to identify trends and emerging issues, and provides a basis for making informed resource management decisions. The data can also be used to measure the effectiveness of the programs and policies that are designed to manage and protect groundwater resources.
- Under the Provincial Groundwater Monitoring Network (PGMN), the LSRCA, in partnership with the Ministry of Environment and Climate Change, currently operates one monitoring well in the southern end the Ramara Creeks subwatershed, just outside the boundary of the Lower Talbot River subwatershed. Well W0000408 is completed to a depth of 13.7 m, and is screened in the overburden/weathered bedrock interface aquifer unit. The well is located near the outfall of the Trent Severn Waterway into Lake Simcoe.
- Water level measurements in the PGMN well show a seasonal fluctuation of approximately 2 m (between 219 masl and 221 masl). Water levels in the well generally increase in late winter/spring until they peak between April and May, after which they experience gradual declines into late fall/early winter (Earthfx,2014)

Table 5 - 3: Water Levels at PGMN well W000408 (overburden/ weathered bedrock interface aquifer).



A limited amount of transient groundwater level data was also available from a small subset of monitoring wells operated by quarry operations in the Talbot River subwatershed. Some of the quarry monitoring wells provided a good record of long-term groundwater levels. The pattern of seasonal fluctuations observed at the PGMN well were also observed in the majority of the quarry monitoring well water data, although the range in water levels varied from quarry to quarry (Earthfx, 2014). In general, water levels in the quarry monitoring wells fluctuated between 1 to 3 metres (m). In a few cases, a limited number of water level measurements for the deeper Green Marker Bed and Shadow Lake aquifers were also collected by quarry monitoring wells. Seasonal fluctuations in water levels for the Green Marker Bed aquifer observed at a quarry monitoring well in the Lower Talbot River subwatershed are presented in Table 5 - 4. The graph indicates a 2 to 4 m fluctuation in water levels for the Green Marker Bed aquifer. Seasonal fluctuations in the Shadow Lake aquifer could not reliably be interpreted from the quarry data.

Table 5 - 4: Water Levels at McCarthy Quarry nested wells TW1-1(Green Bed) and -2(Shadow Lake) (Earthfx, 2014).



Groundwater is exchanged between the different aquifers as leakage across the aquitards. The direction of vertical flow depends on the relative heads in the different aquifers. Leakage rates vary locally depending on the magnitude of the vertical gradients and on the thickness and hydraulic conductivity of the confining units. Gradients across the Whites Creek and Talbot River subwatersheds are generally downward. Quarry monitoring data from the deeper aquifers showed a downward hydraulic gradient from the Green Marker Bed aquifer to the Shadow Lake aquifer, suggesting that a fairly competent confining unit separates the two units (Earthfx, 2014).

To further understand the movement of groundwater in the study area, backward particle tracking analyses were carried out within the study area subwatersheds. Backward or “reverse” particle tracking analyses use models to map the path of groundwater flow in and across subwatershed boundaries. Virtual particles are introduced in dense distribution at a point of known groundwater discharge or around ecologically significant discharge features and traced back to their original point of recharge. Based on reverse particle tracking completed for this area, the regional groundwater flow contribution supports numerous wetland and stream features in the Talbot River and Whites Creek subwatersheds. In general, important features such as wetlands and streams are supported by recharge areas located within the topographic boundaries of the study area subwatersheds. However, despite the relatively contained nature of groundwater flow in the two subwatersheds, some of the headwaters in the upper Talbot River subwatershed are being supported by lateral groundwater inflow from recharge zones outside of subwatershed boundaries, in the Carden Plain Alvar (Earthfx, 2014). As previously mentioned, the Carden Plain Alvar is characterized by Karst topography formed through the solutional weathering of limestone pavement. In the model area, the dissolution of Alvar has resulted in formation of solutionally enlarged joints in the bedrock. These large fractured joints allow significant amounts of recharge to rapidly enter the groundwater system.

Backward particle tracking analyses also highlighted the connection between the groundwater system and specific surface water features. Many of the surface water features in the Talbot River and Whites Creek subwatersheds are located within the lowland portions of the southwest trending bedrock tunnel valleys. As discussed further in section 4.2.6, bedrock tunnel valleys are unique geologic features formed through the action of sub-glacial processes that worked to erode these deep valleys into the bedrock. Within the Talbot River subwatershed, the wetlands and rivers occupying the bottom of the valleys are being sustained by groundwater seepage supplied from atop the valley slopes. This indicates that many of the streams and wetlands, particularly those in the upper Talbot subwatershed are supported by very localized recharge. This is different from many other subwatersheds in the Lake Simcoe watershed, where streams are largely supported by a few key recharge features such as glacial moraines and groundwater recharge mounds.

In the Whites Creek subwatershed, reverse particle tracking analyses indicate that many of the surface water features in the subwatershed are sustained by groundwater discharge that comes from recharge areas located in the Talbot River subwatershed. Furthermore, the presence of the silt-dominated surficial geology in the Whites Creek subwatershed likely reduces the recharge capacity of the landscape. Results of the backward particle tracking analysis are further discussed in Section 4.2.6.

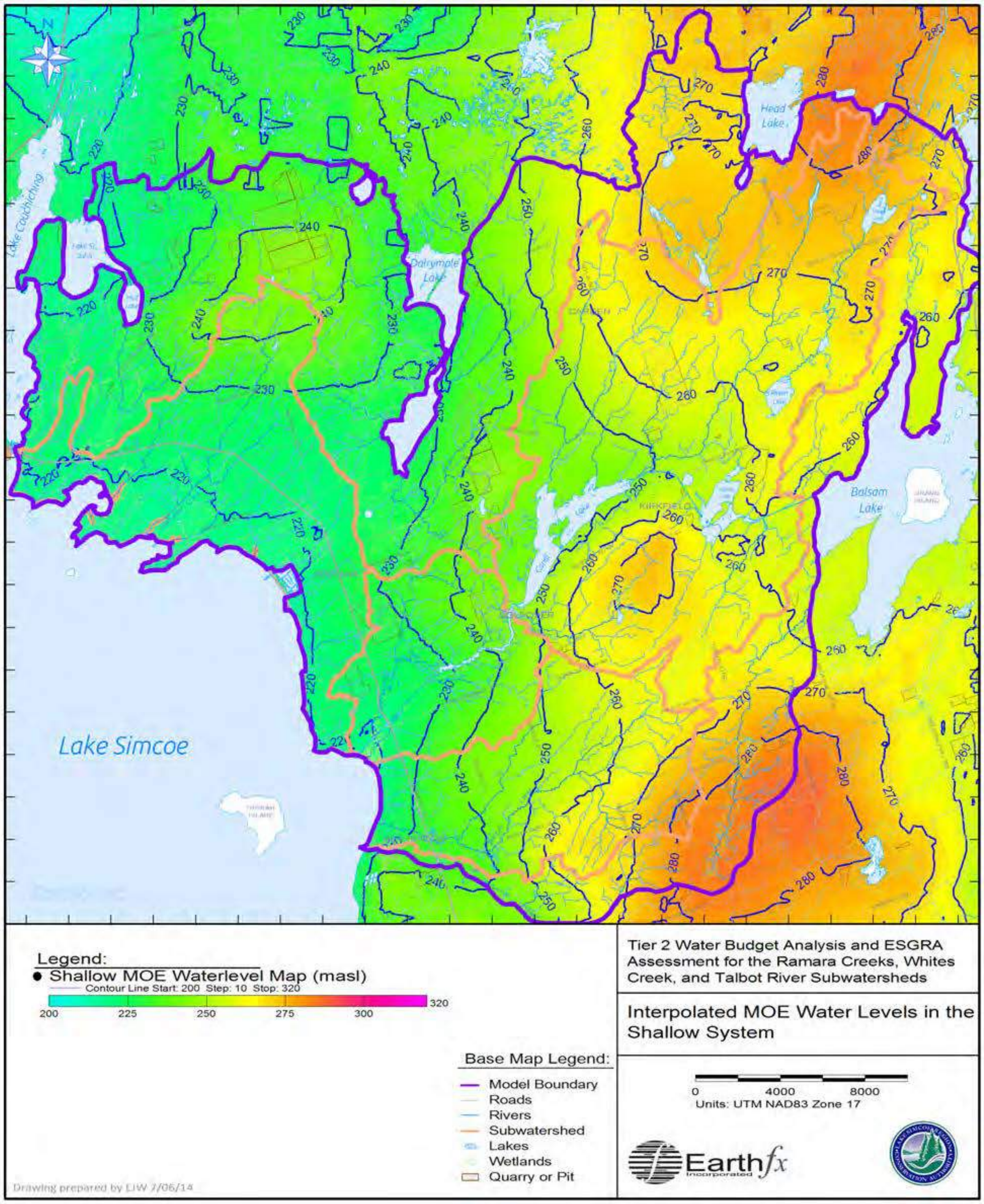


Figure 5 - 11: Interpolated MOE water levels in the shallow groundwater system (Earthfx, 2014).

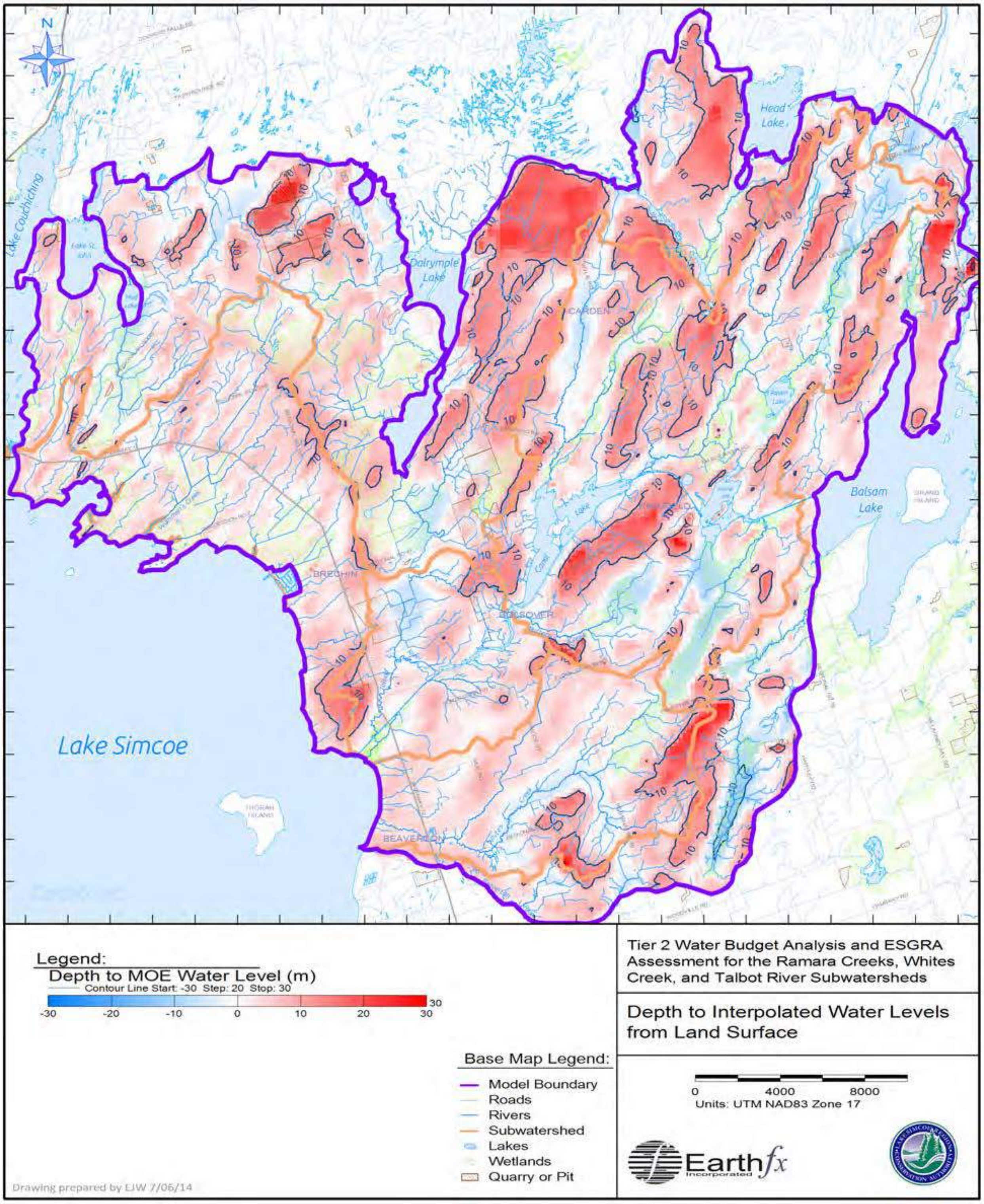


Figure 5 - 12: Depth to Interpolated Water level from Ground Surface (Earthfx, 2014).

5.2.4 Streamflow

The model developed for the Tier 2 Water Budget Assessment simulates streamflow in an area beyond the boundaries of the Whites Creek and Talbot River subwatersheds. The model also incorporates the adjacent Ramara Creeks, as well as small additional areas to the north, south, and east of the three core subwatersheds. The streams, lakes, and wetlands that drain the study area are shown in . The three major study area subwatersheds are bounded by the Beaver River to the south, the Head River to the immediate north and the 12,500 km^2 Trent River watershed to the east. Surface water data from several sources including streamflow measurements, previous modelling efforts, canal operations, and surface feature mapping were compiled. Streamflow monitoring locations are shown in Figure 5 - 15. The LSRCA operates two active stream gauges within the study area; one in the Talbot River subwatershed near the southern boundary of the Ramara Creeks subwatershed (LS0109), and one in the Whites Creek subwatershed at Regional Rd. 23 (LS0402). The Talbot River and Whites Creek gauges have been in operation since 2005 and 2009, respectively. Another streamflow monitoring station was established on Talbot River where it crosses Kirkfield Road, upstream of the Kirkfield lock. This station was established specifically for the purpose of this project in late 2013 and provides continues water levels data, recorded every 30 min. Kawartha Conservation maintains and operates this monitoring location. It will be decommissioned once project is completed.

Monitoring data prove that flow of the Talbot River is strongly influenced by the Trent-Severn Waterway Operations.

Trent-Severn Waterway

Trent-Severn Waterway (TSW) is a 386 kilometre inland navigation route that crosses south central Ontario from Trenton on the Bay of Quinte (Lake Ontario) to Port Severn on Georgian Bay (Lake Huron). The system serves thousands of recreational boaters during its May to October operating season. Water levels are maintained by a series of dams, and navigation is accomplished through locks which rise and lower boats between adjacent sections of the waterway. The Talbot River forms part of the system.

The TSW features 44 locks, including the first and second highest lift locks in the world, two flight locks and one marine railway. It took 87 years to complete, from 1833 when the first lock in Bobcaygeon was constructed until the Severn section was completed in 1920. Currently it is managed and operated by Parks Canada (division of the Environment Canada).

Initially the TSW was planned as a route for trade and commerce, especially for timber. The long delays before the system was complete, the decline in the timber industry, and rapid development of roads and railways, meant that the TSW was never utilized as a commercial corridor. Instead, recreational users and tourists have steadily increased and they are now the primary users of the Trent Severn Waterway system (TSW Panel, 2007).

In order to form a navigable route through two neighbouring watersheds, the Trent and the Severn, natural rivers and lakes was connected by man-made canals, dams and locks. The Trent River watershed makes part of the Lake Ontario drainage area, while Severn River watershed belongs to the Lake Huron basin. The highest waterbody on the waterway is Balsam Lake. Boats transiting from Lake Ontario are raised 182 m to the summit at Balsam Lake and then descent 80 m down to Georgian Bay.

The Trent Severn Waterway consists of three key sections:

- the Trent River Basin;
- the Reservoir Lakes, and
- the Severn River watershed.

The Trent River Basin is the easterly watershed that drains to Lake Ontario. It includes Kawartha Lakes interconnected by number of short channels, and two primary rivers: the Otonabee River and the Trent River. The Reservoir Lakes section to the north consist of some forty-four lakes in the watersheds of Gull, Burnt and Mississauga rivers as well as Nogies, Eels and Jack creeks. They collect spring runoff water to release it over the summer to sustain navigable water levels at the Trent component of the Waterway.

The Severn section is located immediately west of the Trent Basin and drains into Georgian Bay. The Talbot River makes the headwaters of this section.

The part of the TSW system between Lake Simcoe and Balsam Lake, that includes the Talbot River, had posed a unique engineering challenge for construction. The summit at Kirkfield is a dividing line between water flowing east to Lake Ontario and west to Georgian Bay. A canal cut, known as Trent Canal, a hydraulic lock and five conventional locks were constructed to link Balsam Lake with Lake Simcoe.

As a result of the human interference, all aspects of hydrology of the Talbot River, including water level and flow regime and channel morphology have been significantly altered, especially at its middle and lower portions. The Talbot River was connected to Balsam Lake despite of natural settings, two lakes (Mitchell and Canal Lakes) were created, five dams and locks were built at the last 10 kilometres of the river (lock characteristics are shown at Table 5 - 1). At the modern days the Trent Severn Waterway's water level management strategy dictates hydrological regime of the Talbot River.

Table 5 - 5: Characteristics of Trent-Severn Waterway Locks within the Talbot River Watershed

Lock Number	Location	Type of the Structure	Waterbody	Km, from Lake Ontario	Elevation Drop, m
36	Kirkfield	Lift lock	Trent Canal	272.6	14.9
37	Bolsover	Conventional lock	Talbot River	284.9	6.6
38	Talbot			286.5	4.3
39	Portage			289.1	4.0
40	Thorah			289.8	4.3
41	Gamebridge			290.9	3.0

The Trent Severn Waterway's water levels and flows management strategy throughout the system is designed to meet multiple objectives: to allow for safe boating, to reduce flooding of agricultural, residential & commercial property, to protect fish & wildlife habitat, to support municipal services including water supply, to support hydroelectric generation, and to help maintain water quality. Water level management strategy is complex and incorporates many contributing factors. Primary considerations are public safety and flood abatement, protection of the fishery (especially the fall spawn), navigation and recreation. Decisions affecting an individual body of water are analysed for impacts to other water bodies as well as the entire waterway system (Parks Canada, 2012).

The water level and flow of the Severn section, including the Talbot River, are managed by the Trent Severn Waterway, following the pattern known as "seasonal operational regime" (Dave Ness, pers. comm.).

The yearly highest water levels are maintained during the spring season, resulting from the melting snow ("spring freshet"). High water levels in early spring are natural occurrences which help to recharge groundwater, transfer nutrients and sediments to wetlands and shoreline riparian zones, and provide spring spawning fish and amphibians with access to wetlands and shoreline habitats. According to the TSW water level management strategy, spring water levels are restricted to a level that reduces potential damage to docks and boathouses.

A gradual release of water from Canal and Mitchell lakes and slowly declining water levels throughout the late spring and summer period allow for continued recreational use of lakes and the Talbot River while ensuring sufficient water levels in sensitive aquatic areas during periods of hot weather and low precipitation.

During the fall, in preparation to the winter season, water levels at the Canal and Mitchell lakes are forced to decline by gradually opening dams. This pattern is different from the majority of the lakes at Trent-Severn Waterway, where the lakes slowly decline over the winter months. Main reason for the fall drawdown in Mitchell Lake is to protect its fish population. Mitchell Lake is very shallow and when a through ice cover establishes on a lake it creates a danger of trapping fishes in shallow water pockets where they may experience lack of oxygen and potentially die. A slow drawdown before the lake freezes provides fish population with sufficient time to move to the deeper and safer sections of the lake. Therefore, a drawdown is completed before the ice cover establishes. Lots of different factors influence the exact day when the drawdown starts, but generally speaking logs are pulled from dams shortly after the navigation season is finished, after the Thanksgiving Day, in mid-October (Dave Ness, pers. comm.). Mitchell Lake is allowed to decline very gradually, over the course no less than 4 weeks, using a "one log per week" approach (Dave Ness, pers. comm.). As Mitchell Lake is gradually drained, the section of Talbot River that is located directly downstream of the lake experiences elevated flows and water levels, what contradicts the natural fall flow regime pattern. Because Mitchell Lake is uppermost regulated lake on the Talbot River system, drawing down its levels means that the downstream portion of the system, including Canal Lake and Talbot River dams, is gradually lowered as well.

The Trent Canal, that connects two separate watersheds, has its own operation tools and pattern. The guard gate, a temporary dam equipped with valves that can be opened when needed, is erected in the Canal to separate Balsam and Mitchell lakes, and consequently, Trent and Severn watersheds. In early fall, when navigation on the system closes before the drawdown of Mitchell Lake starts, a guard gate is installed in the canal, giving the opportunity to keep the Mitchell Lake and Balsam Lake at different levels. When Canal and Mitchell lakes reach their winter levels, valves at the guard gate are opened to allow some flow (up to 5 m^3/sec) in the Trent Canal and upper portion of Talbot River in order to sustain a sufficient amount of oxygen to support aquatic community (Dave Ness, pers. comm.). To ensure sustainable flow in westerly direction, water levels on Balsam Lake are kept higher than on Trent Canal and Mitchell Lake in winter season.

In spring, Balsam Lake is drawn down to the Mitchell's Lake level, before the guard dam can be lowered and dams on Mitchell and Canal lakes can be closed.

In summer and fall during the navigation season, when water levels at the TSW system are gradually declining, the guard gate is lowered and Balsam and Mitchell Lakes are kept at the same level. It allows minimizing of the outflow occurring from the Kawartha Lakes watershed to the Talbot River, which represents the Severn watershed.

Mean daily discharge (streamflow) on the Talbot River is presented in Figure 5-16. Overall, existing data confirm that the Talbot River have well-defined seasonal pattern, reflecting seasonal variations of water inflow. The highest water levels and flows for were observed in April caused by a spring freshet. The large events recorded during January 2008 and December 2009 were the result of the TSW control operations by staff to divert water from the upper Trent Watershed to Lake Simcoe. These operations are routinely undertaken to create additional winter storage in the central Trent-Severn to accommodate predicted spring freshet flow. The influence of the Trent-Severn Waterway control operations can also be observed during the summer and fall months as gradual or sudden changes in discharge. Since flows at both of those gauges are influenced by the TSW operations, and the timing and volume of releases are not available, further work with Trent Severn Waterway is required in order to improve flow monitoring and data collection on the Talbot River.

As mentioned above, the other gauge in the study area is located in the Whites Creek subwatershed near Regional Road 23. Figure 5-17 illustrates the mean daily discharge at the gauge. The gauge provides a relatively continuous record with few gaps due to ice or vegetation. As illustrated in the figure, a large portion of the annual flow is released from the Whites Creek catchment as freshet, and the peak annual flows generally correspond to the spring freshet. This agrees with the observation that the bulk of the annual flood peaks in rural Ontario watersheds are a result of rain-on-snow events. However, there are also large runoff events observed during the summer and fall months. This may be due to the loose till soils in the area, which allow for quick conveyance and discharge of precipitation that occurs during large convective storm events. Agricultural land uses such as tile drains may also contribute to the large runoff events observed at the gauge. During the summer and fall, recharge occurring as a result of large precipitation events is collected by tile drains and directly deposited into local surface waters, leading to increases in flow.

Measurements from the Whites Creek gauge were the primary calibration targets for calibration of the hydrologic submodel (Earthfx, 2014). Short periods of record at gauges operated by Dr. P.J. Dillon of Trent University from 2010 and 2011 also served as calibration targets. The locations of the TrentU-Dillon stations are illustrated in Figure 5 - 15. Despite having short periods of record, these stations provided valuable insight into the response of streamflow in the study area subwatersheds.

Table 5 - 6 presents the average annual discharge, median flow, and estimated baseflow statistics for the gauges on Whites Creek and Talbot River.

Table 5 - 6: Streamflow and baseflow statistics at study area stream gauges (Earthfx, 2014).

ID	Name	UTM Northing (m)	UTM Easting (m)	Available Period of Record	Days of Available Data	Watershed Area* (km^2)	Average Discharge (m^3/s)	Q_{50} (m^3/s)	Estimated Baseflow (m^3/s)
LS0109	Talbot River at Gamebridge	4,929,960	649,498	2005-2011	2,389	328	5.45	3.79	--
LS0402	Whites Creek at Regional Rd 23	4,922,512	647,493	2009-2013	1,679	88.0	0.863	0.394	0.36
	Talbot River at Kirkfield Rd.	4,939,971	660,872	2014-2015	600	160	2.62	1.777	

Baseflow

Baseflow is the portion of flow in a watercourse that comes from groundwater discharge, rather than direct runoff related to rain or snowmelt events. During most of the year, stream flow is composed of both groundwater contribution and surface runoff. Baseflow conditions are deemed to exist when groundwater provides the entire flow of a stream. Ultimately, sustained groundwater inflow into the tributaries means sustained water levels and healthy conditions for the lakes.

Natural land cover plays an important role in recharging aquifers and hence sustaining baseflow. Human activities such as urbanization, wetland drainage, deforestation, and an increase in impervious surfaces within a watershed can significantly affect recharge to groundwater and subsequently, baseflow conditions.

Baseflow monitoring provides baseline data and long-term trends of baseflow rates throughout the watershed. Monitoring also allows for the determination of the spatial distribution of baseflow, including areas and stream reaches of significant groundwater discharge. It also provides valuable information for fish and water resources management.

Methodology

Baseflow monitoring involves measuring the discharge at designated locations during prolonged periods of dry weather. In general, the sample sites were located at every stream-road crossing throughout the watershed.

Criteria for the site selection include:

- Accessibility – preference was given to easily accessible, public sites;
- Hydrological features – it is important to locate sites upstream and downstream of the confluence of tributaries, suggested groundwater discharge areas etc.; and,
- Water use features – upstream and downstream of water taking or discharge locations.

Baseflow sampling was conducted following standardized procedures described in Hinton, 2005. In order to collect comparable and reliable data, the stream flow measurements are to be performed under consistent groundwater inflow conditions; meaning the volume of groundwater storage should not experience significant change. Therefore, the survey is to be conducted under dry conditions when no significant precipitation has occurred during the previous two weeks, in the shortest possible period of time. Data analysis involves calculation and mapping of discharge and net discharge at every measured point and net discharges per a square kilometer (Figure 5 - 13).

The baseflow data for the upper portion of the Talbot River watershed that forms Mitchell and Canal lakes subwatersheds were collected during the summer of 2015 by Kawartha Conservation. In total, 59 sites throughout the study area were visited (Table 5-7). Nineteen sites were found flowing and were measured. Fourteen sites were visibly flowing, but not suitable for measurements (too deep to measure by wading). Thirteen sites were found dry or with standing water in the channel, indicating that no groundwater contribution was occurring upstream of the sampling location.

Table 5 - 7: Baseflow Monitoring in the upper portion of the Upper Talbot River subwatershed

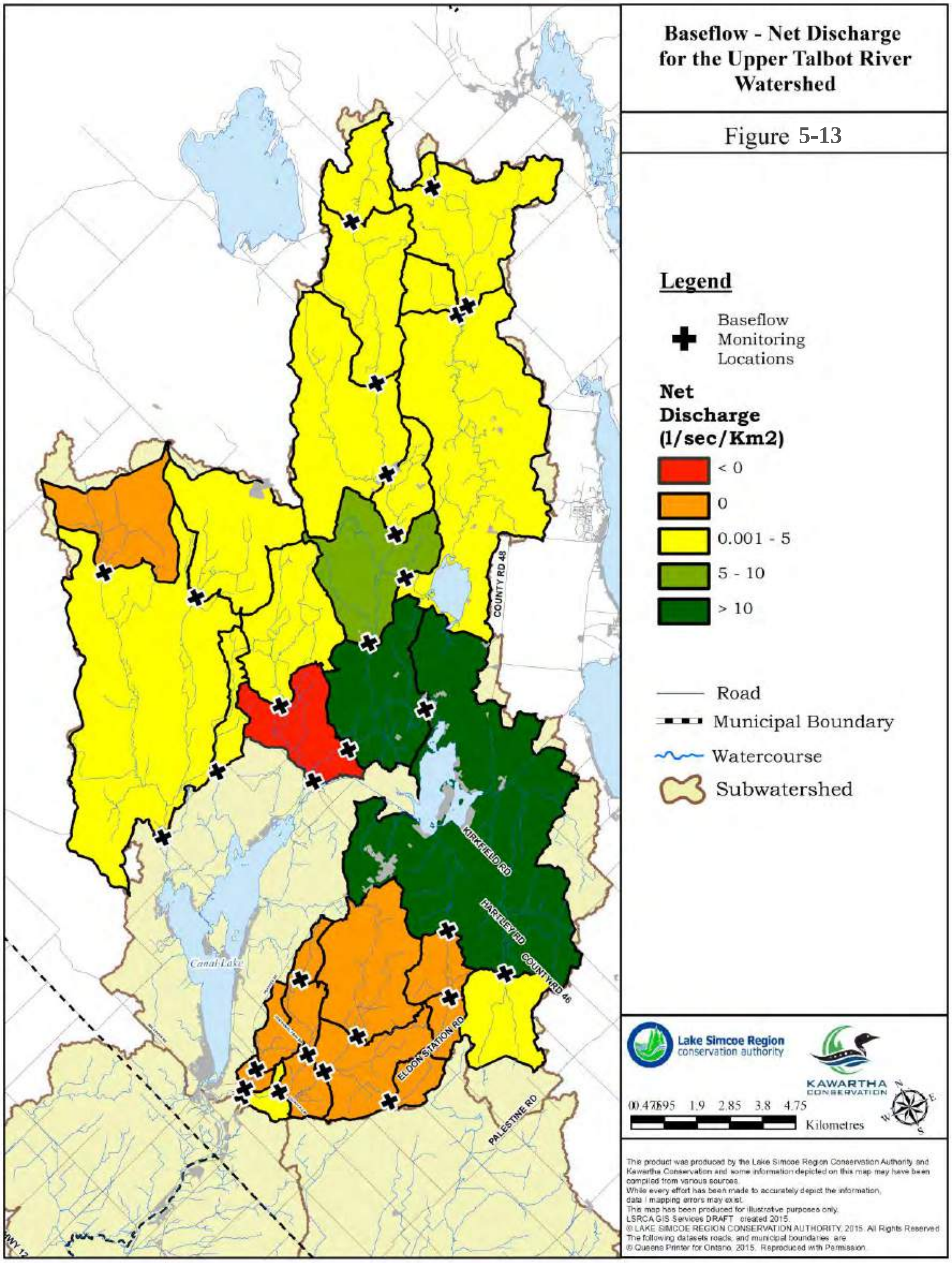
Number of Stations				
Total	**Measured**	**Not suitable for measurement**	**Dry / No Flow**	**Not found / Not accessible**
59	19	14	13	12

Further data analysis involves calculation of net discharges at every measuring point and net discharges per square kilometer. Based on the observed data, map of the groundwater net discharge has been generated (Figure 5 - 13). This map shows distribution of the groundwater discharge throughout the watershed.

Overall, analysis has revealed that:

- Baseflow values throughout the Upper Talbot River watershed vary. The highest baseflow was observed at location situated downstream of Mitchell Lake, recorded at 32.6 l/sec/km^2. At the same time, number monitoring sites were found dry or with standing water.

- Headwaters of the Talbot River, including Perch Creek and northern tributaries of Canal Lake are characterized by low baseflow rates, less than 5 $l/sec/km^2$.
- Tributaries at the south portion of the Upper Talbot River subwatershed were recorded dry, which indicates non existing groundwater inflow during the period of low precipitation.
- Tributaries that flow into Mitchel Lake demonstrate the highest rates of the baseflow within the study area, generally over 10 $l/sec/km^2$.



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created 2015.
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Figure 5 - 13: Baseflow Distribution in the Upper Talbot Watershed

In addition to the field measurements in the study area, calibration of the groundwater submodel also provided useful insights on baseflow in the study area. In the steady state groundwater submodel, stream discharges represent long-term averages of the baseflow that is contributed to the stream reaches. Figure 5 - 19 shows the simulated average groundwater discharge to streams in m^3/d as determined using the calibrated steady-state groundwater model. Areas in blue represent stream reaches where groundwater is discharging to the stream (i.e. gaining reaches), while areas in red represent stream reaches that are losing water to the aquifer (i.e. losing reaches). Losing reaches are also simulated around many of the quarries, where lowered groundwater levels from quarry dewatering and increased discharges to streams imparts a downward gradient into the groundwater system (Earthfx, 2014). Overall, gaining reaches dominate the study area, indicating that many of the streams in the Whites Creek and Talbot River subwatersheds rely on baseflow to sustain their streamflows.

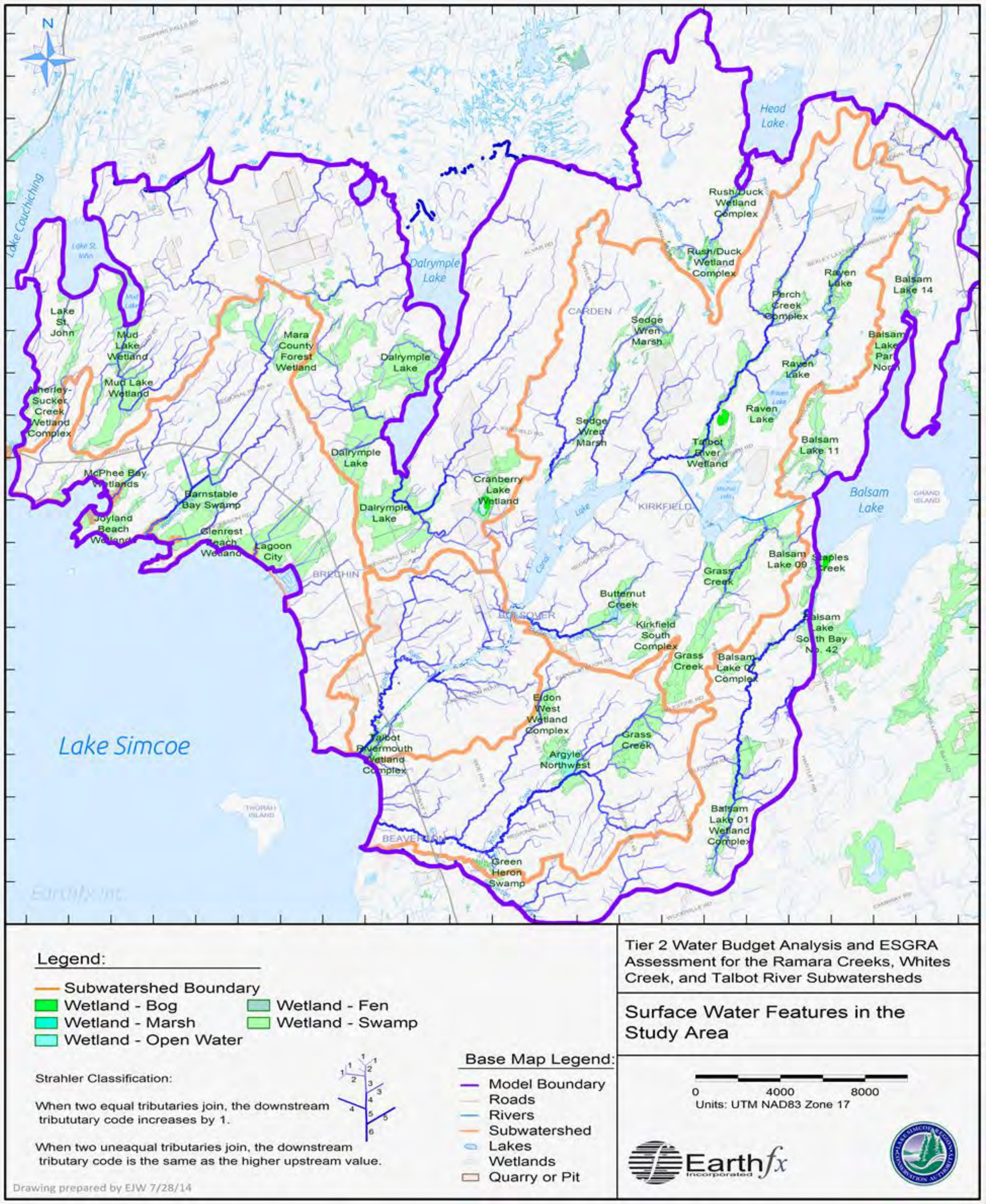


Figure 5 - 14: Study Area Surface Water Features (Earthfx, 2014).

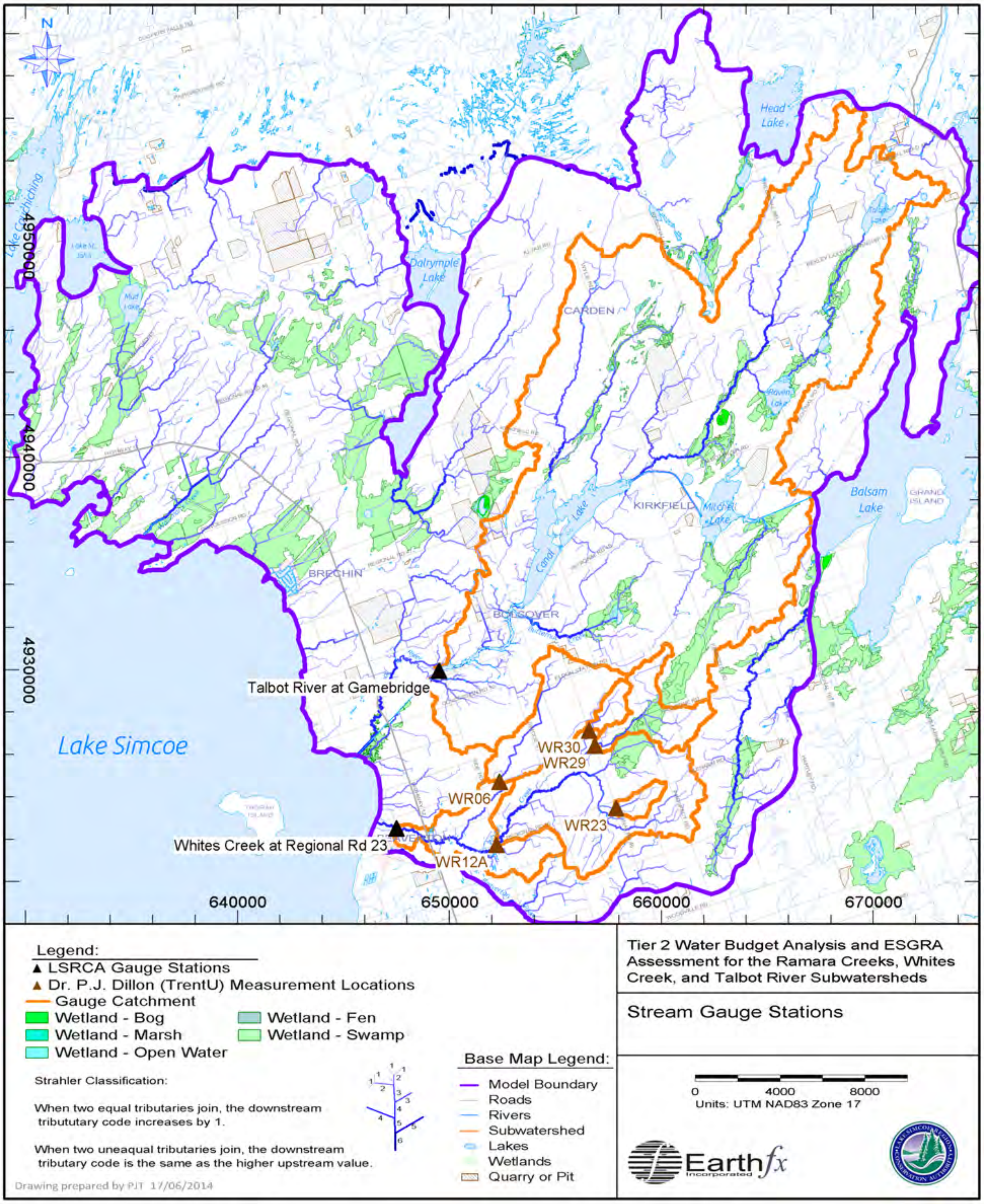


Figure 5 - 15: Stream Discharge Measurement Locations within the Study Area (Earthfx, 2014).

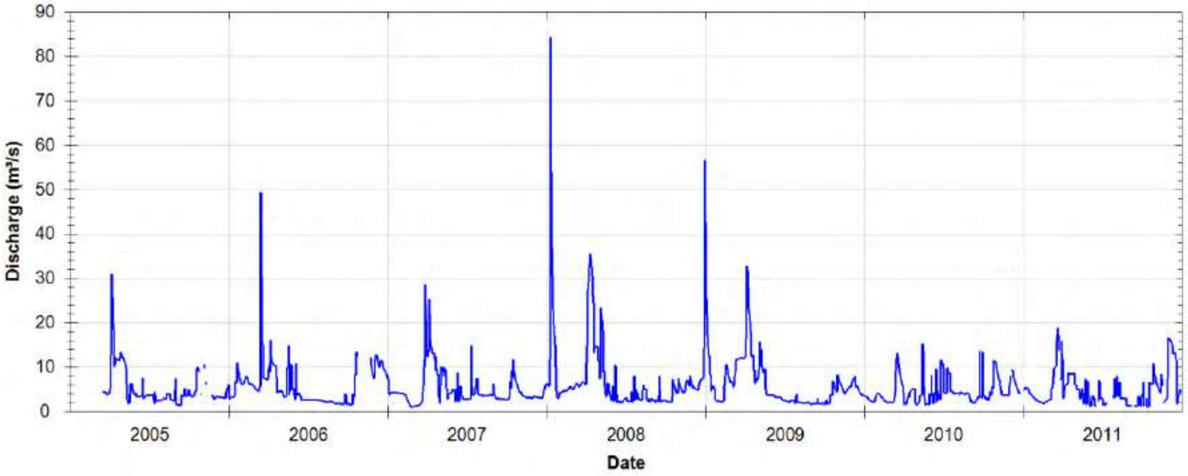


Figure 5 - 16: Mean daily discharge observed at Talbot River near Gamebridge (LS0109) (Earthfx, 2014).

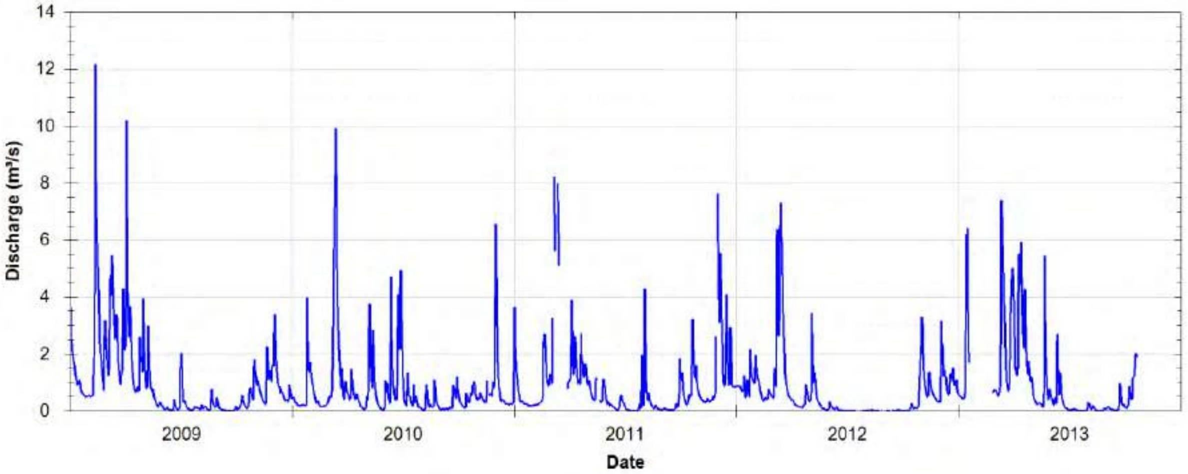


Figure 5 - 17: Mean daily discharge observed at Whites Creek at Regional Rd. 23 (LS0402) (Earthfx, 2014).

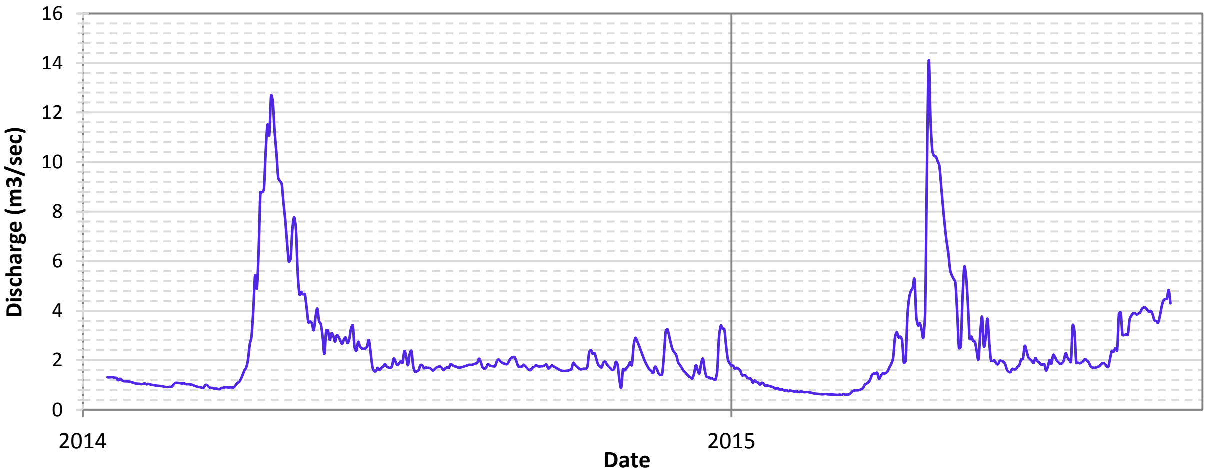


Figure 5 - 18: Mean daily discharge observed at Talbot River at Kirkfield Rd.

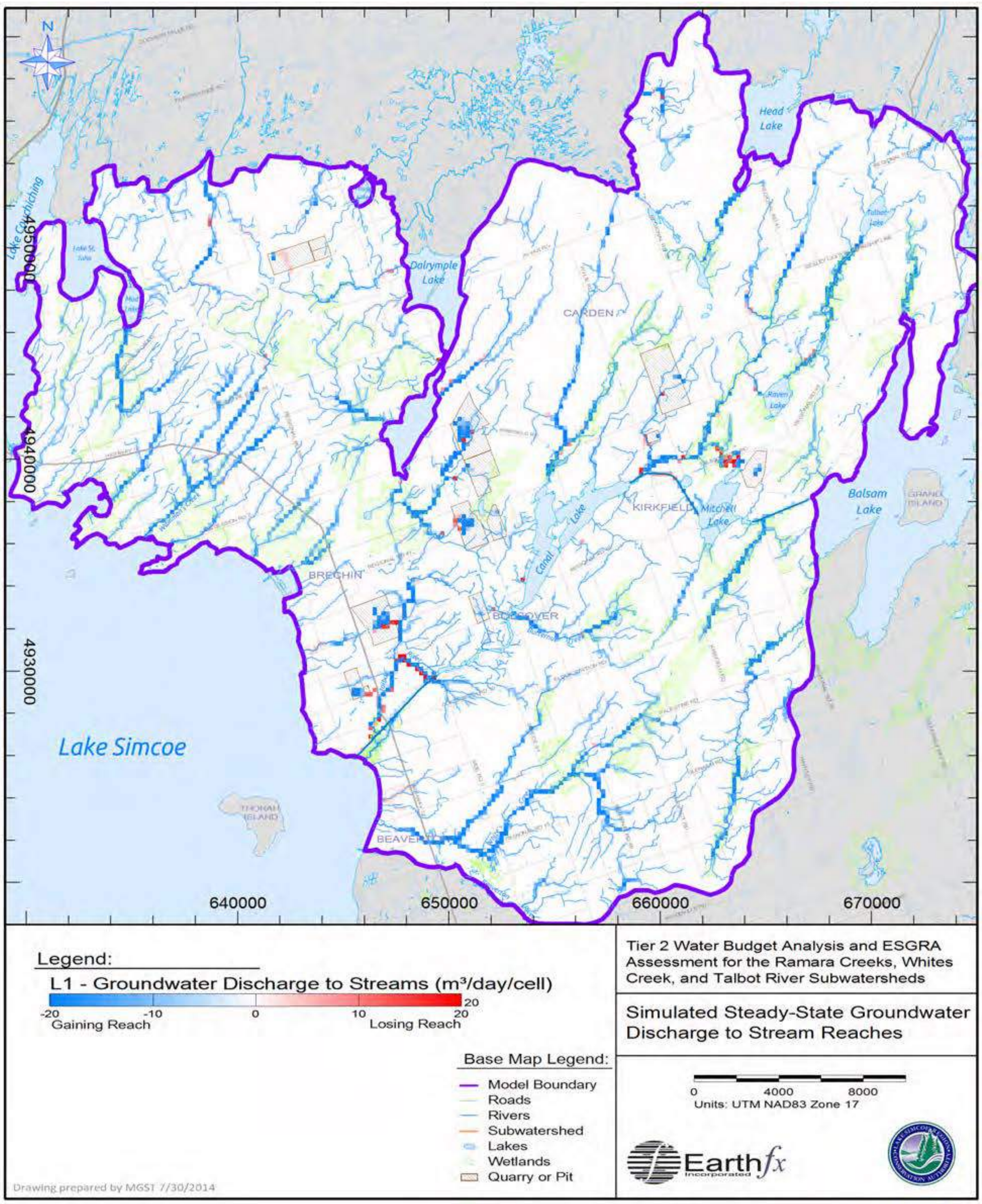


Figure 5 - 19: Gaining and losing reaches within the Talbot River and Whites Creek subwatersheds (Earthfx, 2014).

5.2.5 Groundwater Discharge

In areas where the static water table intersects the ground surface there is potential for discharge to occur. Groundwater discharge areas are often in low topographic areas and can be observed in and around watercourses in the form of springs and seeps, or as baseflow to streams. These areas are characterized by upward vertical hydraulic gradients. As described in the previous section, baseflow is the portion of water that is contributed from groundwater; this provides clean, cool water to streams and wetlands.

Groundwater discharge rates vary throughout the year due to seasonal and longer-term changes in recharge and groundwater potentials. Hydrograph separation techniques (as discussed in the previous section) applied to long term surface water flow records are the best methods for quantifying the portion of streamflow derived from groundwater discharge to streams. However, as discussed in Section 4.2.4 there is only one reliable stream gauge within the study area subwatersheds. The data gathered at this single stream gauge cannot be used to accurately quantify groundwater discharge rates across the entire study area; as a result hydrograph separation techniques were not applied. Instead, groundwater discharge patterns across the Whites Creek and Talbot River subwatersheds were interpreted through the simulation of various scenarios using the integrated surface and groundwater model designed to evaluate water quantity and flow in the greater Tier 2 Ramara Creeks, Whites Creek, and Talbot River model area. The calibration targets for the integrated groundwater/surface water model included the groundwater levels and flow patterns observed from wells in the MOECC water well database (MOECC WWIS database), in conjunction with streamflow data gathered from gauge stations present in the Talbot River and Whites Creek subwatersheds.

Simulated groundwater discharge to streams under current conditions is illustrated in Figure 5 - 20. As seen in the figure, discharge rates range from very low in some of the headwater reaches to high in areas where the Talbot River and Whites Creek discharge to Lake Simcoe. Average groundwater discharge to the study area subwatersheds under current conditions is estimated to be 118,166 m^3/day for the Talbot River subwatershed and 13,647 m^3/day for the Whites Creek subwatershed.

Simulated groundwater discharge values were also used to evaluate the response of surface and groundwater systems under drought scenarios. The Earthfx (2014) study used the integrated surface/groundwater model to simulate the effects of two drought scenarios across the model area. The first analysis represented an extreme 2-year drought condition where recharge across the area was assumed to be zero over that time period. The second scenario was used to evaluate the response of the ground/surface water system to a historic 10-year period of low rainfall from 1957 to 1967. This analysis allowed for the examination of how groundwater discharge would be affected under a similar period of low rainfall. Details regarding the simulation and results of the drought scenarios are further discussed in section 4.4.4.

The monthly average groundwater discharge to the Talbot River and Whites Creeks subwatersheds at the beginning of the 10-year drought is illustrated in Figure 5 - 21, while stream discharge at the worst of the 10-year drought (November 1964) is illustrated in Figure 5 - 22. Simulated groundwater discharge to streams, as shown in these figures, represents the accumulated leakage into the streams across the stream bed (also referred to as hyporheic flow). As illustrated in Figure 5 - 23, the most pronounced impact of the drought occurs at the headwater tributaries in the subwatersheds. This is particularly noticeable around the upland Carden Plain Alvar area in the upper Talbot River subwatershed, where many tributaries exhibit a nearly 100% decrease in flow (Figure 5 - 23). Headwater tributaries in the subwatersheds are sustained mainly by groundwater discharge that occurs where the streambed intersects the water table. Because of their strong reliance on groundwater discharge, these tributaries are sensitive to very small changes in groundwater levels.

As discussed in Chapter 2, **(section 2.4.1.3)** the Carden Plain Alvar is characterized by a very thin to absent soil layer, and the presence of highly fractured Paleozoic limestone bedrock. Due to the fractured nature of the bedrock and largely absent soil layer, the alvar exhibits very low storage capacity. The low storage capacity of the bedrock aquifers means that streams fed by the alvar are less buffered from the effects of long term drought - this explains why the tributaries of the Carden Plain Alvar are so drastically impacted under the simulated drought scenarios. The low storage and fractured nature of the alvar also highlights the localized, highly interconnected nature between the recharge and discharge features of the subwatershed. In other regions of the study area, such as the Whites Creek and lower Talbot subwatersheds, higher storage capacities, and lower hydraulic conductivities, keep water levels higher. Due to the support provided by the groundwater system, tributaries in these other regions of the study area are more resilient to drought.

The yearly average total groundwater discharge to the Talbot River and Whites Creek subwatersheds from 1957 to 1967 is illustrated in Figure 5 - 24, while the monthly average groundwater discharge to study area streams is presented in Figure 5 - 25. Groundwater discharge to streams is at its minimum in late summer/early fall and reaches a maximum in the late spring. The Talbot subwatershed, due to its larger size and high recharge rates associated with the fractured alvar bedrock, has the highest net groundwater discharge of the study catchments (Earthfx, 2014).

Under the 10-year drought scenario, the most severe drop in groundwater discharge for the Whites Creek subwatershed occurs in response to a dry period in April 1959. The subwatershed's response to the dry periods in April 1959 and September/October 1960 is more extreme than in the Talbot River subwatershed. In the Whites Creek subwatershed, the rates of groundwater discharge are less affected by drought after 1960, while the Talbot River subwatershed groundwater discharge rates decrease slightly during that period, reaching a minimum in October/November 1964.

Changes in monthly groundwater discharge to major streams in the subwatersheds from the beginning of the 10-year drought to the height of the 10-year drought were also evaluated as part of the drought analysis. A 32.2% reduction in groundwater discharge to Whites Creek was predicted between July 1956 and November 1964 (the height of the drought period), while 43.9% and 40.7% reductions in groundwater discharge were predicted at the Upper Talbot River and Rohallion Creek in the upper Talbot subwatershed, respectively.

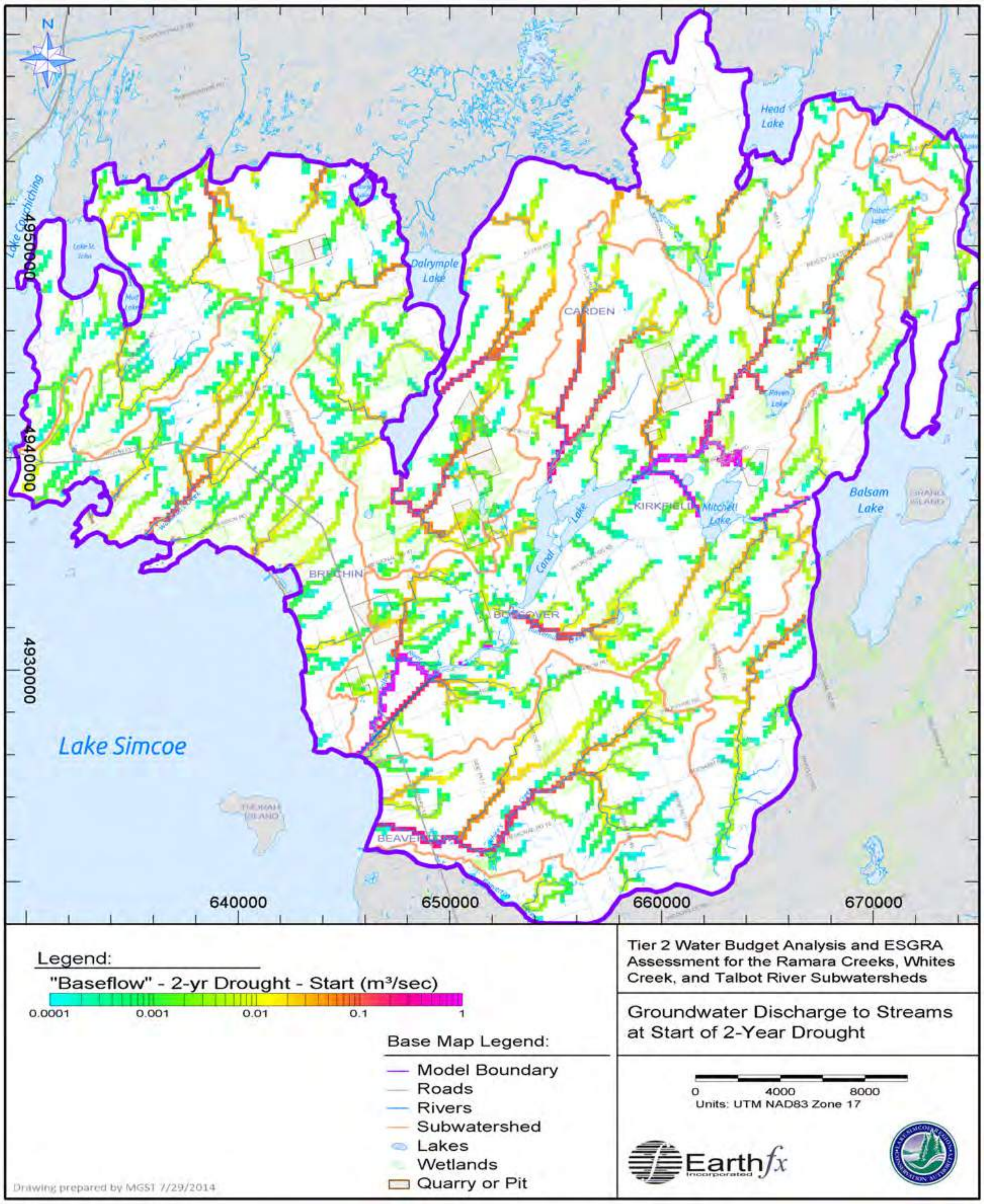


Figure 5 - 20: Simulated Groundwater discharge to streams (baseflow) under current conditions (Earthfx, 2014).

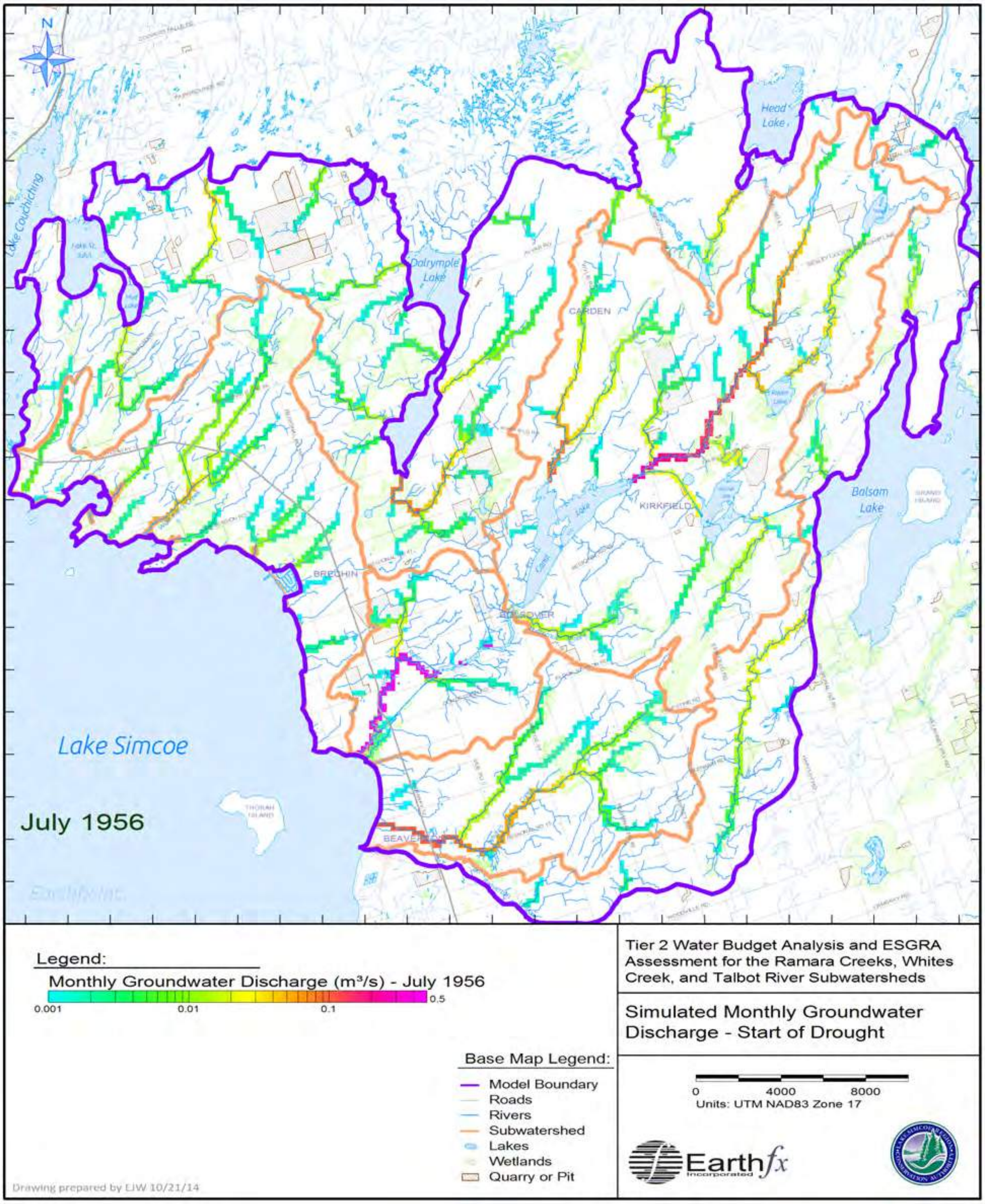


Figure 5 - 21: Simulated groundwater discharge to streams in July 1956 at the start of the 10 year drought (Earthfx, 2014).

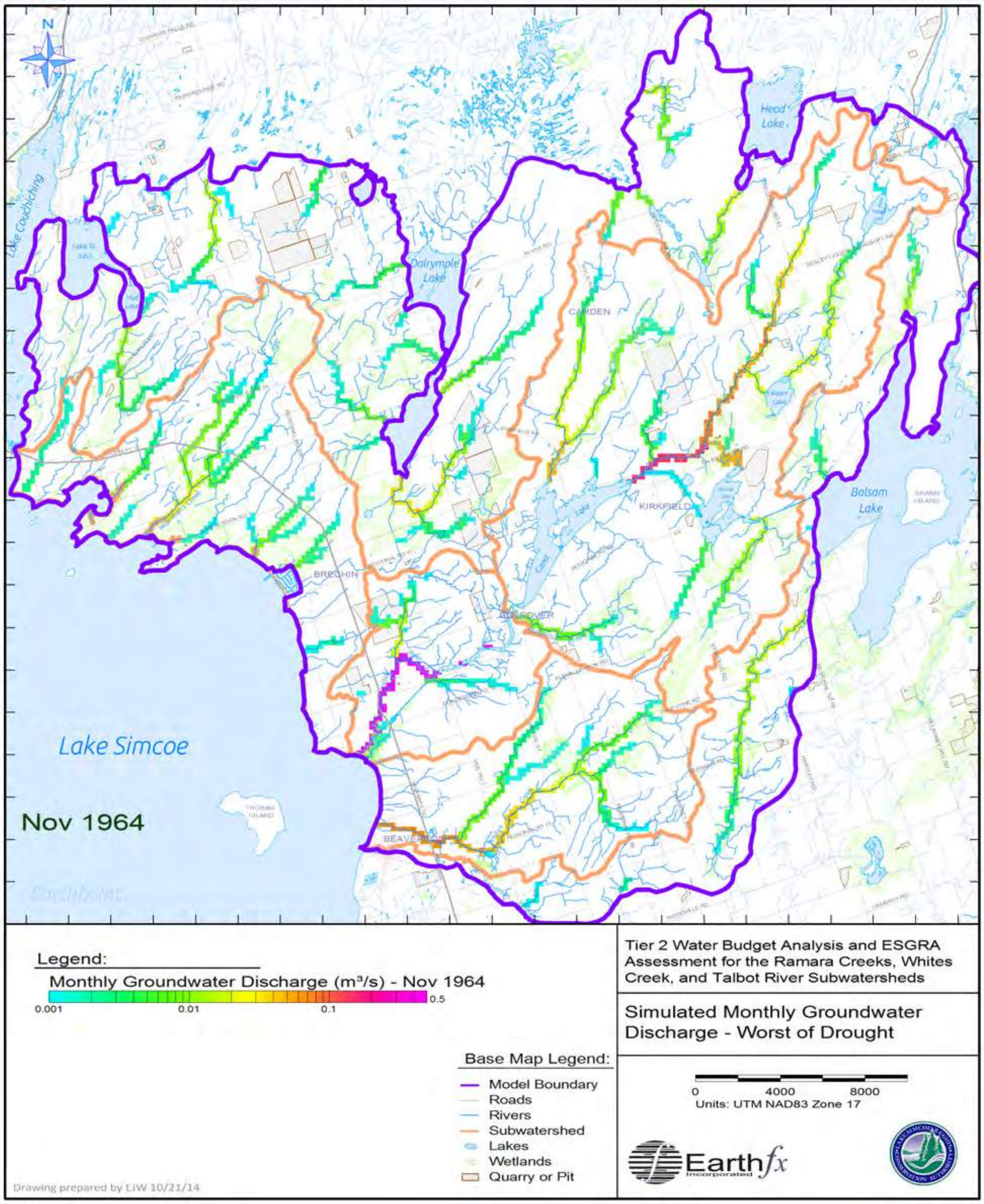


Figure 5 - 22: Simulated groundwater discharge to streams in November 1964 at the worst of the 10 year drought (Earthfx, 2014).

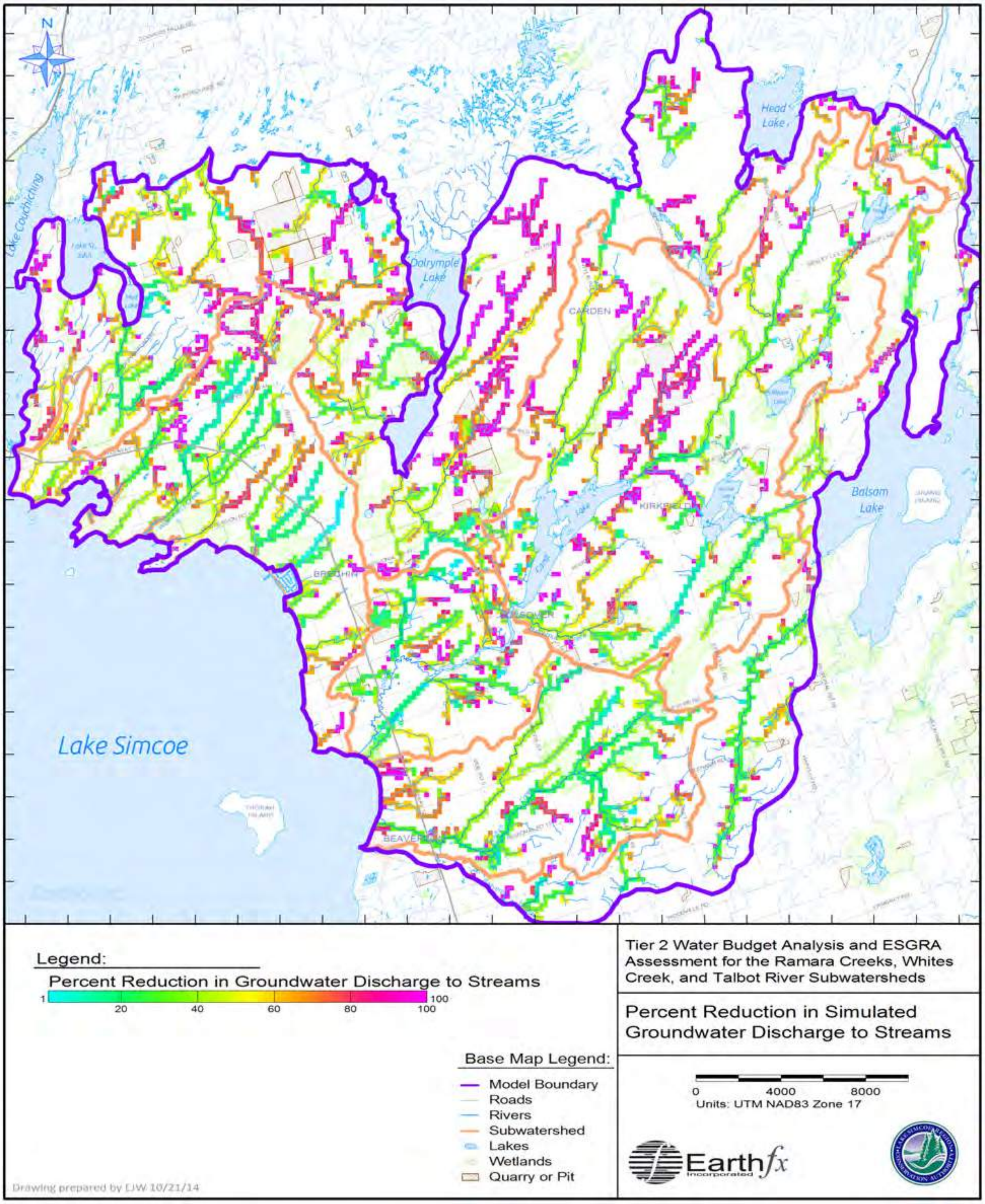


Figure 5 - 23: Percent reduction in simulated groundwater discharge to streams (July 1976 versus November 1964) (Earthfx, 2014).

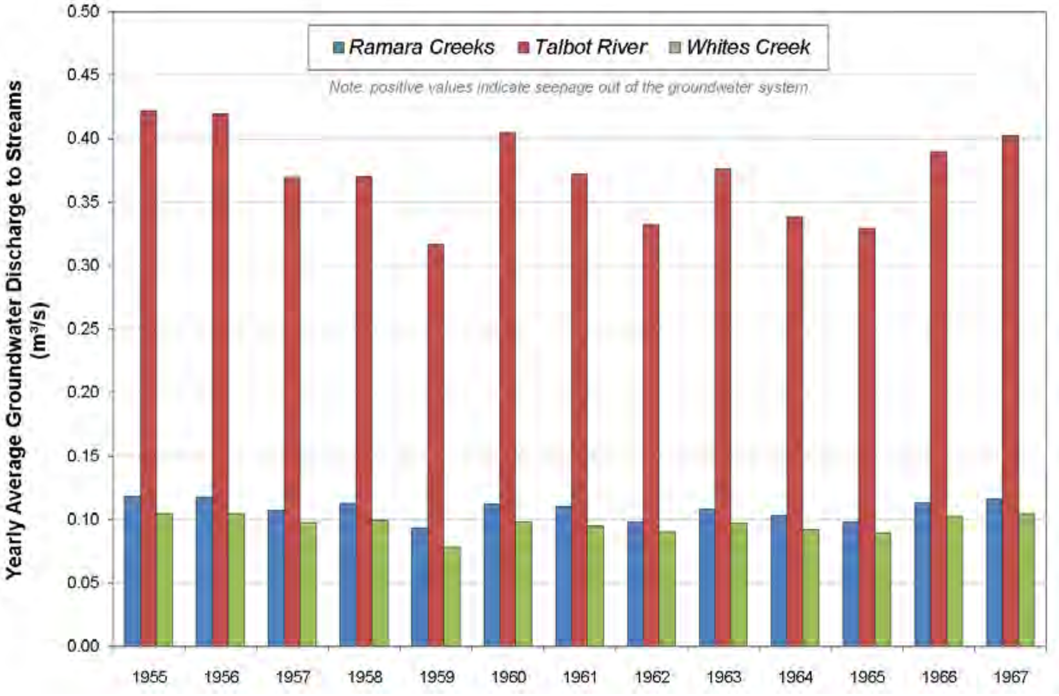


Figure 5 - 24: Simulated annual average groundwater discharge to stream channels (m³/s) in the study catchments (Earthfx, 2014)

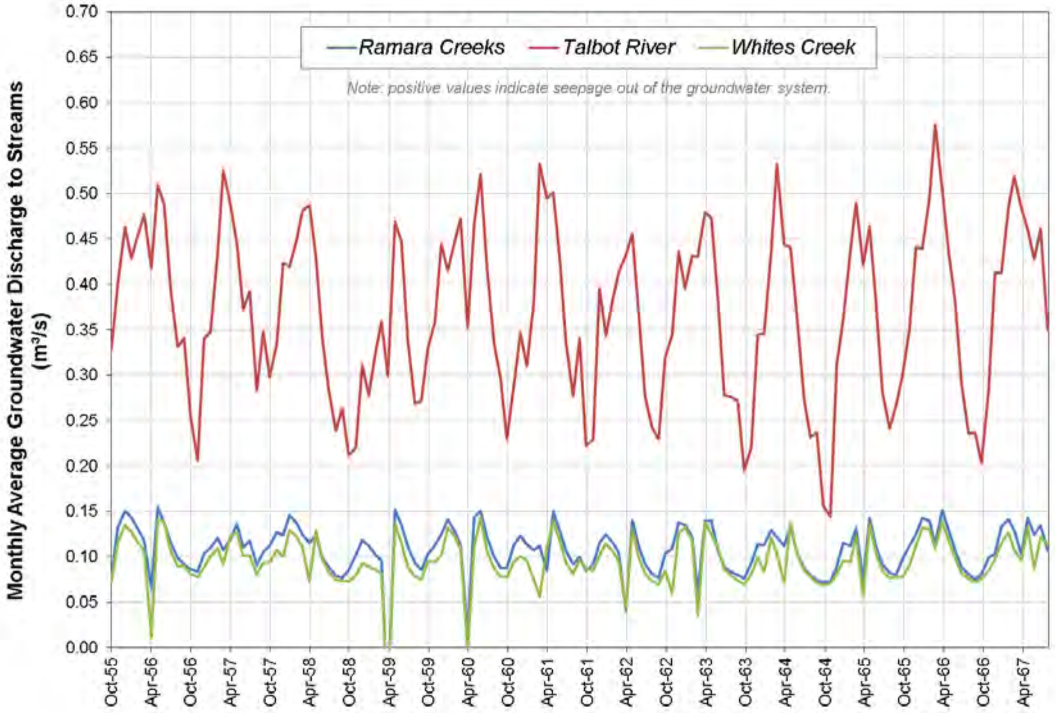


Figure 5 - 25: Simulated monthly average groundwater discharge to stream channels (m³/s) in the study catchments (Earthfx, 2014).

5.2.6 Groundwater Recharge

Groundwater is replenished as precipitation or snowmelt, and infiltrates into the ground surface. Precipitation is the primary source of groundwater recharge (i.e. the amount of water that infiltrates through the unsaturated zone and ultimately reaches the water table). However, the rate and direction of groundwater movement is influenced by the distribution and thickness of surficial geology and associated soil properties, topography, vegetation, land cover, and land use. For example, water will move more readily through coarse loose material and bedrock fractures than through material such as clay or unfractured rock. In areas where there are impervious surfaces, such as within urban areas, the amount of infiltration is reduced, while in areas of sands and sandy loam, infiltration rates are increased.

Mapping of recharge zones and the policies that protect them are necessary to ensure the sustainability of groundwater supplies and a healthy subwatershed. The rate of groundwater recharge varies over the subwatershed area and is controlled by the factors listed above.

Rates of recharge within the Whites Creek and Talbot River subwatersheds were originally predicted by the PRMS model completed by Earthfx (2010) for the whole Lake Simcoe basin in order to support basin wide Tier 2 water budget modelling work. However, through the completion of a more refined Tier 2 Water Budget study conducted specifically for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds, a more refined set of recharge rates were defined for the area.

The Tier 2 Water Budget study for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds was completed using an integrated ground and surface water model; the new integrated GSFLOW model represents an amalgamation of the two widely-recognized USGS models: PRMS and MODFLOW (Earthfx, 2014). The PRMS submodel evaluates the impacts of various combinations of precipitation, climate, topography, soil type, and land use on streamflow and groundwater recharge, while the MODFLOW submodel simulates groundwater flow in multi-layered aquifer systems. The two models are coupled in GSFLOW through an integrated calibration exercise in which parameter values for both of the sub-models are adjusted. This stepwise process is necessary due to the complexity of the surface water and groundwater systems in region. The result of the integration is a detailed representation of surface and groundwater interactions in the study area.

Using the refined PRMS surface water submodel, annual average groundwater recharge across the Ramara Creeks, Whites Creek, and Talbot River subwatersheds was estimated to be 151 mm/year, compared to the 164 mm/year predicted by the 2010 PRMS model completed for the Lake Simcoe basin. Figure 5 - 26 illustrates that the groundwater recharge rates for the Whites Creek and Talbot River subwatersheds range from a low of near zero to 500mm/year. Recharge rates across the study area are highly varied due to the diverse surficial geology found across the landscape. Generally, greater recharge tends to occur on the alvar in the Upper Talbot subwatershed. As discussed in **Chapter 2 (section 2.4.1.3),** the Carden Plain Alvar is characterized by the presence of a bare to very thinly covered, highly fractured, Paleozoic limestone bedrock. Due to its carbonate composition, the alvar is susceptible to dissolution processes by aqueous solutions (i.e. rainwater dissolved with CO^2). The dissolution of the alvar results in the formation of unique features across the landscape known as Karst. Notable karst features found in the model area include solutionally enlarged joints called “grikes”. These large fractured joints allow significant amounts of recharge to rapidly enter the groundwater system, and move vertically through the shallow bedrock (Earthfx, 2014). The presence of these fractures explains the considerably higher recharge rates predicted over these unique alvar areas. Although the Alvar Plain provides high recharge to portions of the study area, the feature (as discussed in section 4.2.5) has a low storage capacity, meaning that much of the recharge that enters the groundwater system is quickly moved through the subsurface and discharged to local streams and tributaries (Earthfx, 2014). Due to the low storage capacity of the alvar, streams fed by alvar recharge features are less buffered to the effects of long term drought (Earthfx, 2014).

High to moderate recharge rates are also observed across the sandier regions of the study area. These areas of sand are associated with the small zones of higher recharge observed in the lower Talbot and Whites Creek subwatersheds. The formation of these sandier areas can likely be attributed to the deposition of ice-contact stratified sediments during the waning stages of glaciation, when meltwater streams deposited bodies of sand and gravel. Other sand deposits in the study area may be the result of wave action or shallow water depositional processes in post- glacial lakes that formed after the last glacial recession.

Recharge rates are lower in areas where the Newmarket and Dummer Till are present (Earthfx, 2014). This is due to the fine grained sandy silt to silty sand composition of the Tills which contributes to lower hydraulic conductivities and therefore lower recharge rates. The Newmarket Till is predominantly found in the Whites Creek and lower Talbot subwatersheds, while the Dummer Till is distinctly found along the north-eastern boundary of the upper Talbot River subwatershed. The distinct connections between geology and groundwater recharge indicate that groundwater recharge in the area is largely dominated by surficial geology.

Significant Groundwater Recharge Areas

Significant groundwater recharge areas can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources. The mapping of these recharge zones is necessary to ensure the sustainability of groundwater supplies. In turn, land development plans should consider the protection of these areas in order to maintain the quantity and quality of groundwater required by a healthy subwatershed.

Significant Groundwater Recharge Areas were developed for the entire Lake Simcoe watershed to meet the technical requirements under the Clean Water Act, 2006. The recharge areas were delineated by using the PRMS – surface water models developed through source water protection studies (Earthfx, 2010b). The Whites Creek and lower Talbot River were included in the Lake Simcoe PRMS modelling study, while the Upper Talbot River subwatershed was included in the Black Severn Modelling study. Significant Groundwater Recharge Areas represent areas where the recharge rate is 15% greater than the average recharge across the watershed. The average recharge for Whites Creek subwatershed and the Lower Talbot River subwatershed was predicted to be 164 mm/year by the 2010 Lake Simcoe PRMS surface water model. As a result, areas with an average recharge rate of 189 mm/year or greater were classified as significant groundwater recharge areas. Whereas, the average recharge of the

Upper Talbot was predicted to be 244 mm/year by the Black Severn PRMS model. The shaded areas within Figure 5 - 27 the significant groundwater recharge areas within both these subwatersheds.

The recharge mapping delineated through the Tier 2 study of the Ramara Creeks, Whites Creek, and Talbot River show that the upper portion of the Talbot River subwatershed is characterized by an area of high recharge due to the presence of the highly fractured, low storage alvar bedrock. In the Lower Talbot and Whites Creek subwatersheds, the significant groundwater recharge areas generally coincide with areas of sand and gravel deposits. Even though the subwatershed is shown to have high recharge rates (Figure 5 - 26), much of the Talbot River subwatershed is not classified as Significant Groundwater Recharge Areas (Figure 5 - 27). This is due to the entire Black Severn Source Protection Area having annual average recharge rates that are high (244 mm/yr) and only those areas that are 15% higher than that average can be classified as Significant Groundwater Recharge Areas.

Ecologically Significant Groundwater Recharge Areas

Ecologically Significant Groundwater Recharge Areas (ESGRAs) are identified as areas of land that are responsible for supporting groundwater systems that sustain sensitive features like streams and wetlands. To establish the ecological significance of a recharge area, a linkage must be present between a recharge area and an ecologically significant feature (e.g. a reach of a stream, a wetland, or pond). The identification of an ESGRA is not related to the volume of recharge that may be occurring; rather they represent pathways in which recharge, if it occurred, would reach an ecologically significant feature.

ESGRAs were delineated for the Whites Creek and Talbot River subwatersheds by Earthfx (2014) using a calibrated GSFLOW model that relies on particle tracking methodology to trace the flow of groundwater to ecologically significant locations within the watershed. The particle tracking methodology involves the release of virtual particles from specified discharge points within the subwatershed (i.e. streams and wetlands). The features from which the virtual particles were released are highlighted in Figure 5 - 28. After being released, particles are tracked backwards until they reach a point where their path intersects the land surface (e.g. a recharge area). These intersection points are referred to as endpoints. Using this methodology, groundwater flow pathlines can be determined by connecting points along the particle path. Particle endpoints and flow paths help establish the parameters of the regional flow system, and outline the flow of groundwater to ecologically significant locations like streams and wetlands.

ESGRAs that support the ecologically significant features within the subwatershed were delineated by a statistical method that analyses the density of endpoints established through particle tracking methodologies. This analysis is done by performing a cluster analysis using a Normalized Bivariate Kernel Density Estimation function. The cluster analysis is then used to convert the distribution of endpoints into an ESGRA.

Figure 5 - 29 identifies the endpoints of reverse tracked particles released from ecologically significant features such as streams and wetlands found within the subwatershed, while Figure 5 - 30 illustrates the flow pathlines outlined by reverse tracked particles. As shown in the figure,

the number of pathlines leaving the study area is not large, and the pathlines generally do not extend far beyond subwatershed boundaries. Nevertheless, some of the pathlines do indicate that certain surface water features, in particular the headwaters of the Talbot River, are likely receiving significant quantities of lateral groundwater inflow from recharge zones on portions of the Carden Plains Alvar that are located outside of subwatershed boundaries. Figure 5 - 31 shows the final ESGRAs delineated for the model area. ESGRAs make up approximately 36% and 27% of the Talbot River and Whites Creek subwatershed area, respectively.

Many of the ecologically significant features in the subwatersheds are located within unique geologic landforms called “tunnel valleys.” Tunnel valleys are formed by the sub-glacial processes that work to erode downward into the bedrock beneath the glacier ice. Over time, the lowland portions of these valleys became occupied by the streams, wetlands and lakes that characterize the landscape of the study area subwatersheds. ESGRAs in the Talbot River subwatershed generally correspond to the tops of the incised bedrock valleys. This trend was noted during the analysis of the backward- tracked particle pathlines, which were found to predominantly terminate at the tops of the interpreted tunnel valley extents. This pattern is particularly apparent in the southwest trending wetland complex originating just south of Mitchell Lake. Overall, the results of the backward tracking analysis indicate that the wetlands, rivers, and streams occupying the bottom of the tunnel valleys are largely being sustained by groundwater seepage supplied from atop the valley slopes; the result is an increased coverage of discrete ESGRAs, particularly within the Upper Talbot River subwatershed (Earthfx, 2014).

In the Whites Creek subwatershed, many of the backtracking particle pathlines terminate beyond the northern edge of the subwatershed boundary, indicating that surface water features in this subwatershed are largely supported by ESGRAs within the Talbot River subwatershed. Furthermore, the presence of the silt dominated Newmarket Till in the Whites Creek subwatershed likely results in reduced groundwater recharge within much of the subwatershed area (Earthfx, 2014).

In addition to the backward particle tracking method, a validation exercise utilizing a forward particle tracking methodology was employed to verify the reverse particle tracking analysis and ensure that significant recharge areas contributing to ecologically sensitive features were not missed. As a verification exercise, forward tracking was conducted from the delineated ESGRAs. Particles were released over the ESGRAs and forward tracked to a final destination. During the forward tracking exercise, particles are released and tracked across all cells in the study area in the direction of flow. During the exercise, a large number of particles are introduced to clearly show the discharge to ecologically significant locations. Forward tracking can be used to help define and visualize the regional flow system and identify linkages between the study area and those in adjacent subwatersheds. Results of the exercise are presented in Figure 5 - 32. In general, particle tracks end either in, or adjacent to, the stream and wetland features – this confirms the adequacy of the backward tracking methodology in delineating ESGRAs. Because of cross-watershed boundary flows, some particles released from within subwatershed boundaries travel outside of the study area to help support ecological features in other catchments. The presence of particle tracking endpoints from the Talbot River and Whites Creek subwatersheds in one another’s catchment areas indicates that surface water features along the shared catchment boundary of the two subwatersheds are supported by groundwater recharge from both subwatersheds (Earthfx, 2014). Other evidence of cross-boundary flow includes a number of forward tracking endpoints located just outside of the southern and eastern study area boundaries. These endpoints indicate that some of the recharge occurring within the study area may help support ecologically significant features in adjacent subwatersheds.

While Significant Groundwater Recharge Areas (SGRAs) represent high volume recharge areas, ESGRAs represent areas of land that contribute recharge to sensitive features of ecological significance. Areas of ESGRA and SGRA overlap (i.e. the tops of the incised bedrock valleys in the Talbot River subwatershed) provide significant volumes of recharge to ecologically sensitive features in the subwatershed (Figure 5 - 33). The modelling of SGRAs and ESGRAs can help illustrate the interaction between the surface and groundwater processes that affect the distribution of recharge and groundwater flow patterns. As an example, SGRAs identified along the lower portion of the Talbot and Whites Creek subwatersheds are associated with areas mapped as surficial sands; however the presence of an underlying low permeability till sequence restricts recharge, and therefore limits ESGRA support.

Areas designated as ESGRAs that do not coincide with areas of significant recharge (SGRAs) tend to represent lower volume, localized flow systems which provide flows needed to maintain nearby ecologically significant features. Both SGRAs and ESGRAs for the study area are shown in (Figure 5 - 33).

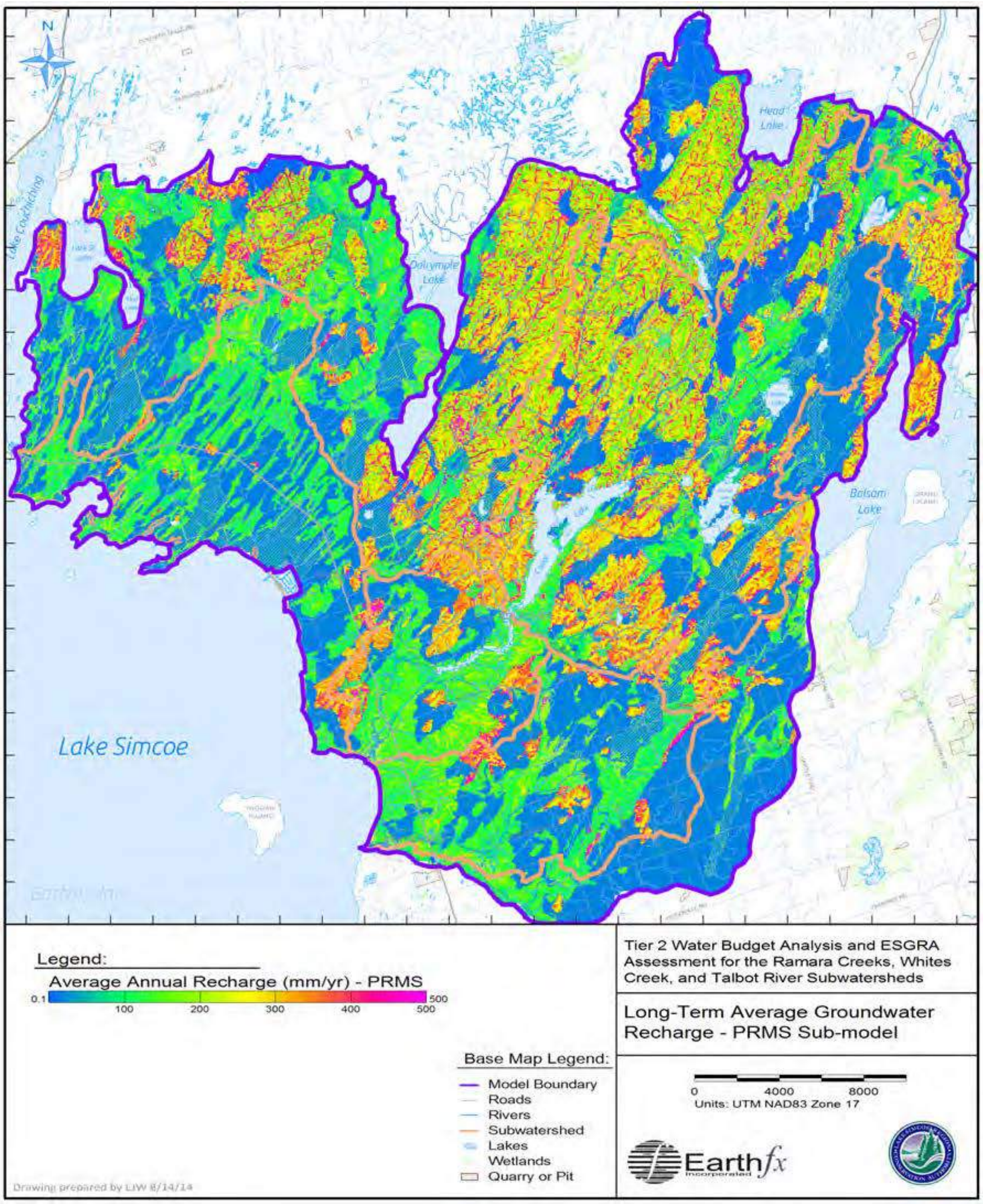


Figure 5 - 26: Simulated long-term average distribution of groundwater recharge (Earthfx, 2014).

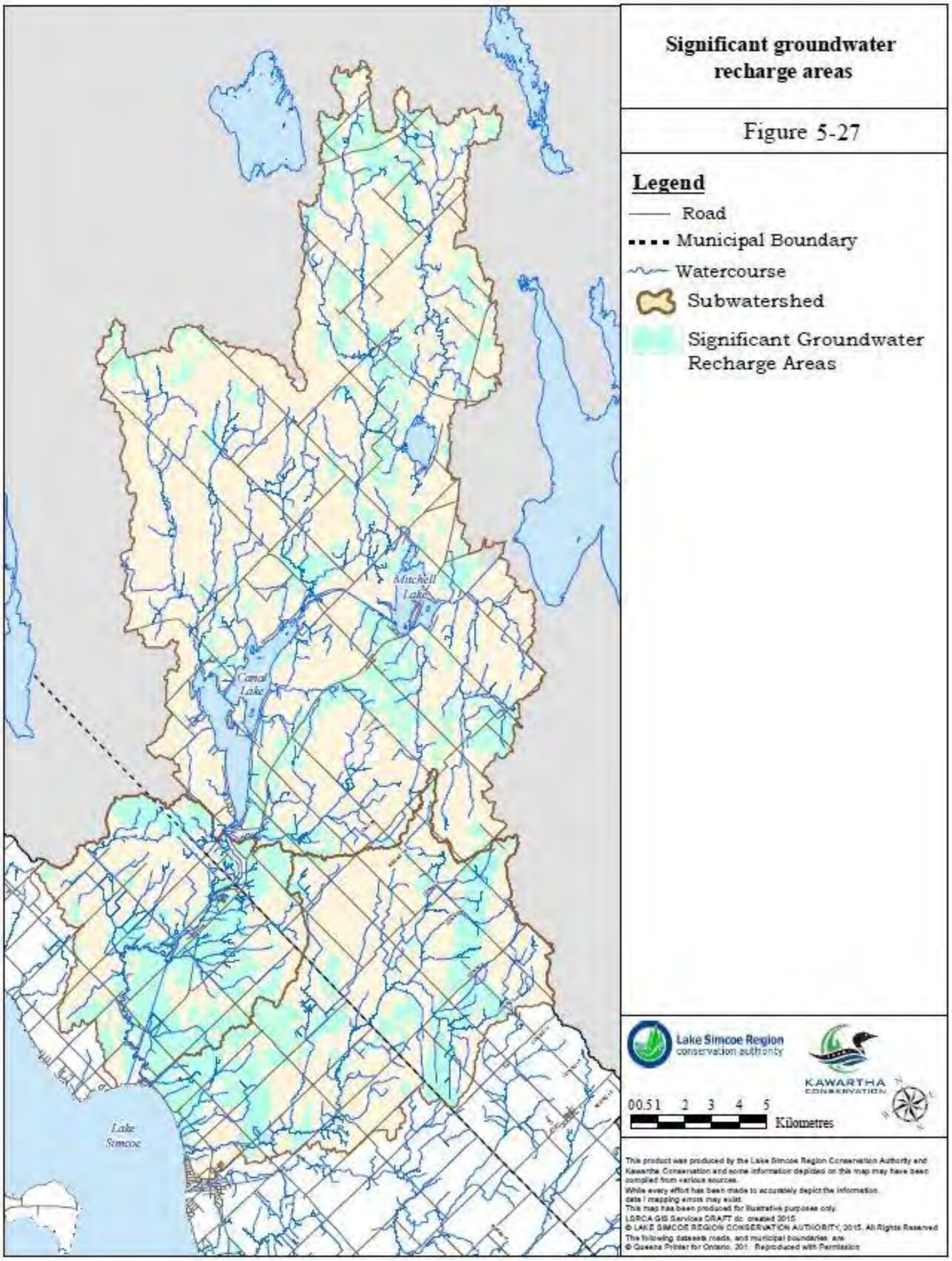


Figure 5 - 27: Significant Groundwater Recharge Areas.

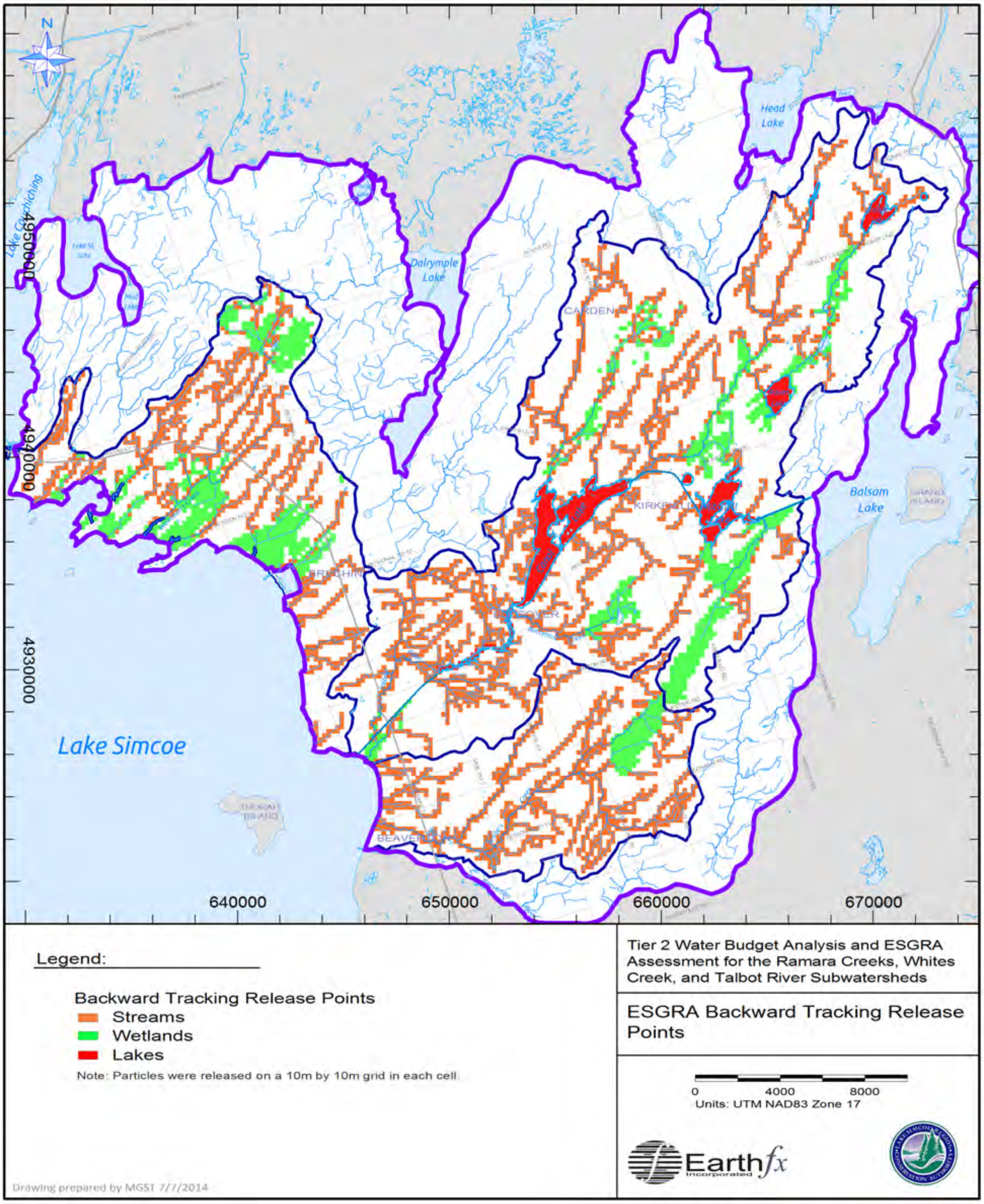


Figure 5 - 28: ESGRA backward tracking release points (Earthfx, 2014).

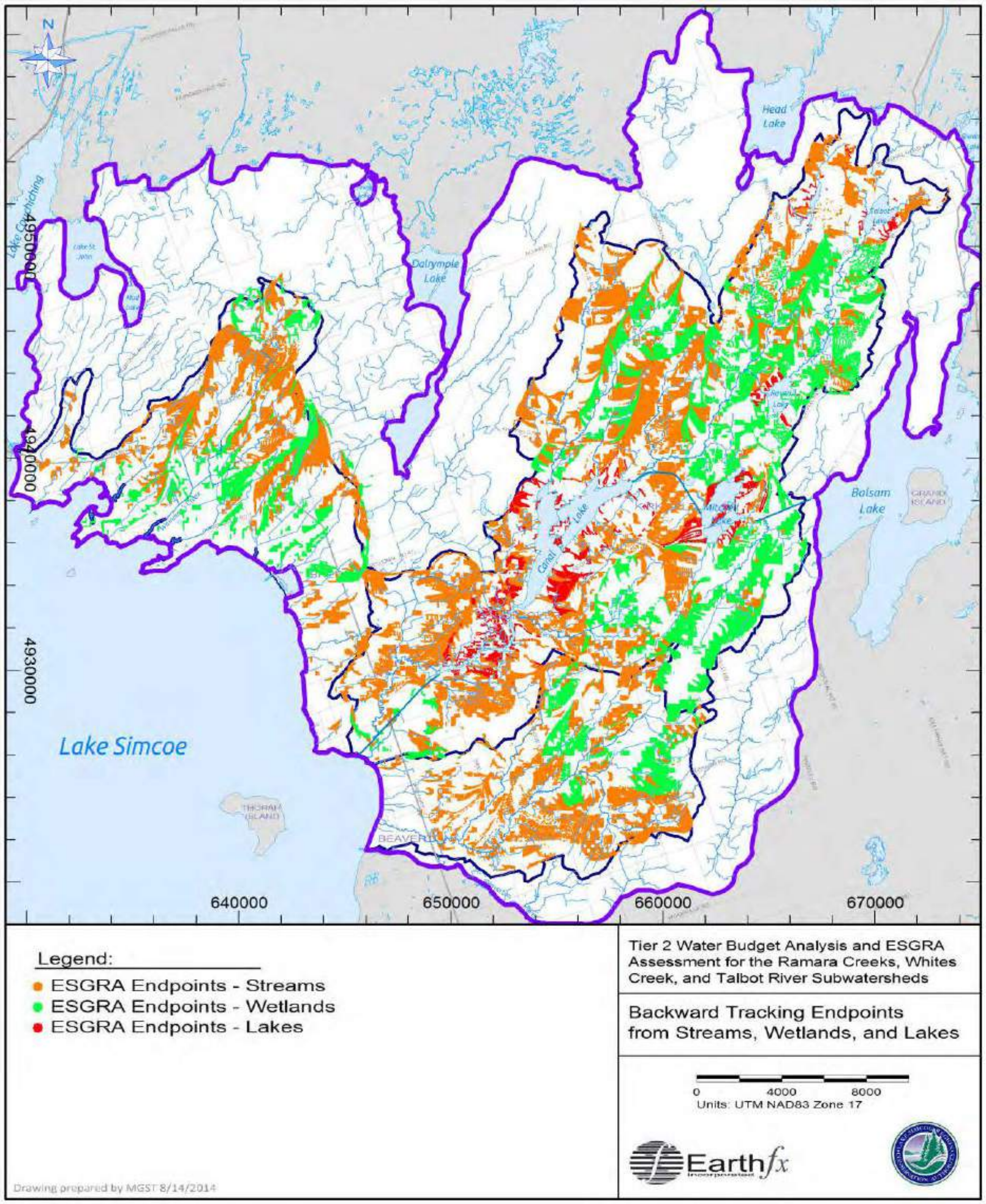


Figure 5 - 29: ESGRA endpoints for backward tracking from streams, wetlands and lakes (Earthfx, 2014).

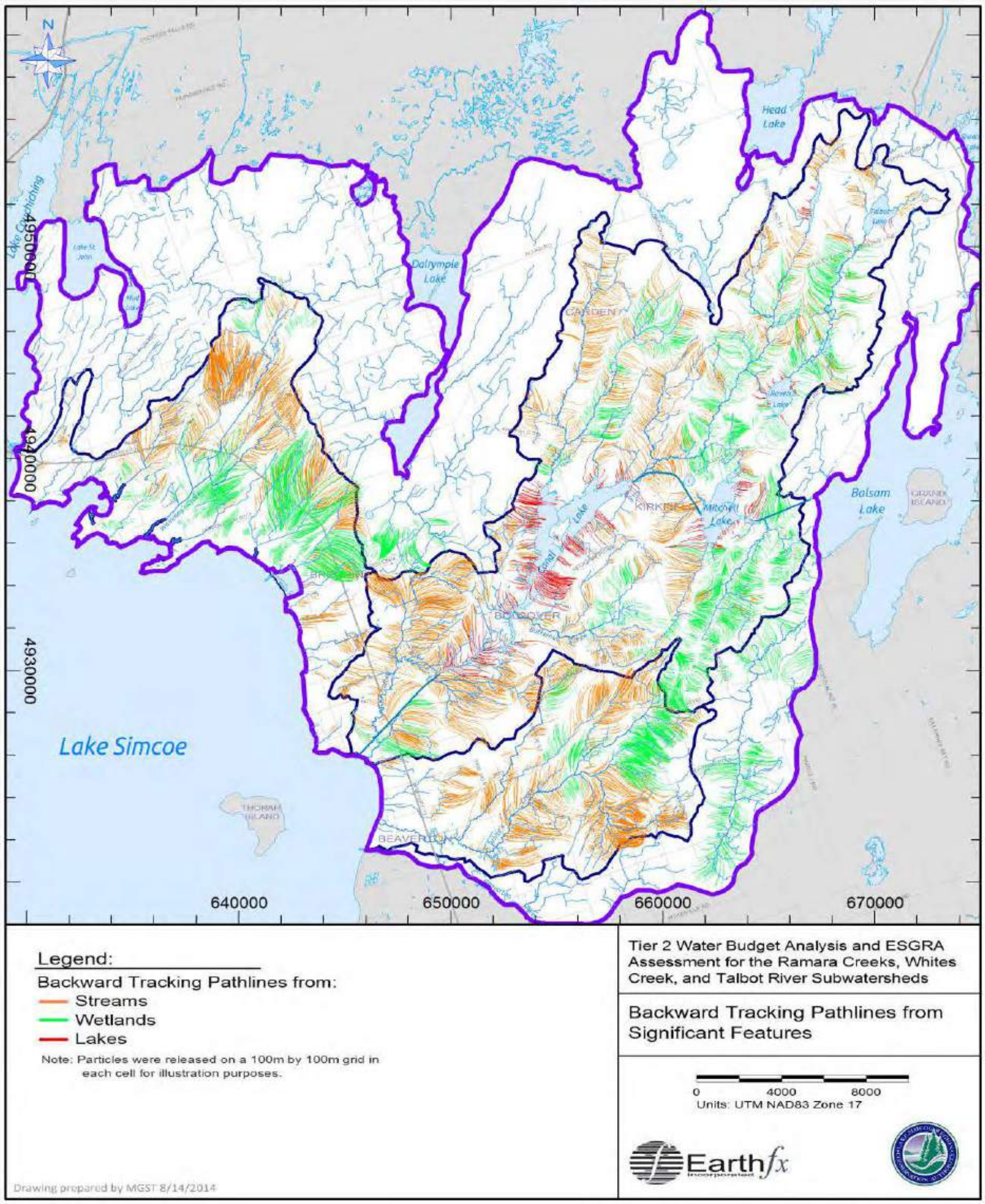


Figure 5 - 30: Backward tracking pathlines from significant features (Earthfx, 2014).

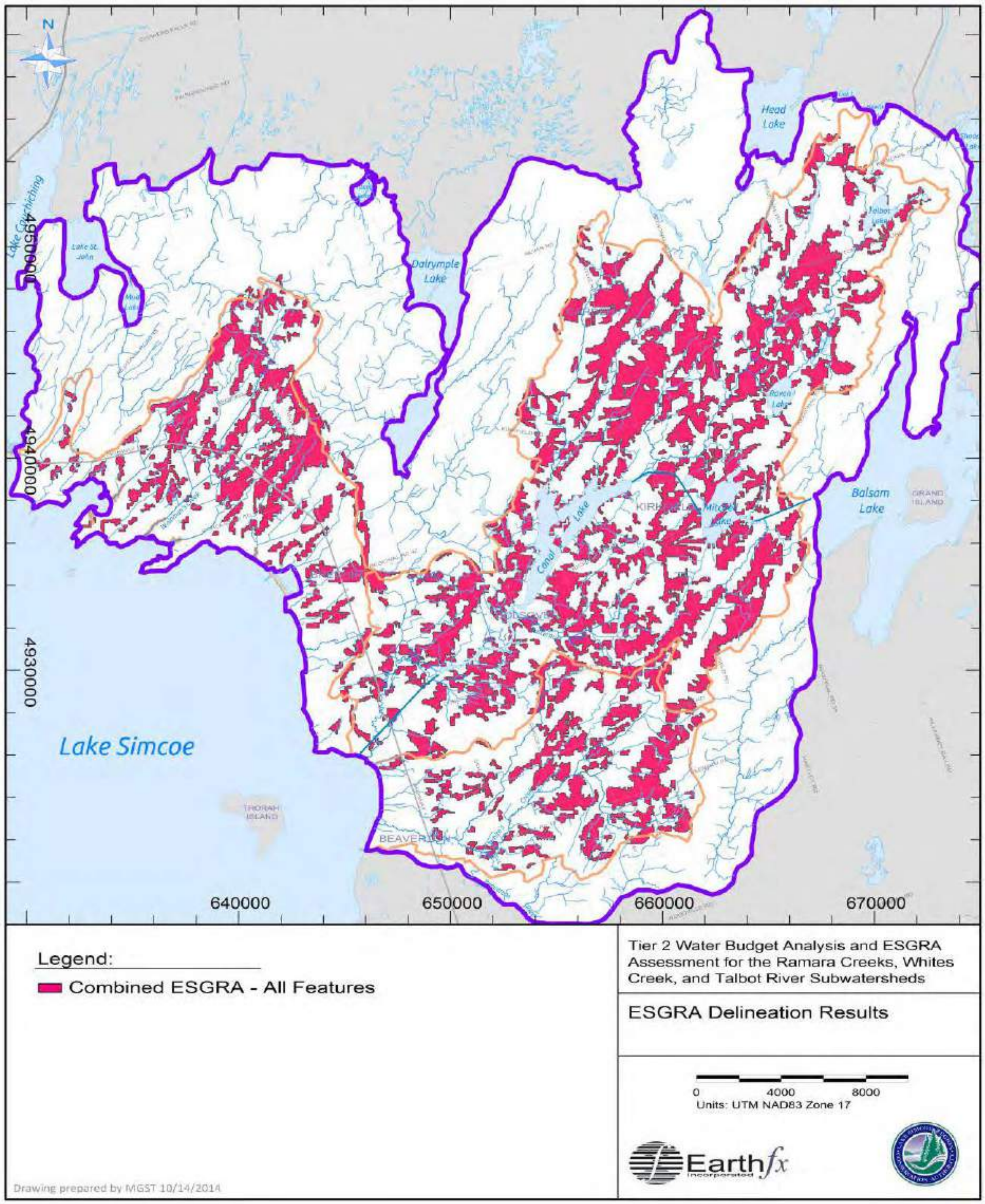


Figure 5 - 31: Combined ESGRA delineation by backward tracking from all features (Earthfx, 2014).

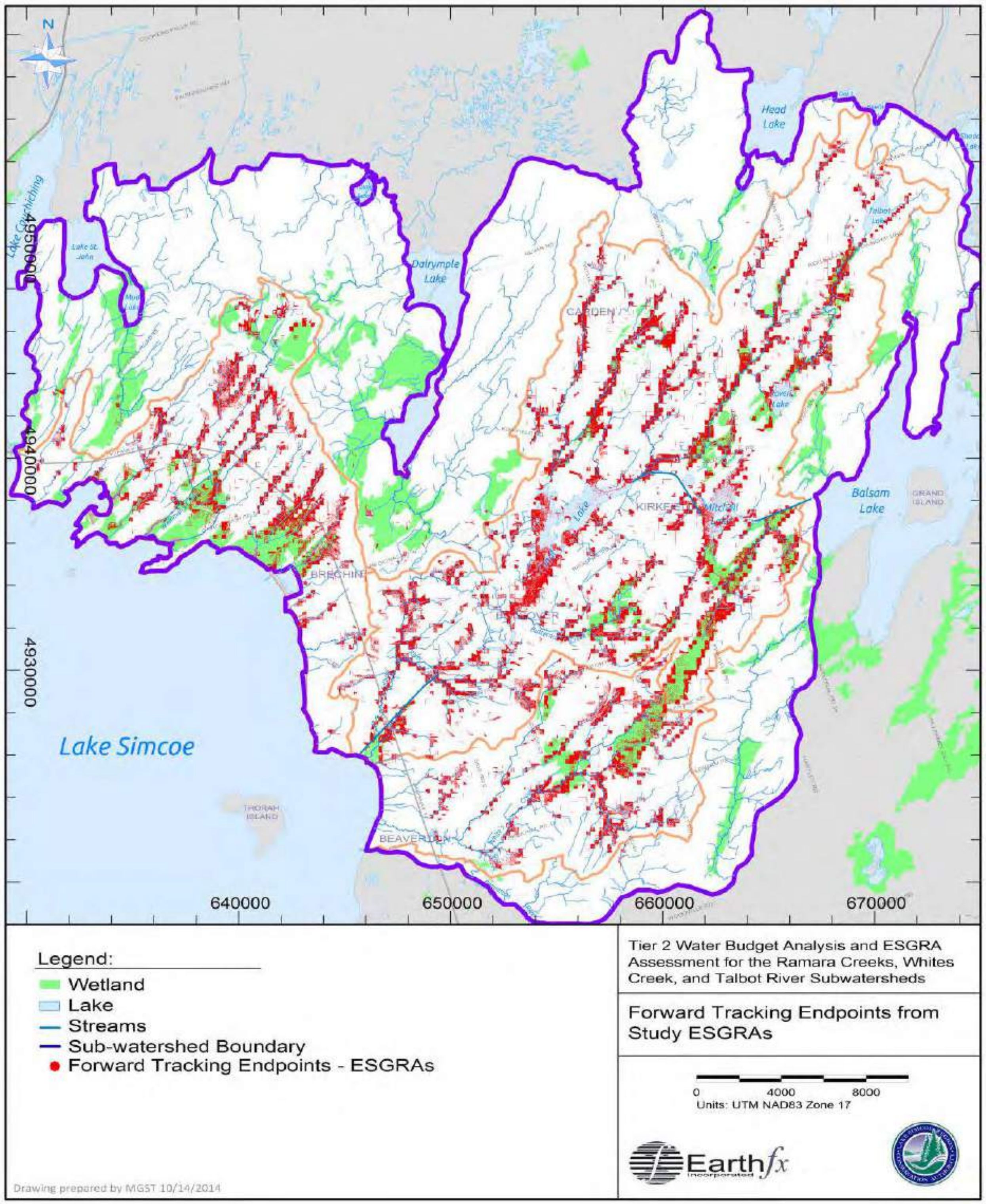


Figure 5 - 32: Endpoints from forward tracking particles released in delineated ESGRAs (Earthfx, 2014).

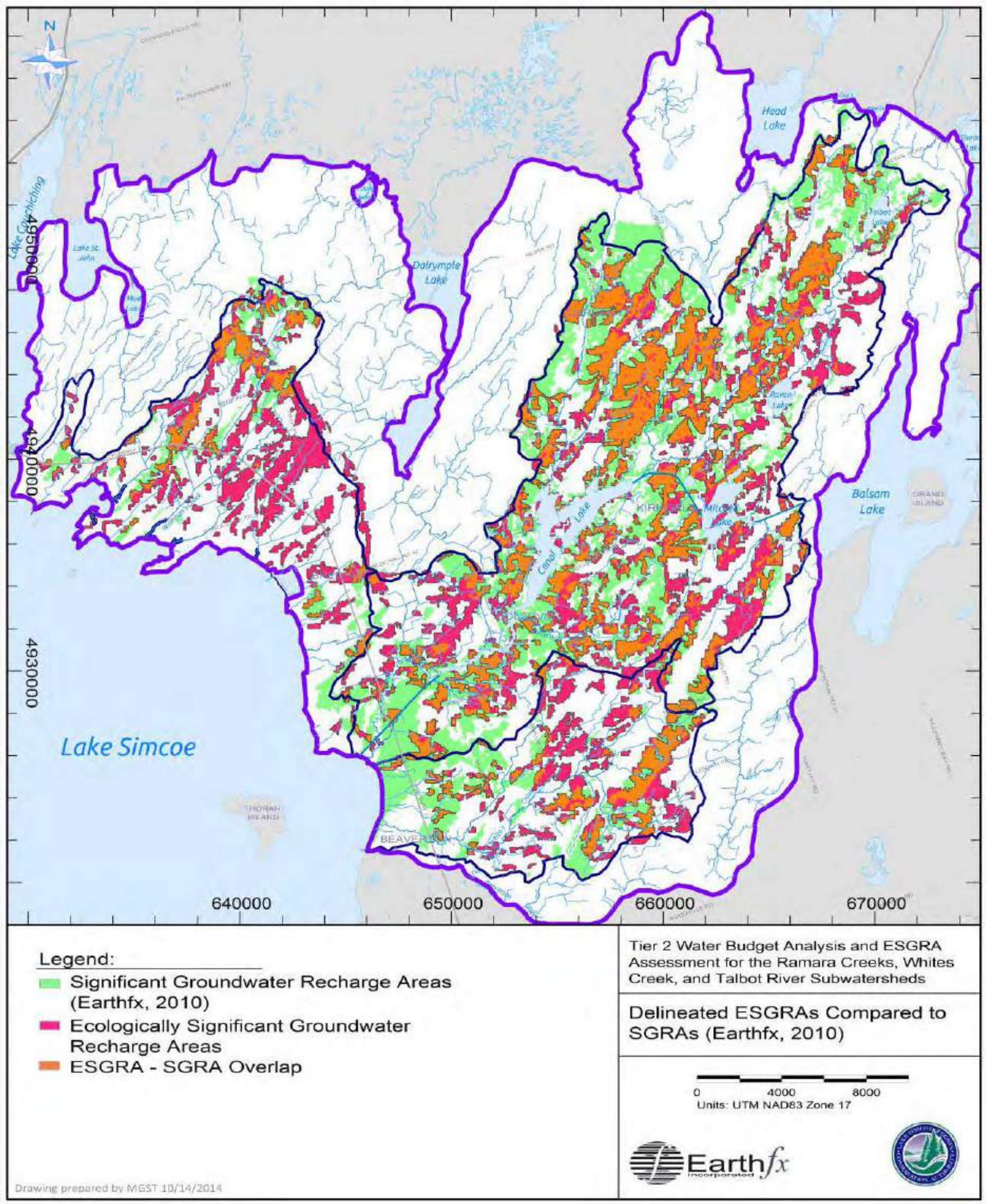


Figure 5 - 33: Delineated ESGRAs compared to previously identified SGRAs (Earthfx, 2014).

5.2.7 Current Climatic Conditions

Precipitation and Temperature

Precipitation in the form of rain or snow replenishes both the surface water and groundwater systems within a subwatershed. Typically, precipitation will vary seasonally and from year to year due to climatic factors. Precipitation is often measured at one or more meteorological stations within a subwatershed using precipitation gauges. Precipitation is an input value in the water balance calculation accounting for a portion of the available water supply.

An assessment of the climate in the Whites Creek and Talbot River subwatershed was undertaken as part of the Tier 2 Water Budget study completed by Earthfx (2014) for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds. Due to the small number of climate stations located within the Tier 2 model area, data from additional stations outside of the study area were accessed to conduct the climate analysis. A total of 28 Environment Canada climate stations (located both inside and out of the core study area), and one LSRCA station were consulted for the climate assessment. The greatest distance from the study area to a station was approximately 28 km, while the average distance was about 10 km. Out of all of the stations consulted, there are three active climate stations found in and around the Whites Creek and Talbot River subwatersheds. Environment Canada's Lagoon City (6114295) station is located in the adjacent Ramara Creeks subwatershed. The other two climate stations are found within subwatershed boundaries and include LSRCA's Talbot River near Gamebridge (LS0109) and Whites Creek at Regional Road (LS0402) stations. In addition, there are four inactive stations with varied periods of record that have historic information within the study area. Periods of record for historic information varied among the available climate stations. Characterization of the climate of the study area began with the assessment of the data over a 55 year period spanning from 1955 to 2011. Over the 55 year period, median annual rainfall varied from 580 mm to 1130 mm across the study area as illustrated in Figure 5-34, however interstation variability was high. Monthly precipitation totals were also analysed for a period spanning from 2000 to 2010 (Figure 5 - 35). Over the 11 year period median monthly precipitation ranged from 20 to 175mm, however interstation variability remained high. The winter months were determined to have slightly lower average median precipitation (as either rain or snow). The average monthly median precipitation ranged from a late winter low of 60 mm to a summer/fall plateau of about 80 mm (Figure 5 - 36). The relative frequency of precipitation form (as snow, rain, or mixed event) is illustrated in Figure 5 - 37 for the full range of temperatures observed in the study area. For the selected climate stations used in the study, 68% of precipitation events are rain only, while 27% are snow only, and 5% are mixed (Earthfx, 2014).

Evapotranspiration

Evapotranspiration (ET) is the water lost to the atmosphere by two processes, evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other than the physical characteristic of the water, soil, snow, and plant surface also affect the evapotranspiration process. Areas covered by plants will have more evapotranspiration occurring than developed areas with impervious surfaces. Unlike precipitation, evapotranspiration is accounted for as a loss to the system in the water budget calculation.

Actual evapotranspiration (AET) depends on several factors including potential evapotranspiration (PET), the amount of water in interception storage, the amount of water in depression storage, the soil type, and the amount of water in the soil zone. Potential evapotranspiration is the sum of evaporation and plant transpiration from the earth's land surface to the atmosphere. In the PRMS submodel, the soil zone is stratified into two layers, of which the capillary soil zone is susceptible to ET. Water is extracted from the gravity soil zone, if available, to replenish the capillary zone when it is not at capacity. The capillary zone has an evaporation extinction depth, below which only transpiration can occur (Earthfx, 2014).

Figure 5 - 38 illustrates that actual evapotranspiration in the Ramara, Whites, Talbot model area is sensitive to land use and land cover. Within the developed areas of the subwatersheds, reductions in pervious surfaces result in increased runoff, decreased infiltration, and a reduction in the soil moisture available for evapotranspiration. Areas of reduced perviousness also indicate a reduction in vegetative surfaces and soil zone water holding capacity. Lower evapotranspiration rates are particularly evident around the quarries in the model area, where the absence of vegetation results in minimal evapotranspiration. Moreover, since much of the runoff on quarry floors is routed directly to stream networks, there is often little to no soil moisture available for evapotranspiration.

The distribution of actual evapotranspiration (Figure 5-38) shows that the areas of exposed alvar bedrock in the Upper Talbot subwatershed exhibit lower evapotranspiration rates. As previously mentioned, these areas are characterized by thin soils with low moisture storage capacities. The low storage capacity of these thin soils in turn limits the amount of soil water available for evapotranspiration, resulting in the low evapotranspiration rates presented in Figure 5 - 38.

The distribution of actual evapotranspiration (Figure 5 - 38) also illustrates evidence of dendritic patterning. Dendritic patterning is indicative of the concept that downstream areas receiving more run-on from surrounding upslope areas will have more infiltration and therefore more soil water available for evapotranspiration. As a result, due to greater soil water availability, downstream areas, particularly in the Lower Talbot and Whites Creek subwatersheds, exhibit higher evapotranspiration rates than upslope areas.

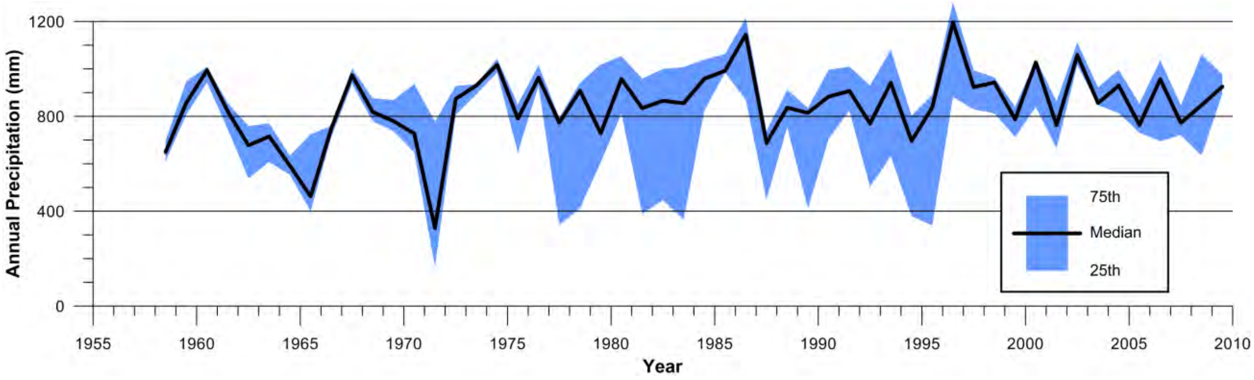


Figure 5 - 34: Annual precipitation quartiles at AES climate stations (Earthfx, 2014).

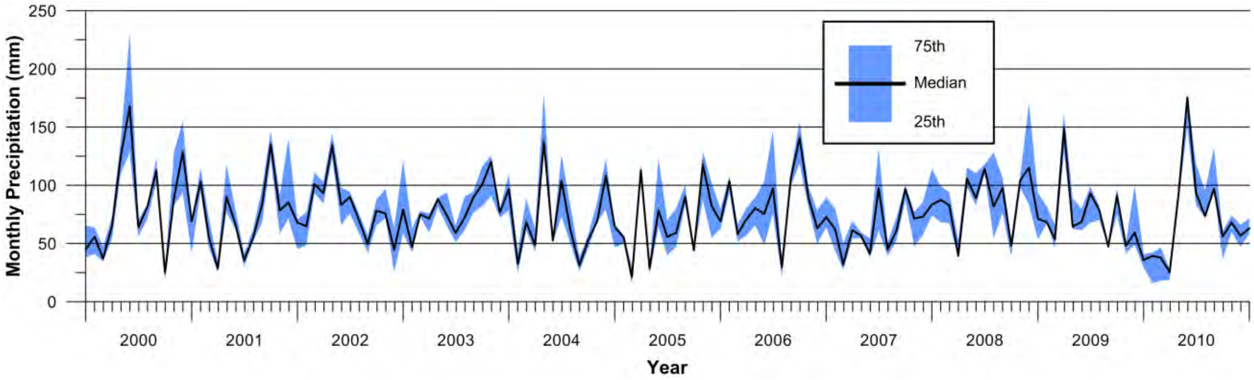


Figure 5 - 35: Monthly precipitation quartiles at AES climate stations (2000 through 2010) (Earthfx, 2014).

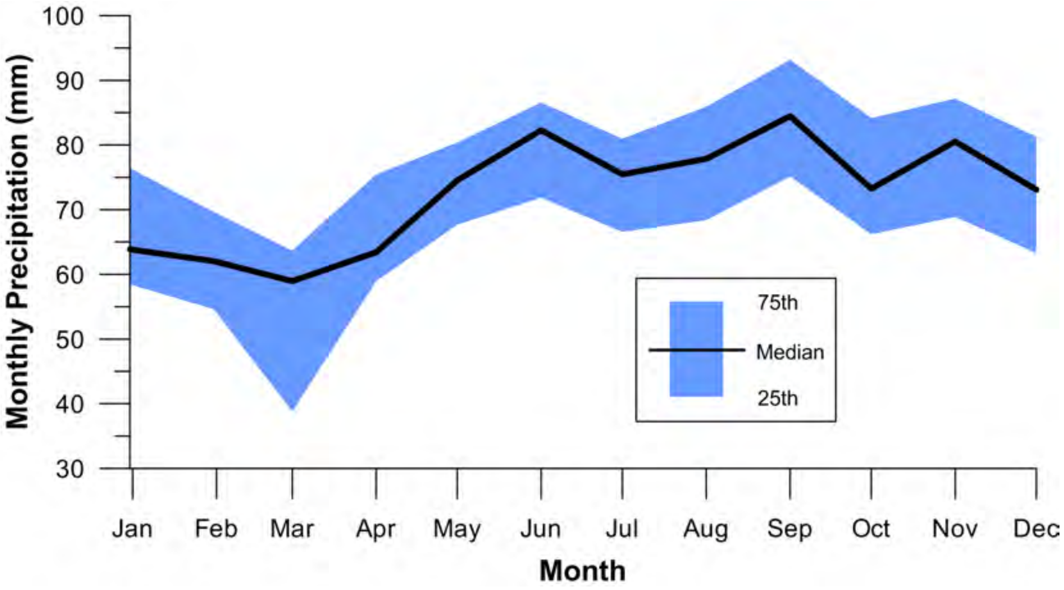


Figure 5 - 36: Average monthly precipitation quartiles for AES climate stations (2000-2010) (Earthfx, 2014).

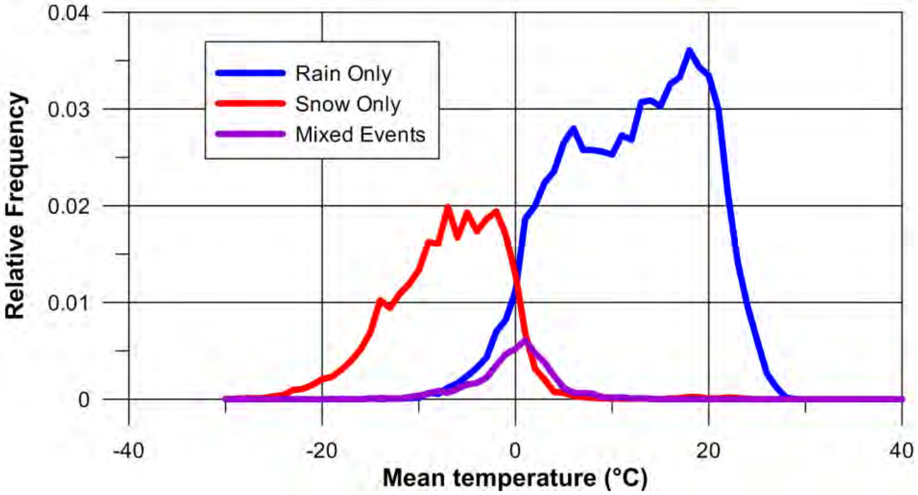


Figure 5 - 37: Relative frequency and daily mean temperature of observed precipitation types at AES climate stations (1955 -2010) (Earthfx, 2014).

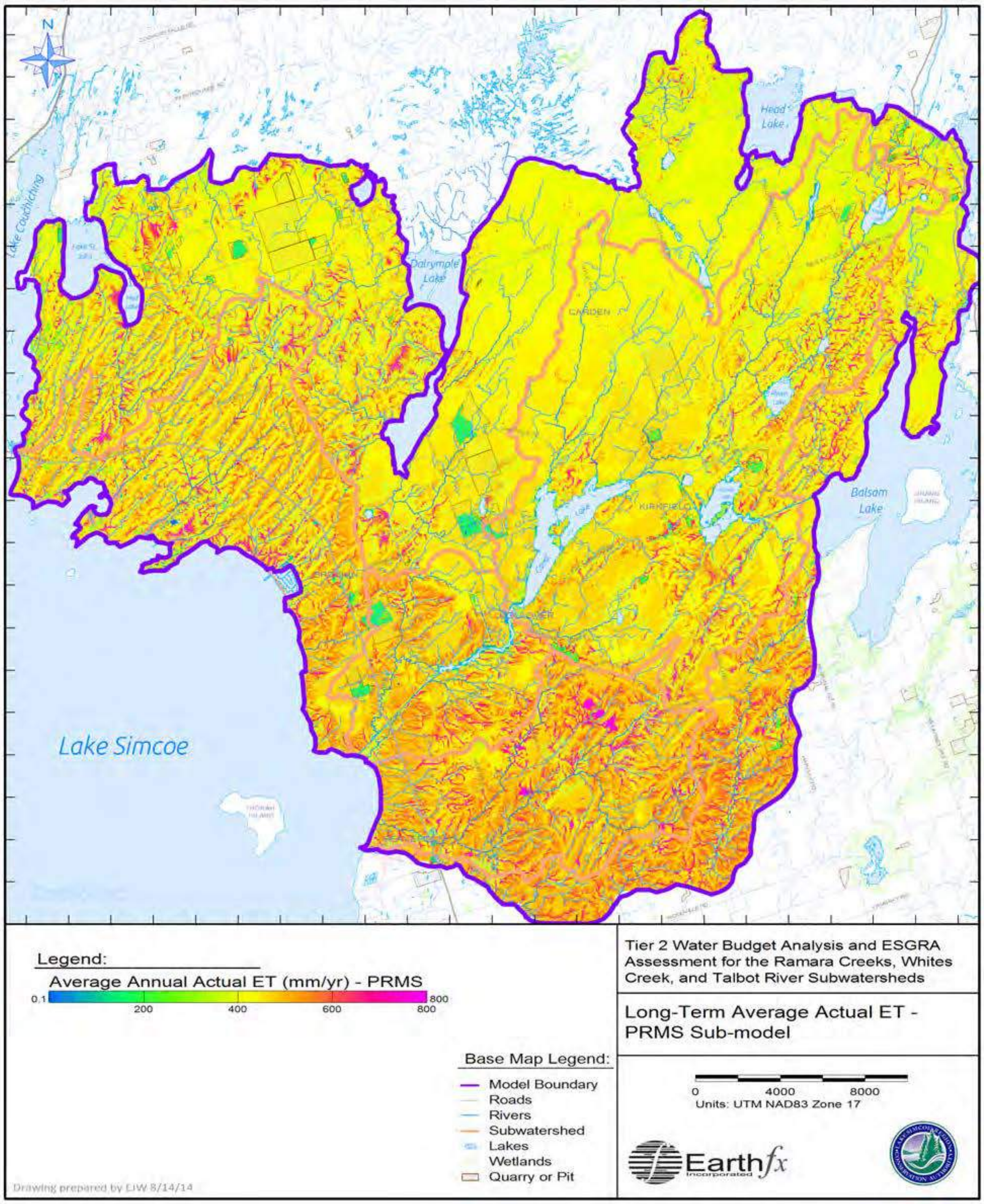


Figure 5 - 38: Simulated long-term average distribution of actual evapotranspiration (Earthfx, 2014).

Key points – Current Status:

- The physical properties of a watershed, such as drainage area, slope, geology and land use can influence the distribution of the water and the processes that function within a watershed.
- Regional groundwater flow in the Whites Creek and Talbot River subwatersheds generally moves in a westward to south-westward direction toward the eastern shores of Lake Simcoe
- Groundwater levels across the study area subwatersheds are at their highest elevation of 290 metres above sea level (masl) at three key upland recharge areas located in the north- eastern and south- eastern regions of the study area. Groundwater levels are at their lowest elevation of 220 masl along the eastern shores of Lake Simcoe.
- Many of the surface water features in the study area subwatersheds are situated within the lowland portions of southwest trending bedrock tunnel valleys. Bedrock tunnel valleys are unique geologic features formed through the action of sub-glacial processes that worked to erode deep valleys into the bedrock.
- Wetlands and streams occupying tunnel valleys are largely sustained by groundwater recharge supplied from atop the tunnel valley slopes. This indicates that many of the streams and wetlands in the study area, particularly those in the Talbot River subwatershed, are largely supported by very localized recharge.
- Many of the surface water features in the Whites Creek subwatershed are sustained by groundwater discharge that comes from recharge areas located in the Talbot River subwatershed. The silt-dominated surficial geology that characterizes the subwatershed reduces the recharge capacity of the landscape in this subwatershed.
- Under a drought scenario, the headwater tributaries in the study area would be the most significantly affected surface water features. Because of their strong reliance on groundwater discharge, these tributaries are sensitive to very small changes in groundwater levels.
- The tributaries in the Carden Plain Alvar region of the upper Talbot River subwatershed would be the most severely affected surface water features in the study area. Due to the fractured nature of the alvar bedrock and largely absent soil layer, the alvar exhibits very low storage capacity. The low storage capacity of the alvar bedrock means that streams fed by the alvar are less buffered from the effects of long term drought - the low storage and fractured nature of the alvar also highlights the localized, highly interconnected nature between the recharge and discharge features of the subwatershed.
- There are two active stream gauges within the study area; one in the Talbot River subwatershed, near the southern boundary of the Ramara Creeks subwatershed, and one in the Whites Creek subwatershed. Streamflow at the Talbot River gauge is strongly influenced by the Trent-Severn Waterway Canal Operations and as a result, measurements at this gauge were not considered a reliable representation of streamflow patterns in the study area. Measurements at the Whites Creek gauge indicate a large portion of the annual flow is released from the Whites Creek catchment as freshet, and the peak annual flows generally correspond to the spring freshet.
- The highest groundwater recharge rates in the study area are found across the Carden Plain alvar in the Upper Talbot River subwatershed. Karst features, such as the solutionally enlarged joints and fractures that dominate the Upper Talbot landscape, allow significant amounts of recharge to rapidly enter the groundwater system, and move vertically through the shallow bedrock.
- Recharge rates are lowest in areas where the surficial geology is dominated by the Newmarket and Dummer Tills. The fine grained sandy silt to silty sand composition of the Tills contributes to lower hydraulic conductivities and therefore lower recharge rates. The Newmarket Till is predominantly found in the Whites Creek and lower Talbot subwatersheds, while the Dummer Till is distinctly found along the north-eastern boundary of the Upper Talbot River subwatershed. The distinct connections between geology and groundwater recharge indicate that groundwater recharge in the study area is largely dominated by surficial geology.

5.3 Water Budget and Stress Assessment

A water budget characterizes the hydrologic conditions within a subwatershed by quantifying the various elements of the hydrologic cycle, including precipitation, interception, and evapotranspiration. It can therefore be used to identify areas where a water supply could be under stress, now or in the future. This will help protect the ecological and hydrological integrity of an area by establishing water supply sustainability targets and strategies.

The following section describes how the input and output values of the water budget equation were determined for the Whites Creek and Talbot River subwatersheds. The findings of the water budget study are further discussed within Section 5.4. Earthfx (2014) completed the water budget study on behalf of the LSRCA. The study included water budget assessments for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds in support of the water budget requirements under the Lake Simcoe Protection Plan, 2009.

The general water budget may be expressed as an equation with water Inputs = Outputs + Change in Storage; or

$$P + SW_{in} + GW_{in} + ANTH_{in} = ET + SW_{out} + GWout + ANTH_{out} + \Delta S$$

Where:

P = Precipitation

SWin = surface water flow into the watershed

GWin = groundwater flow into the watershed

ANTHin = anthropogenic or human inputs such as waste discharges

ET = evapotranspiration

SWout = surface water flow out (includes runoff)

GWout = groundwater flow out

The project objectives were to provide estimates of each component of the hydrologic cycle for the subwatershed based on various land and water use scenarios and to determine if the subwatersheds could be potentially under stress (i.e. water demand outweighs water supply). This required constructing a new model using the U.S. Geological Survey (USGS) fully-integrated GSFLOW model code.

The groundwater and land use scenarios analysed within this study include:

- Current Conditions – current land use and groundwater use;
- Future Conditions – future land use and groundwater use;
- Planned Conditions
- Drought scenario
- Climate Change scenario

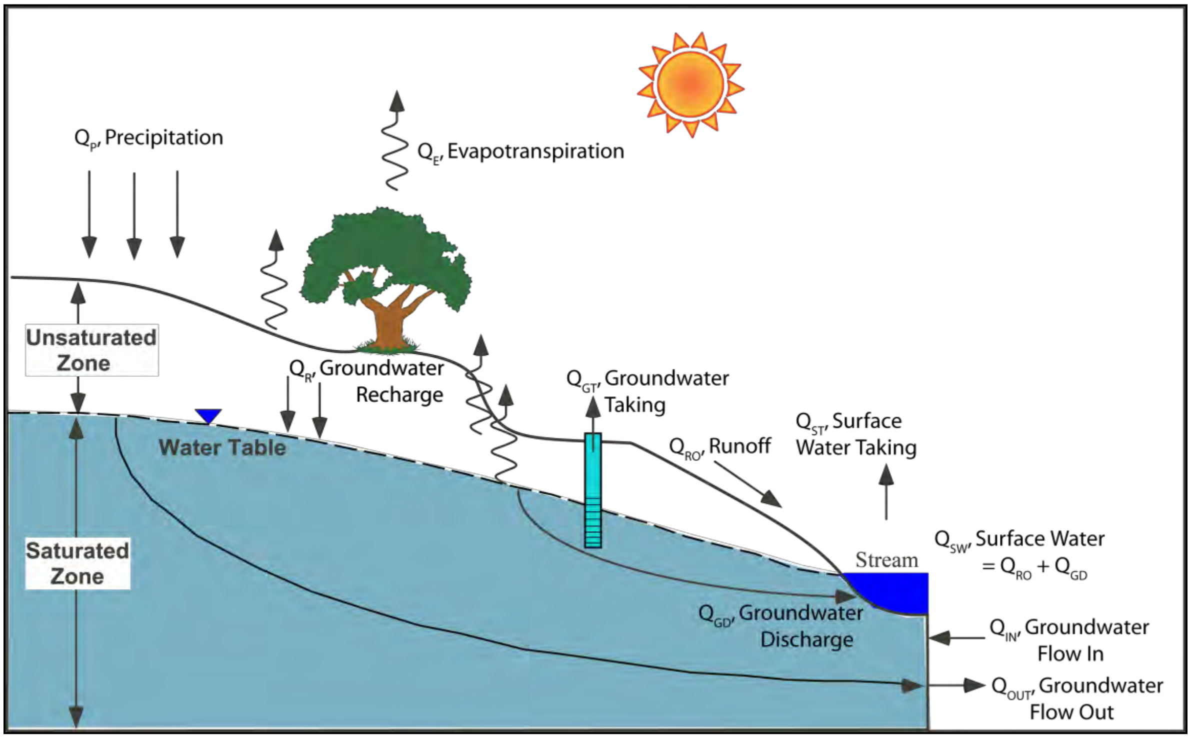


Figure 5 - 39: Water budget components (Earthfx, and Gerber, 2008).

5.3.1 Local Water Budget Initiatives

The water budget methodology presented in this chapter includes an assessment of existing hydrologic conditions within the subwatershed using both a conceptual model and numerical modelling information developed through the Lake Simcoe Protection Plan initiatives (discussed in Section 4.1.2).

Water budgets are generally developed using an approach that estimates the amount and location of water conceptually; however they can be refined by using surface and groundwater models. These models are referred to as numerical models, and use mathematical equations to approximate existing hydrogeologic conditions. While models can quantify the various components of the hydrologic cycle they can be also used to estimate the direction of groundwater or surface water flow within a subwatershed, and therefore aid in the identification of potentially stressed areas. Numerical model outputs are intended to provide estimates of possible conditions that may exist within the subwatershed; these estimates or predictions may point to possible areas of concern and may also be considered when providing solutions to identified problems.

The numerical model used to assess the Whites Creek and Talbot River subwatersheds is an integrated surface water/groundwater model developed by Earthfx (2014). In addition to the Whites Creek and Talbot River subwatersheds, the model's boundaries were extended to include the Ramara Creeks subwatershed, as well as small portions of adjacent catchments that could potentially contribute flows to the study area.

The modelling approach centred on constructing a new model using the U.S. Geological Survey (USGS) fully-integrated GSFLOW model. GSFLOW incorporates two submodels – the PRMS hydrologic model (surface water model) and the MODFLOW-NWT (groundwater model). The PRMS model was already applied to the Whites Creek and Talbot River subwatersheds as part of a larger hydrological model development study for the entire Lake Simcoe basin (Earthfx, 2010a). For the 2014 Tier 2 water budget study, the PRMS model was refined and extended to cover adjacent catchments. The groundwater model built on the previously developed LSRCA Tier 2 numerical models and incorporated a more refined conceptual hydrostratigraphic model.

Figure 5 - 2 in section 4.2 shows the model boundaries for the Tier 2 Water Budget study. Further information about the model can be obtained from the "Tier 2 Water Budget, Climate Change, and Ecologically Significant Groundwater Recharge Area Assessment for the Ramara Creeks, Whites Creek and Talbot River Subwatersheds" study completed by Earthfx (2014).

5.3.2 Water Supply Estimation

Water supply is the amount of water available at any given instant for use as a water supply. In surface water resources, available supply is considered to be a proportion of streamflow, which is monitored at a number of stations across the Lake Simcoe basin. Surface water supply thus involves the interpolation of gauge data to the outlets of subwatersheds in gauged systems, and interpolation from similar subwatersheds for ungauged systems. Typically, surface water supply has been based on expected monthly flows (as determined through statistical analysis of observed flows or through surface water modelling). For groundwater, the available supply for a subwatershed is considered to be the sum of the recharge and subsurface inflows (lateral inflow or underflow in). The water supply component of the stress assessment was estimated using the integrated model discussed in the previous section. The groundwater recharge term was determined from the PRMS submodel.

In the Tier 2, study lateral inflows into the Whites Creek and Talbot River subwatersheds were calculated by summing the predicted MODFLOW inter-cell flux across the subwatershed boundaries. A visual representation of the lateral flux can be seen by looking at the groundwater flow gradients. The total lateral inflow (Q_{in}), in all layers, was calculated. Per the guidance for the Tier 2 study the lateral outflows were not subtracted from the inflows for the study area subwatersheds. The total current and future lateral inflow for the Whites Creek and Talbot River subwatersheds are tabulated in Table 5 - 8 and Table 5 - 9 respectively (Earthfx, 2014).

Together the PRMS groundwater recharge and MODFLOW predicted lateral inflows from the water supply term in the Tier 2 calculation. Table 5 - 8 and Table 5 - 9 present the current and future water supply estimates used in the water budget calculation. The current total groundwater inflow for the Talbot River subwatershed is 158,693 m^3/day, while the total groundwater inflow for the Whites Creek subwatershed is 33,410 m^3/day.

Table 5 - 8: Current water budget estimates (Earthfx, 2014).

Inflows and Outflows (all values in m^3/d)	Whites Creek	Talbot River
Recharge in	24,250	142,990
Stream leakage in	121	2,722
Lake leakage in	0	252
Lateral inflow	9,039	12,729
Total Groundwater Inflow:	**33,410**	**158,693**
Lateral outflow	11, 365	14,204
Net groundwater discharge to surface features	18,150	132,369
Net outflow in at constant head cells	3,894	0
Wells	0	89
Total Groundwater Outflow:	**33,409**	**146,662**

*values subject to round off

Table 5 - 9: Future water budget estimates (Earthfx, 2014).

Inflows and Outflows (all values in m^3/d)	Whites Creek	Talbot River
Recharge in	24,250	143,315
Stream leakage in	120	2,902
Lake leakage in	0	307
Lateral inflow	9,051	12,672
Total Groundwater Inflow:	**33,421**	**159,196**
Lateral outflow	11,381	14,043
Net groundwater discharge to surface features	18,148	133,291
Net outflow in at constant head cells	3,892	0
Wells	0	97
Total Groundwater Outflow:	**33,421**	**147,430**

*values subject to round off

5.3.3 Water Demand Estimation

The water demand component of the water budget refers to water taken as a result of an anthropogenic activity (e.g. municipal drinking water takings, private water well takings, and other permitted takers). The water demand for the Whites Creek and Talbot River subwatersheds have been estimated from a number of information sources, including the

Ministry of the Environment's Permit to Take Water and Water Taking Reporting System (WTRS) databases, as well as population estimates, and water well records.

Demand from other non-permitted water use sectors was also estimated. Three types of non-permitted uses were estimated, including estimates of unserviced population consumption, agricultural irrigation, and agricultural livestock consumption. Some of the water pumped for these uses is lost to evapotranspiration while some may infiltrate back to the subsurface as irrigation return flow (actual consumption, i.e. water removed from the subwatershed, will differ by the specific application).

When evaluating future demand scenarios, only the future demand on municipal supply wells and surface water intakes was considered; future demands of other permitted and non-permitted takings were not simulated (Earthfx, 2014).

Permit To Take Water (PTTW)

The most important source of consumptive demand information was the MOECC Permit to Take Water (PTTW) database and actual municipal water use data obtained from the MOECC Water Taking Reporting System. Municipal and other water supplies are obtained from both surface water (lakes and rivers) and groundwater. Section 34 of the Ontario Water Resources Act (OWRA) requires that any person or business taking more than 50,000 litres of surface or groundwater per day (L/day) are required by law to obtain a Permit To Take Water (PTTW) from the Ministry of the Environment and Climate Change (MOECC). Permits are not required to take water for domestic purposes, livestock watering, or firefighting. Significant efforts have been made to quantify the amount of water takings within the subwatersheds through studies such as LSRCA Tier 1 Water Budget (SGBLS, 2009), and the Ramara Creeks, Whites Creek, and Talbot River subwatershed Tier 2 Water Budget and Stress Assessment (Earthfx, 2014).

Verifying and estimating actual consumption is difficult, but recent legislation (387/04) now requires that actual extraction rates be recorded through the Ministry of Environment's Water Taking Reporting System (WTRS), and over time the actual demand estimates will improve. The MOECC Water Taking Reporting System (WTRS) database contains self-reported information on actual takings, as opposed to permitted takings. Water taking data contained within the database is generally complete for municipal takings. Non-municipal pumping information is not as complete due to changing permit numbers, incomplete records, backlogs in the transcription of paper records, and non-compliance with reporting requirements. A subset of WTRS data for 2005 to 2011 was used for the Tier 2 water budget analysis despite some noted data gaps, particularly in records prior to 2007. For takings where no historical reported rates could be found, it was assumed that pumping rates were at their maximum permitted daily value (Earthfx, 2014). Actual water use rates were received for most of the permitted water users in the Whites Creek and Talbot River subwatersheds. The data was reviewed, corrected as needed, and incorporated into this study. A list of the most recent PTTW information is presented in Table 5 - 10 and Table 5 - 11. Best available location data for groundwater and surface water permits are shown in Figure 5-40 (Earthfx, 2014).

Two municipal and two non-municipal permits governing the use of 4 wells (two municipal, two non-municipal) were identified within the Talbot River subwatershed. Three additional permits for non-municipal surface takings were also identified on the Talbot River and Canal Lake. There were no permits identified within the Whites Creek subwatershed. Estimates for actual water use were available for three of the groundwater permits in the study area. Actual water use rates were not available for only one of the non-municipal groundwater permits. In this case, the average demand was assumed to equal the maximum permitted taking. Table 5 - 10 summarizes the permitted municipal groundwater takings in the study area subwatersheds, while Table 5 - 11 summarizes the non-municipal permitted groundwater takings.

Table 5 - 10: Summary of operational limits and historical average pumping rates for municipal takings (Earthfx, 2014).

Permit Holder	MOE Permit Number	Source Name	Subwatershed	Maximum Permitted Taking (m^3/d)	Average Demand (m^3/d)
Western Trent Municipal Well	6784-7JDRFS	Well #1 (Palmina)	Talbot River	294.0	36.5
	7211-7JCMRV	Well #1 (Western Trent)		392.0	36.0

Table 5 - 11: Summary of operational limits and historical average pumping rates for permitted groundwater takings (Earthfx, 2014).

Permit Holder	MOE Permit Number	Sub-watershed	Well Name	Purpose	Maximum Permitted Taking (m^3/d)	Average Demand (m^3/d)
Western Trent Golf Club Ltd.	0664-9BTKX4 (8422-5ZKNND)	Talbot River	Well #1	Water Supply	64.8	64.8 [1]
City of Kawartha Lakes Campgrounds Well	2424-6SKJ9R	Talbot River	Well 1	Campgrounds - Water Supply	200.0	19.0

1) *Average demand for Western Trent Golf Ltd. Well was based on maximum permitted taking.*

Municipal Water Supply

Two municipal wells are located within the study area; both are within the boundaries of the Talbot River subwatershed. Average municipal pumping was calculated from data provided in the MOECC Water Taking Reporting System (WTRS) database. All municipal wells within the subwatershed have actual reported takings from WTRS. Table 5 - 10 summarizes the average pumping values determined for the municipal wells in the Talbot River subwatershed (Earthfx, 2014).

Future pumping demand was estimated using projected population growth data provided by the City of Kawartha Lakes for the year 2031. In the Talbot River subwatershed, future population is expected to be similar to the current population, and as such, no future water demand increases are anticipated for the Western Trent/Palmina municipal wellfield. As there are no major municipal expansions expected in the study area, only an additional 10% was added to the current demand at the Western Trent/Palmina municipal wells to represent possible future increases in demand (Earthfx, 2014). Estimated current and future pumping rates for the municipal wells within the subwatershed are presented in Table 5 - 12.

Table 5 - 12: Current and future demand for municipal wellfields (Earthfx, 2014).

Settlement	Well	Current Demand (m^3/d)		Future Demand (m^3/d)	
Western Trent Municipal Well (Talbot River)	Well 1 (Palmina)	72.5	36.5	79.8	40.2
	Well 1 (Western Trent)		36.0		39.6

Non-Permitted Water Use - Agricultural Consumption

Under the Ontario Water Resources Act (Revised Statutes of Ontario 1990, Chapter O.40), farmers using 50,000 litres or less per day, and farmers who are taking water for livestock watering but not storing the water, are exempt from obtaining a PTTW, and are therefore non-permitted agricultural consumers. To estimate this agricultural consumption, MOE Guidance Module 7 (MOE, 2007) has suggested using water-use coefficients documented by deLoe (2001, 2005). The 2001 data compiled by deLoe has been allocated to subwatersheds using area weighting to estimate subwatershed water use as per the following process.

Agricultural demand was estimated for each study subwatershed in the Tier 1 Water Budget and Water Quantity Stress Assessment (LSRCA, 2009) using de Loe's methodology. Although this method provides an estimate of total water consumption, there is no method to differentiate what is taken from groundwater versus surface water. For the purpose of this study, non-permitted agricultural demand was treated as a groundwater taking. Table 5 - 13 below presents the agricultural water demand estimated for the Whites Creek and Talbot River subwatersheds. When de Loe's methodology is applied, the non-permitted agricultural demand is estimated to be 31,960 m^3/year in the Whites Creek subwatershed, and 18,607 m^3/year in the Talbot River subwatershed.

Non-Permitted Water Use - Unserviced Domestic Water Use

Municipal water supply services are typically not available within rural areas and therefore residents and businesses rely solely on private water wells or surface water to meet their water needs.

For the purposes of this report an assumption has been made that all households in the study area not serviced by municipal water are obtaining water from a private well. To derive an estimate of the average volume of groundwater used for domestic purposes, the 2006 Statistics Canada census data were used to determine the "un-serviced" population within each subwatershed relying on private wells. This un-serviced population was then multiplied by a per-capita usage of 335 L/day, based on the recommendation within Guidance Module 7 (MOE, 2007). A relatively low consumptive factor (0.2) has been used to calculate domestic water consumption, as residences on private wells most often utilize a private septic system, which returns the majority of water used to the local subsurface. This variable of the water consumption calculation is a relatively small proportion of the overall subwatershed demand and therefore the variation of household use is not a factor that will change the outcome of the stress assessment significantly; therefore this somewhat simple method is suitable for this assessment.

Table 5 - 13 presents the current unserviced domestic demand within the Whites Creek and Talbot River subwatersheds. When the value is corrected using the consumptive factor, the unserviced domestic demand is estimated at 29,224 m^3/year in the Whites Creek subwatershed, and 6,725 m^3/year in the Talbot River subwatershed . These values were incorporated within the study area model by decreasing the applied recharge over the subwatershed by the estimated unserviced demand.

Table 5 - 13: Summary of unserviced domestic and non-permitted agricultural consumption (Earthfx, 2014).

Subwatershed	Unserviced Domestic Demand (m^3/yr)	Unserviced Domestic Consumption (m^3/yr)	Non-permitted Agricultural Demand (m^3/yr)	Non-permitted Agricultural Consumption (m^3/yr)
Whites Creek	146,119	29,224	39,950	31,960
Talbot River	33,626	6,725	23,259	18,607

Quarry Takings

Surface and groundwater takings by quarry operations were also represented in the integrated surface/groundwater model and accounted for in the Tier 2 water budget. A total of 11 quarry related permits were identified and simulated within the Tier 2 model area for the Ramara Creeks, Whites Creek, and Talbot River subwatersheds. Of the 11 quarries identified, 8 are within the Talbot River subwatershed; there were no quarries identified in the Whites Creek subwatershed. Quarry-related permits to take water in the study area represent combined surface water and groundwater takings because surface water runoff and groundwater leakage are both collected and stored in sumps in the quarry floors. These sump ponds are dewatered to control local groundwater, and the water is used in processing (Earthfx, 2014). The quarry permits in the Talbot River subwatershed are summarized in Table 5 - 14 .

Table 5 - 14: Summary of operational limits and historical average pumping rates for permitted quarry takings (Earthfx, 2014).

Permit Holder	MOE Permit Number	Well Name	Purpose	Maximum Permitted Taking (m^3/d)	Average Demand (m^3/d)
Lafarge Brechin Quarry	**2446-98JKGW (4100-8T2R5R)**	**Quarry Sump (Brechin Quarry)**	**Quarry Dewatering**	**3,600.0**	**982.1**
Five W Farms Inc.	3274-62UJCV	Quarry Sump	Quarry Dewatering	12,528.0	537.2
James Dick South	6536-7QJH9L	Sump Pond	Quarry Dewatering	2,880.0	500.3
Lafarge Kirkfield Quarry [1]	1346-7ELPP2	Quarry Sump	Quarry	4,320.0	0.0

Permit Holder	MOE Permit Number	Well Name	Purpose	Maximum Permitted Taking (m^3/d)	Average Demand (m^3/d)
		(Kirkfield Quarry)	Dewatering		
Ferma Aggregates Inc.	3745-648QTH	Quarry Sump A	Quarry Dewatering	1,569.6	7.7
McCarthy Quarry	5716-7L6KBF	Quarry Sump (McCarthy Quarry)	Quarry Dewatering	6,544.8	0.0
Holcim (Canada) Inc.	1573-7RYPR7	Carden Quarry Sump	Quarry Dewatering	5,237	1,877.1
		Carden Quarry Clear Pond 2	Industrial	1,310.4	163.2
K.J. Beamish Construction Ltd. [2]	6758-883KVV	Sump Pond	Quarry Dewatering	5,011.0	0.0
		West Pond	Industrial	50.0	0.0

***Bold** indicates permit is partially located within the Ramara Creeks subwatershed.

Consumption Correction Factor

A number of corrections and adjustment factors were applied to the permitted and non-permitted consumptive demand estimates, as appropriate for a Tier 2 analysis.

The selected consumptive demand factors were applied to the PTTW permits based on the default values (Table 5 - 15) provided in the Water Budget & Water Quantity Risk Assessment Guide (MNR and MOE, 2011). A consumption factor for the unserviced population was estimated at 20% (i.e. 80% of the water is assumed to be returned to the shallow aquifer through the septic system). This value is consistent with water supply consumption values listed in the guidance document. The consumption factor for the un-permitted agricultural use (primarily livestock, including dairy operations) was estimated as 80%, close to the recommended factor of 78% suggested by de Loe (2001) (Earthfx, 2014).

As the municipal wells in the model area extract water from deep aquifer units these takings are treated as 100% consumptive.

Table 5 - 15: Consumptive use factors (MOE, 2011)

Category	Specific Purpose	Consumptive Factor	Category	Specific Purpose	Consumptive Factor
Agricultural	Field and Pasture Crops	0.80	Institutional	Hospitals	0.25
Agricultural	Fruit Orchards	0.80	Institutional	Other - Institutional	0.25
Agricultural	Market Gardens / Flowers	0.90	Institutional	Schools	0.25
Agricultural	Nursery	0.90	Miscellaneous	Dams and Reservoirs	0.10
Agricultural	Other - Agricultural	0.80	Miscellaneous	Heat Pumps	0.10
Agricultural	Sod Farm	0.90	Miscellaneous	Other - Miscellaneous	1.00
Agricultural	Tender Fruit	0.80	Miscellaneous	Pumping Test	0.10
Agricultural	Tobacco	0.90	Miscellaneous	Wildlife Conservation	0.10
Commercial	Aquaculture	0.10	Recreational	Aesthetics	0.25
Commercial	Bottled Water	1.00	Industrial	Manufacturing	0.25
Commercial	Golf Course Irrigation	0.70	Industrial	Other - Industrial	0.25
Commercial	Mall / Business	0.25	Industrial	Pipeline Testing	0.25
Commercial	Other - Commercial	1.00	Industrial	Power Production	0.10
Commercial	Snowmaking	0.50	Recreational	Fish Ponds	0.25
Construction	Other - Construction	0.75	Recreational	Other - Recreational	0.10
Construction	Road Building	0.75	Recreational	Wetlands	0.10
Dewatering	Construction	0.25	Remediation	Groundwater	0.50
Dewatering	Other - Dewatering	0.25	Remediation	Other – Remediation	0.25
Dewatering	Pits and Quarries	0.25	Water Supply	Campgrounds	0.20
Industrial	Aggregate Washing*	0.10	Water Supply	Communal	0.20
Industrial	Brewing and Soft Drinks	1.00	Water Supply	Municipal	0.20
Industrial	Cooling Water	0.25	Water Supply	Other - Water Supply	0.20
Industrial	Food Processing	1.00			

Monthly Correction Factor

Many water permit holders do not require the use of water at a constant rate throughout the year. For example, there are several golf courses, campgrounds, and aggregate washing permits in the subwatershed study area. Additionally, many of the permits in the study area are limited by time, only allowing pumping during a subset of the year. For permits without WTRS data, monthly allocation of takings was done based on restrictions listed in the individual permit to take water. If the permit did not have any restrictions, the monthly allocation was assigned based on the suggested monthly values for the usage classes and sub-classes listed in the Water Budget & Water Quantity Risk Assessment Guide (MNR, 2011). The time-limited permits were allocated to months based on an analysis of each permit. In some cases, only a portion of a month was allocated. In general, the monthly allocation was applied in a manner consistent with that in the Water Budget & Water Quantity Risk Assessment Guide (MNR, 2011). Overall, permitted water demand in the study subwatersheds is higher in the summer due to these activities.

The agricultural demand estimates given by de Loe (2001) were reported on an annual basis. Although it is quite likely that agricultural demand for the summer season exceeds winter demands, there was no information available to allocate seasonal water taking using the data provided by de Loe (2001). Therefore, the given annual agricultural water demand estimates were assumed to be constant year-round (Earthfx, 2014).

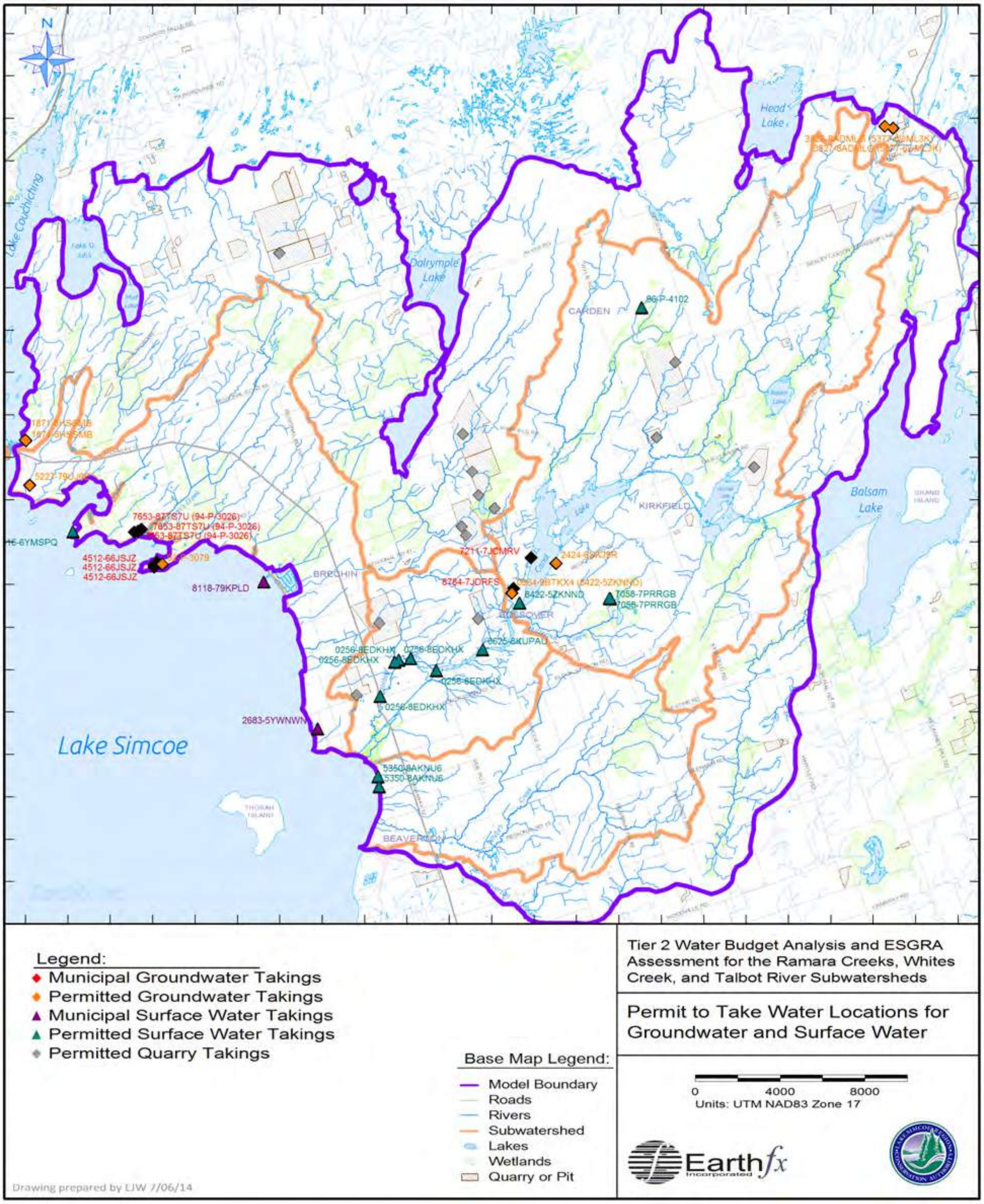


Figure 5 - 40: Location of permitted groundwater and surface water takings within the Whites Creek, and Talbot River subwatersheds (Earthfx, 2014).

5.3.4 Water Reserve Estimation

The MOECC Guidance Module (MOE, 2007) defines water reserve as that portion of water required to support other water uses within the watershed including both ecosystem requirements (instream flow needs) and human uses (aside from permitted uses). Examples of human uses could include dilution for sewage treatment plant discharge, hydroelectric power needs, recreation, and navigation needs. Ecological needs include sustaining groundwater discharge to sensitive coldwater fish habitat. The reserve quantity is subtracted from the total water source supply prior to evaluating the percent water demand.

The Guidance Module recognized that groundwater discharge to streams must be maintained to sustain baseflow throughout a watershed. Instream flow requirements are used to estimate the ecological component of the surface water reserve term for the Tier 2 stress assessment. As it is difficult to separate out the groundwater and surface water components of the instream requirements, Guidance Module 7 recommends a simplified estimation method whereby the reserve is estimated as at least 10% of the existing groundwater discharge (Earthfx, 2010).

There are several alternative methods for estimating groundwater discharge. Discharge can be determined either through (1) a groundwater flow model, if available; (2) baseflow separation applied to long-term flow gauge data, or (3) from spot flow measurements if no other data are available. The groundwater reserve was estimated as 10% of the MODFLOW simulated groundwater discharge to streams.

It is recognized that preserving 10% of baseflow is a simplified approach to preserving ecological requirements. Future work on determining instream flow needs will have to focus on identifying a flow regime that captures the range of seasonal high and seasonal low flows.

5.4 Factors Impacting Status - Stressors

Land use change, increased water use, short-term summer droughts and long-term climate change can all result in stress on the quantity of water within a watershed. Potential impacts of these stressors include reduced groundwater recharge or discharge, increased surface water runoff, well interferences, and changes to groundwater flow patterns and groundwater-surface water interaction.

The purpose of completing a water budget and water quantity risk assessment is to determine if the watershed can support current or future water takings without exhibiting a continued long-term decline in groundwater levels or surface water flow. The most basic definition of stress is whether a watershed can support the current levels of pumping without exhibiting a continued long term decline in water levels.

5.4.1 Water Demand

Potential water quantity stress has been estimated on a subwatershed scale through the Source Water Protection and Lake Simcoe Protection Plan initiatives. Several water budget initiatives have been undertaken to identify potential water quantity stress within the study area subwatersheds. The indicators of stress presented in this report are based on these studies and more information can be obtained from the following reports: SGBLS (2009) and Earthfx (2014). Considerable effort was made in the Tier 1 Water Budget and Water Quantity Assessment (SGBLS, 2009) and Tier 2 Water Budget (Earthfx, 2014), discussed in previous sections, to document the various sources of water demand.

The results of the water demand analyses are presented as a series of summary tables. The overall total water demand includes the total of permitted usage, population, municipal, and agricultural demand, as shown in Table 5 - 16 and Table 5 - 17 for current and future scenarios. All values were corrected for consumption factors (i.e., locally returned flow is not included). The current total groundwater demand from all sources in the Talbot River subwatershed is 3045 m^3/d, while the total groundwater demand in the Whites Creek subwatershed is 69 m^3/d, equalling a grand total of 3114 m^3/d across the two subwatersheds, or 1,137,413m^3/year.

Table 5 - 16: Current groundwater consumption summary (Earthfx, 2014).

Current Groundwater Consumption (m^3/yr)						
Watershed Name	**Municipal**	**Unserviced**	**PTTW**	**Quarry Dewatering**	**Agricultural**	**Total Consumption**
Talbot River	26,481	29,224	6,136	1,018,280	31,960	1,112,081
Whites Creek	0	6,725	0	0	18,607	25,332
Current Groundwater Consumption (m^3/d)						
Watershed Name	**Municipal**	**Unserviced**	**PTTW**	**Quarry Dewatering**	**Agricultural**	**Total Consumption**
Talbot River	73	80	17	2,788	88	3045
Whites Creek	0	18	0	0	51	69

Table 5 - 17: Future groundwater consumption summary (Earthfx, 2014).

Future Groundwater Consumption (m^3/yr)						
Watershed Name	**Municipal**	**Unserviced**	**PTTW**	**Quarry Dewatering**	**Agricultural**	**Total Consumption**
Talbot River	29,147	29,224	6,136	3,341,344	31,960	3,437,811
Whites Creek	0	6,725	0	0	18,607	25,332
Future Groundwater Consumption (m^3/d)						
Watershed Name	**Municipal**	**Unserviced**	**PTTW**	**Quarry Dewatering**	**Agricultural**	**Total Consumption**
Talbot River	80	80	17	9,148	88	9,412
Whites Creek	0	18	0	0	51	69

Currently, in the Talbot River subwatershed municipal and permitted uses (not including quarry operations) account for 3% of the consumptive groundwater demand in the subwatershed, while agriculture and the unserviced domestic supply each account for just under 3% of the total consumptive groundwater demand. Permitted quarry dewatering activities account for approximately 92% of the consumptive groundwater demand, and therefore make up the greatest proportion of the total consumptive groundwater use in the subwatershed.

In the Whites Creek subwatershed there are no active municipal or permitted groundwater takings, therefore these activities do not account for any of the consumptive groundwater demand in the subwatershed. There are also no quarry operations taking place within the boundaries of the subwatershed. The unserviced domestic supply accounts for 27% of the consumptive groundwater demand, while agriculture makes up the largest proportion of consumptive groundwater use at 73%.

Under the Tier 2 water budget, water demand analyses were also completed for future scenarios (Table 5 - 17). Tier 2 future demand analyses only consider increases in groundwater demand from municipal pumping and quarry operations; increases in demand from other permitted and non-permitted uses, including unserviced domestic consumption are not considered. As there are no municipal systems or quarry operations occurring within the Whites Creek subwatershed, consumptive groundwater demand remained consistent between the current and future conditions scenarios.

In the Talbot River subwatershed, projected population estimates are similar to the current population; as a result, future increases in municipal water demand are not expected (Earthfx, 2014). To account for any possible minor increases, municipal consumptive demand was increased by 10% under the future conditions scenario (Table 5 - 18).

In the Talbot River subwatershed, the greatest increase in consumptive demand under the future conditions scenario is expected to result from expanding quarry operations. In order to predict future changes in consumptive groundwater demand, Earthfx 2014 made use of 20 year build-out plans provided by quarry operators in the Talbot River subwatershed. Using the 20 year build-out strategies, quarry depths and build out were estimated by calculating the total material removed in a 20 year period, assuming the maximum permitted extraction rates and applying them uniformly over the full licensed extraction area for each of the quarries (Earthfx, 2014). Groundwater and surface inflows into the quarries were then calculated by the models based on changes in the quarry elevations. Under the future conditions scenario, consumptive demand from quarry dewatering operations was projected to increase over twice the current demand (a 228% increase) due to quarry expansion activity.

Table 5 - 18: Estimated future demand for the Western Trent/ Palmina Municipal Wellfield.

Settlement	Well	Current Demand (m3/d)		Future Demand (m^3/d)	
Western Trent /Palmina (Talbot River)	Well #1 (Palmina)	72.5	36.5	79.8	40.2
	Well #1 (Western Trent)		36.0		39.6

Municipal Water Supplies

There are two municipal water supply wells that service the communities within the Talbot River and Whites Creek subwatersheds. Municipal groundwater takings account for just over 2% of the current estimated total groundwater takings within the Talbot Creek subwatershed. As previously mentioned, there are no municipal water supplies located within the Whites Creeks subwatershed. Municipal well locations are shown on Figure 5 - 40. The data presented in this report were analysed to estimate actual annual average pumping rates, which are often less than the permitted rates. The numerical groundwater flow model, discussed in Section 5.3, incorporated average pumping rates where the data were available.

Agricultural

The total consumption for agricultural use in the Talbot River subwatershed is estimated to be 31,960 m^3/yr, which is approximately 3% of the total consumptive demand within the subwatershed. In the Whites Creek subwatershed, agricultural use is estimated to be 18,607 m^3/yr, or approximately 74% of the consumptive demand in the subwatershed. Water used for irrigation is consumed only through the growing season, from May through mid-October. Therefore, the average daily water consumption can be much higher in the growing season when compared to other times in the year. This water is used mainly for irrigation and in some cases livestock watering. The agricultural water supply is derived from both ground and surface water resources. For the purpose of this study, there was no differentiation between groundwater and surface water takings, and the non-permitted agricultural demand was treated as a groundwater taking. Some of the water used for irrigation will return back to the groundwater system as an irrigation return flow, and some will be lost to the atmosphere due to evapotranspiration. Water extracted for irrigation generally leads to an overall water loss in a water budget.

Other Permitted Uses

Several aggregate pits and quarries within the Talbot River subwatershed have a Permit To Take Water. Quarry-related permits to take water in the study area represent combined surface water and groundwater takings because surface water runoff and groundwater leakage are both collected and stored in sumps in the quarry floors. These sump ponds are dewatered to control local groundwater, and the water is used for dewatering, aggregate washing activities, or for dust suppression. A total of eight quarries are found in, or partially in, the Talbot River subwatershed. The takings from these quarries are accounted for in the Tier 2 water budget calculations. In the Talbot River subwatershed, quarry dewatering activities represent the greatest proportion of consumptive demand at 92%. Under future conditions, consumptive demand from quarry operations is expected to increase due to planned quarry expansions.

In addition to the quarry operations, there are a number of permits related to golf course irrigation and campground facilities with the Talbot River subwatershed. As with the agricultural irrigation, some of the water applied over the golf courses will infiltrate back into the shallow groundwater system, and some will be lost to the atmosphere through evapotranspiration. Campgrounds generally use the domestic supply, such as drinking water and restroom facilities, therefore most of the water will be returned via septic systems with some being lost.

5.4.2 Land Use

It is important to consider land cover within a water budget study because it affects several aspects of the water budget including surface water runoff, evaporation, and infiltration. Developed land will often have a higher proportion of impervious surface, such as roadways, parking lots, and building roofs than natural or rural lands. Increased runoff rates result in erosion and reduced infiltration to recharge groundwater reserves. The potential for the introduction of contaminants to both groundwater and surface water must be a consideration when a new land use is being proposed. Each type of land use can affect the quantity of both ground and surface water in the subwatershed.

Natural land cover and land use was simulated in the water budget using LSRCA Ecological Land Classification (ELC). Land use patterns were defined using the LSRCA ELC land use coverage which covered all of the immediate study area. SOLRIS data (MNR, 2008) and SIL data (Southern Ontario Interim Land Cover) (MNR, 2006) was used to infill the remaining areas.

A large number of land use types and categories are found across the Ramara Creeks, Whites Creek, and Talbot River subwatersheds assessed as part of the Tier 2 Water Budget study. For illustrative purposes only the five primary types of land use types (forest, agricultural, urban, water bodies, and wetlands) are shown in Figures 5 - 41 and 5 - 42. Across the Whites Creek subwatershed specifically, natural areas, including forests and wetlands, cover approximately 38% of this relatively rural subwatershed, while agricultural land uses (including intensive and non-intensive agriculture) cover 59% of the area. Developed/settled areas (including urban and rural development, residential, institutional, transportation, parks, industrial, and commercial land uses) cover only 1.9% of the subwatershed.

Across the Talbot River subwatershed, natural areas (including forests and wetlands) cover 76% of the landscape, and therefore account for the greatest distribution of land use in the subwatershed. Agricultural land uses cover 20% of the area, while developed/settled areas (including urban, rural, residential, transportation, industrial, institutional, and commercial land uses) cover only 2.5%. Aggregate pits and quarries cover just under 1% of the landscape.

Some notable features in the subwatersheds include the Trent- Severn Waterway, which bisects the study area through the Talbot River, Canal and Mitchell Lakes, to Balsam Lake. The Trent- Severn Waterway provides a navigable chain of interconnected rivers and lakes for recreational boaters during the operating season. There are also a number of wetlands found across the subwatersheds, particularly in the upper portion of the Talbot River subwatershed.

It should be noted that the percentage of impervious surfaces used in the surface water model (PRMS) developed by Earthfx (2014) for the water budget exercise may differ from the percentage discussed in Chapter 2. The percent impervious cover reported in **Chapter 2** assumes specific land uses are 100% impervious, whereas the model assumes that each type of land use varies in the percentage of impervious area. It should also be noted that although the most accurate available land use information was used, these numbers will continue to change as development occurs.

The following will discuss the various land uses within the Whites Creek and Talbot River subwatersheds in the context of Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas. The subwatersheds contain a low level of impervious (hardened) surfaces due to the lack of urban areas. Figure 5 - 42 illustrates the distribution of land uses within recharge areas in the Whites Creek and Talbot River subwatersheds. Settled areas (including urban, industrial, commercial, institutional, park, and residential land uses) only comprise approximately 3% of the land within the SGRAs and ESGRAs; of this 3%, 1 % is devoted to urban, industrial, commercial, institutional, and park areas, while 2% of this 3% is devoted to rural development. Aggregate pits and quarries cover just less than 1% of lands designated as SGRAs or ESGRAS.

Agriculture practices, like urban development, can influence the quantity of both surface and groundwater within a watershed. Agricultural land use leaves the ground in a more natural state, allowing for groundwater infiltration to occur. Agricultural land uses (including intensive and non-intensive agricultural land) account for 34% of the landscape cover within SGRAs and ESGRAs at 16% and 18%, respectively. When groundwater infiltration occurs in agricultural and rural areas the ground can become supersaturated following a prolonged precipitation event, leading to the ponding of water at the surface. Before and after the growing season the land is left open allowing for increased erosion and runoff following a precipitation event. During the growing season a large volume of water will be lost to the atmosphere through evapotranspiration. The water lost through evapotranspiration is removed from the ground as the plants draw the water up through their root system.

As mentioned in Section 5.4.1 agricultural practices also place a huge demand on the water supply for livestock watering and irrigation. The water used for irrigation is often supplied by groundwater and surface water where available. To obtain a surface water supply many farms construct on-line ponds. On-line ponds are built in an existing watercourse and allow water to flow in and out. The volume of water in the pond is controlled by a berm or other form of control structure. On-line ponds restrict the natural streamflow as a large volume of water becomes contained in the pond. When surface water is unavailable, large volumes of water are pumped from the ground. Some of the water used for irrigation infiltrates back into the groundwater system.

Natural heritage features comprise the largest land use within the significant and ecologically significant groundwater recharge areas at 62% cover (Figure 5 - 43). Natural heritage features leave the landscape in a natural state, promoting infiltration. Future land development plans should focus on promoting land use activities that maintain and protect the recharge occurring within SGRAs and ESGRAs.

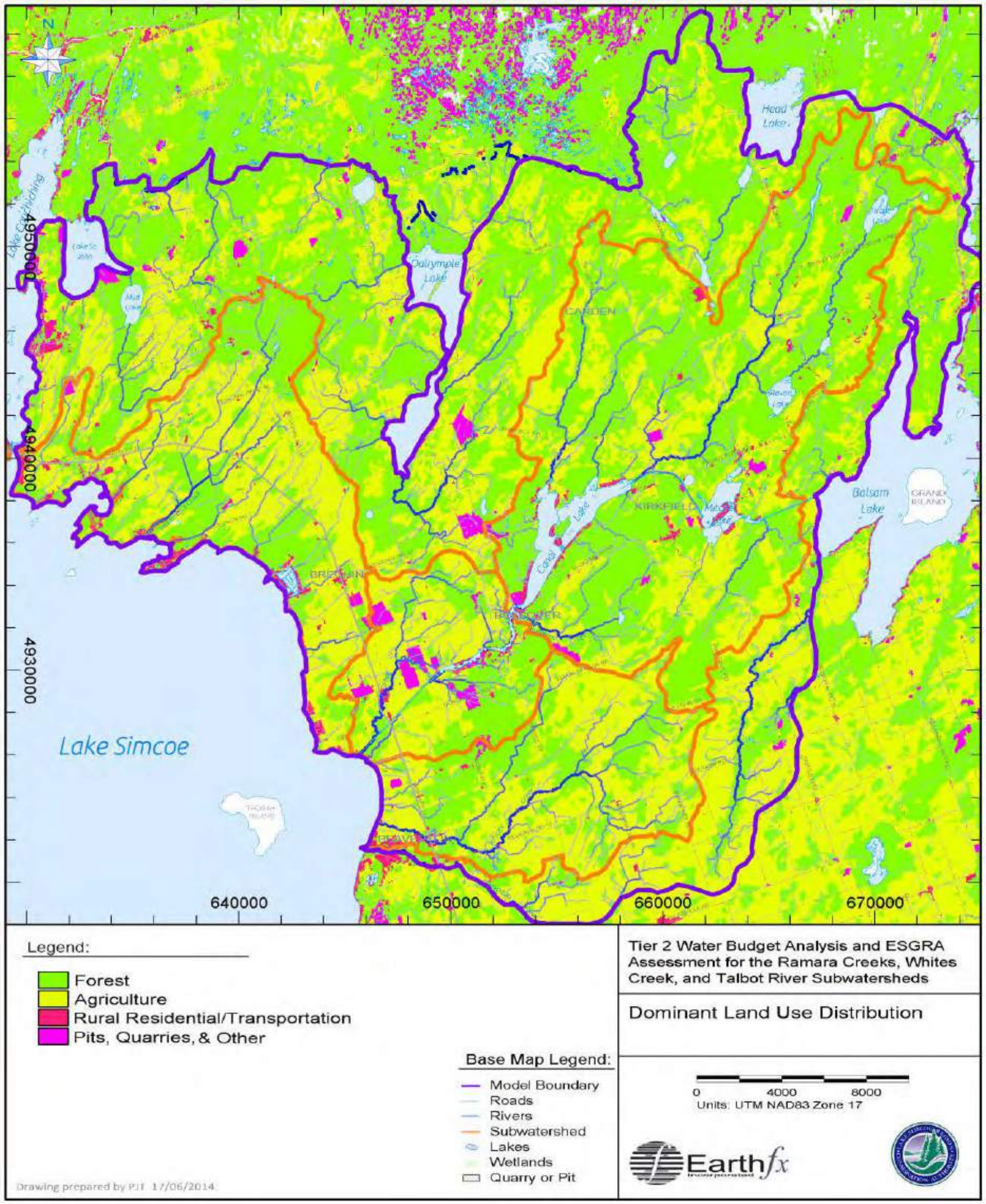


Figure 5 - 41: Distribution of dominant land use types used in the integrated surface/groundwater model (Earthfx, 2014).

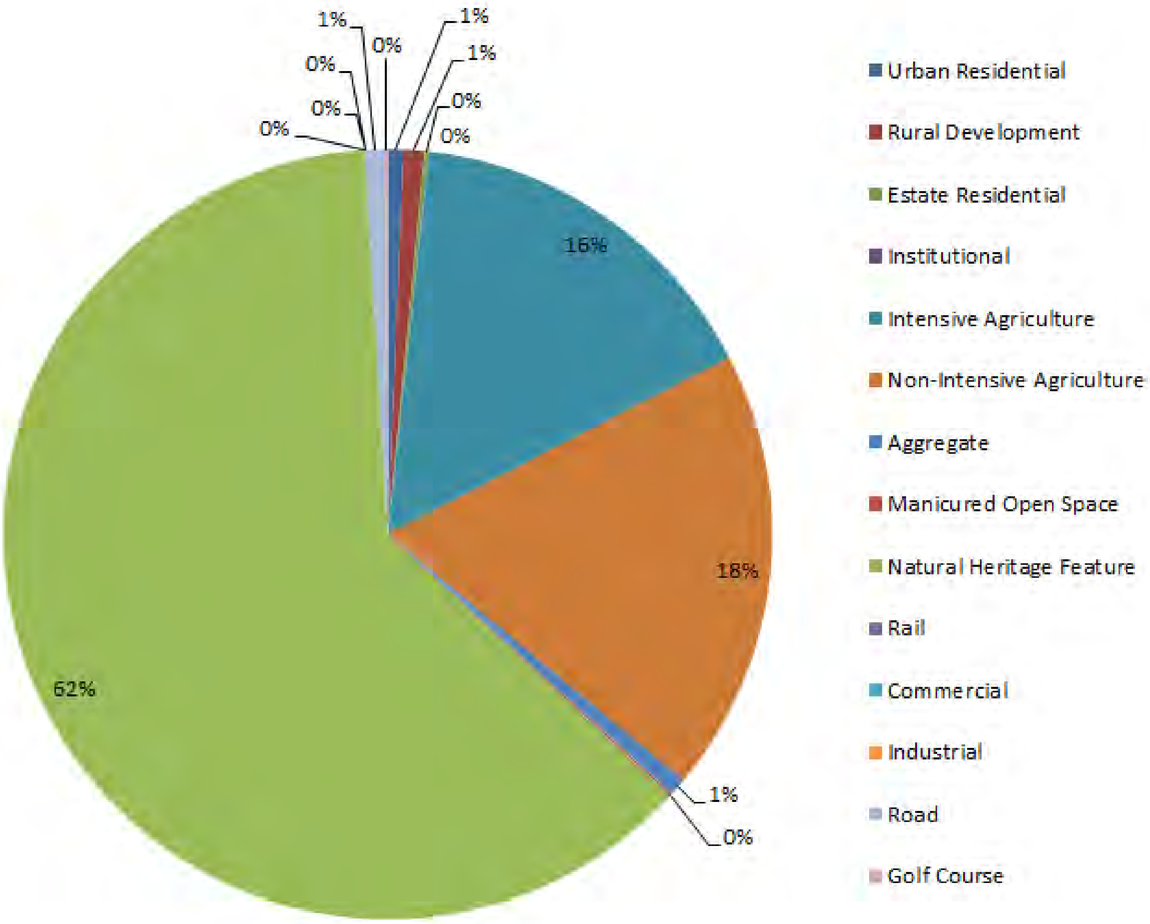
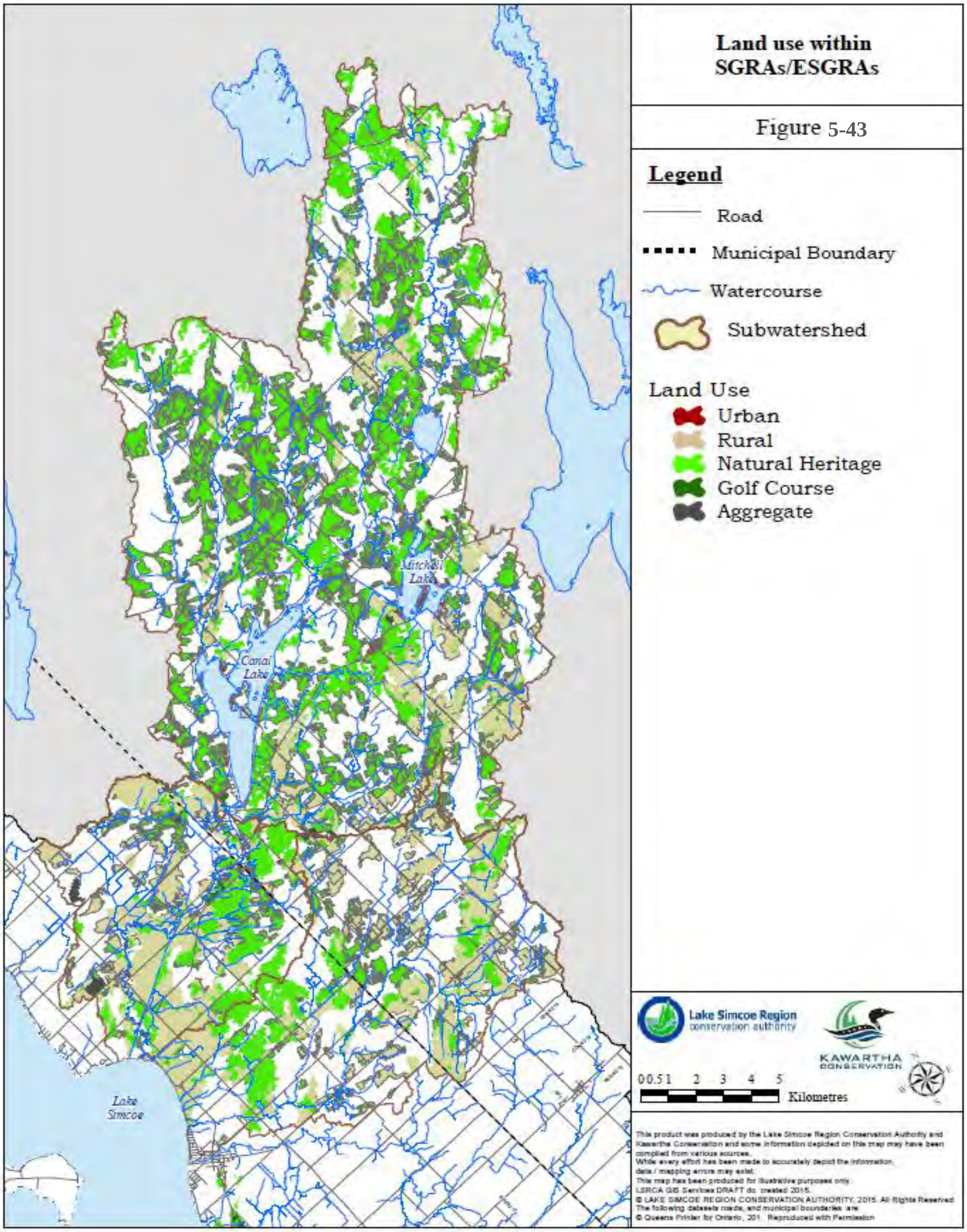


Figure 5 - 42: Land use distribution within Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas in the Talbot River and Whites Creek Subwatersheds.



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT dc created 2015.

Figure 5 - 43: Spatial distribution of land use within Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas in the Talbot River and Whites Creek subwatersheds.

5.4.3 Water Budget Stress Assessments

Potential water quantity stress has been estimated on a subwatershed basis through the Source Water Protection and Lake Simcoe Protection Plan initiatives. Several water budget initiatives have been undertaken to identify potential water quantity stress within the Whites Creek and Talbot River subwatersheds. The indicators of stress presented in this report are based on these studies and more information can be obtained from the following reports; LSRCA (2009), Earthfx (2014).

The percentage of quantity demand can be expressed as in the following equation:

$$\%WaterDemand = \frac{Q_{DEMAND}}{Q_{SUPPLY} - Q_{RESERVE}}$$

where:

Q_{Demand} = amount of water consumed (pumped);

Q_{Supply} = recharge plus lateral groundwater inflow into the subwatershed (Qr + Qin); and

$Q_{Reserve}$ = the portion of available surface water or groundwater reserved for other needs such as navigation, assimilative capacity, and ecosystem health. This is estimated as 10% of the model predicted baseflow discharge to the streams in the subwatershed

Tier 1 Water Budget Results

The Tier 1 Water Budget Study (LSRCA, 2009) conducted a comparison of current conditions and future demand for the Whites Creek and Talbot River subwatersheds, on both an average annual and monthly basis. The completion of the analysis helps to determine whether stress on the groundwater and surface water resources can be anticipated under various scenarios. The stress assessment evaluates the ratio of the consumptive demand for permitted and non-permitted users to water supplies, minus water reserves, within each subwatershed (equation shown in blue text box above). The major components of the water budget have been estimated and tabulated as described in the preceding sections, including water supply, water demand, and water reserve.

Results of the current and future groundwater stress assessment, using annual average demand, are shown in Table 5 - 20 and Table 5 - 21. Under both the current and future conditions scenarios the Whites Creek subwatershed had a 0% water demand, meaning that water demand did not exceed water supply. In the Talbot River subwatershed, under the current and future conditions scenarios, water demand was 4% (i.e. water demand exceeded water supply by 4%). Both subwatersheds were found not to be potentially stressed with regard to average annual water demand under current and future conditions.

Results of the current monthly groundwater stress assessments are shown in Table 5 - 21. As presented in the Table, the Whites Creek subwatershed was estimated to have a stress level of 0% throughout all months of the year. The lack of seasonal changes in stress levels is a result of a fairly consistent groundwater and surface water supply and fairly consistent water demand within the subwatershed.

The stress level in the Talbot River subwatershed ranged from between 3%-5%, with the greatest stress occurring in the dryer summer months of June to September.

Overall, the results provide a reasonable assessment of the annual groundwater and monthly surface and groundwater supply and demand conditions. As a result of the current and future average annual stress assessment the Whites Creek and Talbot River subwatershed didn’t advance to a Tier 2 Water Budget Assessment per the Clean Water Act Technical Rules. However, the Lake Simcoe Protection Plan requires that a Tier 2 assessment be undertaken; this is discussed further below.

Table 5 - 19: Tier One results - current annual groundwater stress assessment (LSRCA, 2009)

Subwatershed	Area	Precip	AET	Surplus	Annual Mean Flow	Baseflow	Available Supply		Reserve		Groundwater Consumption		GW Stress
							GW	SW	GW	SW			
	km^2	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	m^3/a	mm/a	%
Whites Creeks	105	962	557	405	247	114	271	149	11	75	61,000	1	0
Talbot River	71	957	557	400	235	107	272	181	11	72	761,000	11	4
Note:	Values rounded for presentation purposes				🟩				AET - Actual Evapotranspiration				
					🟧				GW - Groundwater				
									SW - Surface Water				

Table 5 - 20: Tier One results - future annual groundwater stress assessment (LSRCA, 2009).

Subwatershed	Area	Precip	AET	Surplus	Annual Mean Flow	Baseflow	Available Supply		Reserve		Groundwater Consumption		GW Stress
							GW	SW	GW	SW			
	km^2	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	mm/a	m^3/a	mm/a	%
Whites Creeks	105	962	557	405	247	114	271	149	11	75	61,000	1	0
Talbot River	71	957	557	400	235	107	272	181	11	72	761,000	11	4
Note:	Values rounded for presentation purposes				🟩				AET - Actual Evapotranspiration				
					🟧				GW - Groundwater				
									SW - Surface Water				

Table 5 - 21: Tier One results - current monthly groundwater stress assessment (LSRCA, 2009).

Subwatershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Whites Creek	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Talbot River	4%	3%	4%	4%	4%	5%	5%	5%	5%	4%	3%	4%
Notes:		🟧	>50% of available supply being taken									
		🟩	>25% & <50% of available supply being taken									

Tier 2 Water Budget Results

The objectives and approach of the Tier 2 Water Budget Assessment are similar to those of the Tier 1 in that the overall goal is to quantify water supply, reserve, and demand. Once these budget components are estimated, the "percent water demand" equation and stress level assessment screening thresholds are the same between tiers. The methods used to quantify the water budget components, however, are more robust in a Tier 2 study.

The Ramara Creeks, Whites Creek, and Talbot River subwatersheds Tier 2 Water Budget (Earthfx, 2014) conducted a comparison analysis of current and future conditions for average annual, monthly, and two-year drought conditions. The completion of the analysis helps to determine whether stress on the groundwater resources can be anticipated under various scenarios. The stress assessment evaluates the ratio of the consumptive demand for permitted and non-permitted users to water supplies, minus water reserves, within each subwatershed. The major components of the water budget for the Whites Creek and Talbot River subwatersheds have been estimated and tabulated as described in the preceding sections, including water supply, water demand, and water reserve.

Results of the stress assessment for annual average demand under current and future conditions are shown in Table 5 - 22 and Table 5 - 23. This assessment suggests that the Whites Creek subwatershed is estimated to have a potential stress level of 0.2%. Under the future conditions scenario this stress level remains unchanged, indicating that the subwatershed is not stressed from a groundwater perspective. In the Talbot River subwatershed, the estimated potential stress level under current conditions is 2.1%; under future conditions this stress level increases slightly to 6.5%, indicating a 4.4% change in overall groundwater demand between current and future conditions. Overall these values suggest that both the Talbot River and Whites Creek subwatersheds are at a low stress level, and will remain at the low stress level under future conditions.

Some differences exist between the consumptive demand values derived in the Tier 1 and the values derived under the Tier 2. Differences in methods for estimating recharge, discharge to streams, and cross-watershed flows result in additional variances in the values used in the water demand computations between the two studies.

Table 5 - 22: Percent water demand stress assessment – current conditions (Earthfx, 2014).

Component		Whites Creek	Talbot River
Groundwater Supply	Recharge In	24,250	142,990
	Stream Seepage	121	2722
	Lake Seepage	0	252
	Lateral Inflow	9,039	12,729
	Total:	33,410	158,693
Groundwater Reserve		1,815	13,237
Groundwater Demand		69	3045
Percent Water Demand		**0.2%**	**2.1%**

Table 5 - 23: Percent water demand stress assessment – future conditions (Earthfx, 2014).

Component		Whites Creek	Talbot River
Groundwater Supply	Recharge In	24,250	143,315
	Stream Seepage	120	2,902
	Lake Seepage	0	307
	Lateral Inflow	9,051	12,672
	Total:	33,421	159,196
Groundwater Reserve		1,815	13,329
Consumptive Demand		69	9,412
Percent Water Demand		**0.2%**	**6.5%**

*values subject to round off

Drought Scenarios

The effects of sustained drought on the water budget were also evaluated as part of the Tier 2 water budget analyses for the Whites Creek and Talbot River subwatersheds. To determine the potential impacts of drought on groundwater discharge and streamflow, two drought scenarios were simulated for the study area. The first represents an extreme condition assuming that no recharge occurs in the groundwater system for a two-year period. The second scenario considers how the subwatersheds would respond to a historic 10-year period of low rainfall.

A Tier 2 level two-year drought assessment was completed by setting recharge to zero and running the transient groundwater model for a two-year period. Under the extreme conditions, the water table is seen to decline and groundwater discharge to streams is reduced. Table 5 - 24 summarizes the change in groundwater discharge to surface features in the Whites Creek and Talbot River subwatersheds under the extreme two-year drought for both current and future conditions. Average groundwater discharge to the Whites Creek subwatershed under current conditions is estimated to be 13,647 m^3/day. At the end of the two-year drought, groundwater discharge in the subwatershed is reduced to 3,567 m^3/day, indicating a 74% reduction in groundwater discharge over the extreme two-year drought scenario. Similarly, in the Talbot River subwatershed, groundwater discharge is reduced by 73% under the two-year drought scenario, from 118,166 m^3/day to 32,488m^3/day. Groundwater discharge to streams at the start and end of the two-year drought (under current conditions) are presented in Figure 5 - 44 and Figure 5 - 45, respectively. The percent change in the surface discharge due to the drought is presented in Figure 5 - 46 for the current conditions scenario. The largest impacts due to drought are seen in the headwater tributaries across the model, which are sustained mainly by groundwater discharge that occurs where the streambed intersects the water table. These tributaries are therefore sensitive to small changes in groundwater levels (Earthfx, 2014).

Table 5 - 24: Two-year drought impact on groundwater discharge to surface features (Earthfx, 2014).

Component	Whites Creek	Talbot River
Current Conditions		
Average groundwater discharge (m^3/d)	13,647	118,166
Groundwater discharge at end of 2-year drought (m^3/d)	3,567	32,488
Percent Reduction	**74%**	**73%**
Future Conditions		
Average groundwater discharge (m^3/d)	13,644	113,466
Groundwater discharge at end of 2-year drought (m^3/d)	3,566	30,558
Percent Reduction	**74%**	**73%**

Figure 5 - 47 presents the change in groundwater levels in the weathered bedrock aquifer (layer 3) after the two-year drought. As illustrated in the figure, the largest declines in groundwater water levels occur around the topographic high points in the model, which typically represent areas of groundwater recharge. In the study area subwatersheds, water level changes as high as 15 m were noted in several locations. In the upper Talbot in particular, changes in the water level from the beginning to the end of the 2-year drought commonly surpassed 1 m, with the largest declines in water levels occurring in the northern alvar portions of the subwatershed. Notable declines in water levels were also simulated in the north-eastern portion of the Whites Creek subwatershed. Despite the drop in water levels, none of the municipal pumping wells went dry during the two-year drought simulation.

The 10-year drought scenario utilized the transient GSFLOW model. A model run spanning from October 1953 to October 1967 was executed using MNRF in-filled hourly precipitation data. The areas most affected by the drought are similar to those in the two-year drought simulation. As expected, the drawdowns are not as severe as those predicted under the two-year extreme drought scenario. The decrease in simulated monthly average water levels between July 1956 (the beginning of the drought period) and November 1964 (the most severe drought year) are shown in Figure 5 - 48. In the Whites Creek and lower Talbot River subwatersheds drawdown is generally predicted to be less than 1 m; in the central areas of the subwatersheds, water levels appear unaffected, even during the most severe drought episodes. Alternatively, in the upper Talbot, drawdowns are more pronounced, particularly in areas where the Carden Plain Alvar characterizes the surficial geology. Water levels in these northern upland alvar areas are simulated to decline by 1 m or more. Water level declines in this area are noteworthy, as these areas are predicted to contribute significant volumes of groundwater recharge to support ecologically significant features in the subwatershed. Despite the declines in groundwater levels, no municipal pumping wells went dry during the 10-year drought assessment.

Table 5 - 25 summarizes the change in total streamflow and groundwater discharge to four creeks in the Talbot River and Whites Creek subwatersheds from the beginning of the 10-year drought to the most severe period of drought (November 1964). Whites Creek runs through the central portion of the Whites Creek subwatershed, while Butternut Creek runs along the southern boundary of the upper Talbot subwatershed, just north of the Whites Creek boundary. Rohallion Creek is located in the alvar plain region of the upper Talbot subwatershed, while the Upper Talbot River spans from the northern tip of the upper Talbot subwatershed to Canal Lake. As presented in the Table, reduction in streamflow across the four streams ranges from 56% to 69%, while reduction in groundwater discharge ranges from 32% to 46%. The greatest reduction in both streamflow and groundwater discharge occurs at Butternut Creek. Figure 5 - 49 presents the percent reduction in simulated monthly average streamflow. As presented in the figure, the greatest decreases occur in the headwater tributaries, with many showing a near 100% decrease in flow. These decreases accumulate downstream and are added to the losses experienced in the downstream reaches. The main tributaries are generally affected to a lesser degree.

The percent decrease in groundwater discharge to streams from the beginning of the 10 year drought to the worst of the drought is shown in Figure 5 - 49. Model results indicate the largest relative impact on groundwater discharge occurs in the alvar plain area of the upper Talbot, where many tributaries show a nearly 100% decrease in flow (Earthfx, 2014). This is most likely due to the combination of the high hydraulic conductivity and low storage properties of the alvar. The main tributaries of Rohallion Creek and Upper Talbot Creek are affected to a lesser degree.

Table 5 - 25: Ten-year drought impact on total streamflow and groundwater discharge to creeks in the Whites Creek and Talbot River subwatersheds (Earthfx, 2014).

Component (m^3/s)	Butternut Creek	Rohallion Creek	Upper Talbot River	Whites Creek
Monthly average total streamflow – July 1956	0.062	0.222	0.411	0.222
Monthly average total streamflow – November 1964	0.019	0.092	0.173	0.097
Percent Reduction	**69%**	**59%**	**58%**	**56%**
Monthly groundwater discharge to streams - July 1956	0.021	0.100	0.158	0.104
Monthly groundwater discharge to streams - Nov. 1964	0.011	0.056	0.094	0.071
Percent Reduction	**46%**	**44%**	**41%**	**32%**

Key points – Water Budget & Stressors:

- The total current groundwater demand from all sources in the Whites Creek and Talbot River subwatersheds are estimated to be 1,137,413 m^3/year or 3114 m^3/d.

- Municipal and Permitted wells account for 3% of the consumptive groundwater demand in the Talbot River subwatershed. In the Whites Creek subwatershed there are no active municipal or permitted groundwater takings. Future increases in municipal demand are not expected for either of the subwatersheds.

- Together, agricultural uses and the unserviced domestic supply account for 3% of the consumptive groundwater demand in the Talbot River subwatershed, and 100% of the consumptive demand in the Whites Creek subwatershed.

- Permitted quarry dewatering activities account for 92% of the consumptive groundwater demand in the Talbot River subwatershed. In the future, the greatest increase in consumptive groundwater demand is expected to result from expanding quarry operations.

- In the Talbot River subwatershed natural areas are the predominant land use type. Despite accounting for the greatest consumptive groundwater demand, aggregate pits and quarries cover just under 1% of the landscape.

- In the Whites Creek subwatershed agricultural land uses are the predominant land use type.

- The Tier 1 water budget for the Talbot River subwatershed estimated current groundwater consumption to be 761,000 m^3/annum, which represents 4% of the available groundwater supply. Future groundwater use is projected to be 763,000 m^3/annum which represents 4% of the available groundwater supply for Talbot River subwatershed. Overall, the Tier 1 indicated that the Talbot River subwatershed was not stressed from a groundwater perspective.

- Under the Tier 2 water budget, the Whites Creek subwatershed is estimated to have a potential stress level of 0.2%. Under the future conditions scenario this stress level remains unchanged, indicating that the subwatershed is not stressed from a groundwater perspective. In the Talbot River subwatershed, the estimated potential stress level under current conditions is 2.1%; under future conditions, this stress level increases slightly to 6.5%. Overall both the Talbot River and Whites Creek subwatersheds are at a low groundwater stress level, and will remain at the low stress level under projected future conditions.

- Under simulated drought scenarios, streamflows are expected to decrease between 56% to 69% in four of the major streams in the study area subwatersheds. Reductions in groundwater discharge are predicted to range from 32 – 46%. The greatest decreases in streamflow and groundwater discharge are expected to occur in the headwater tributaries.

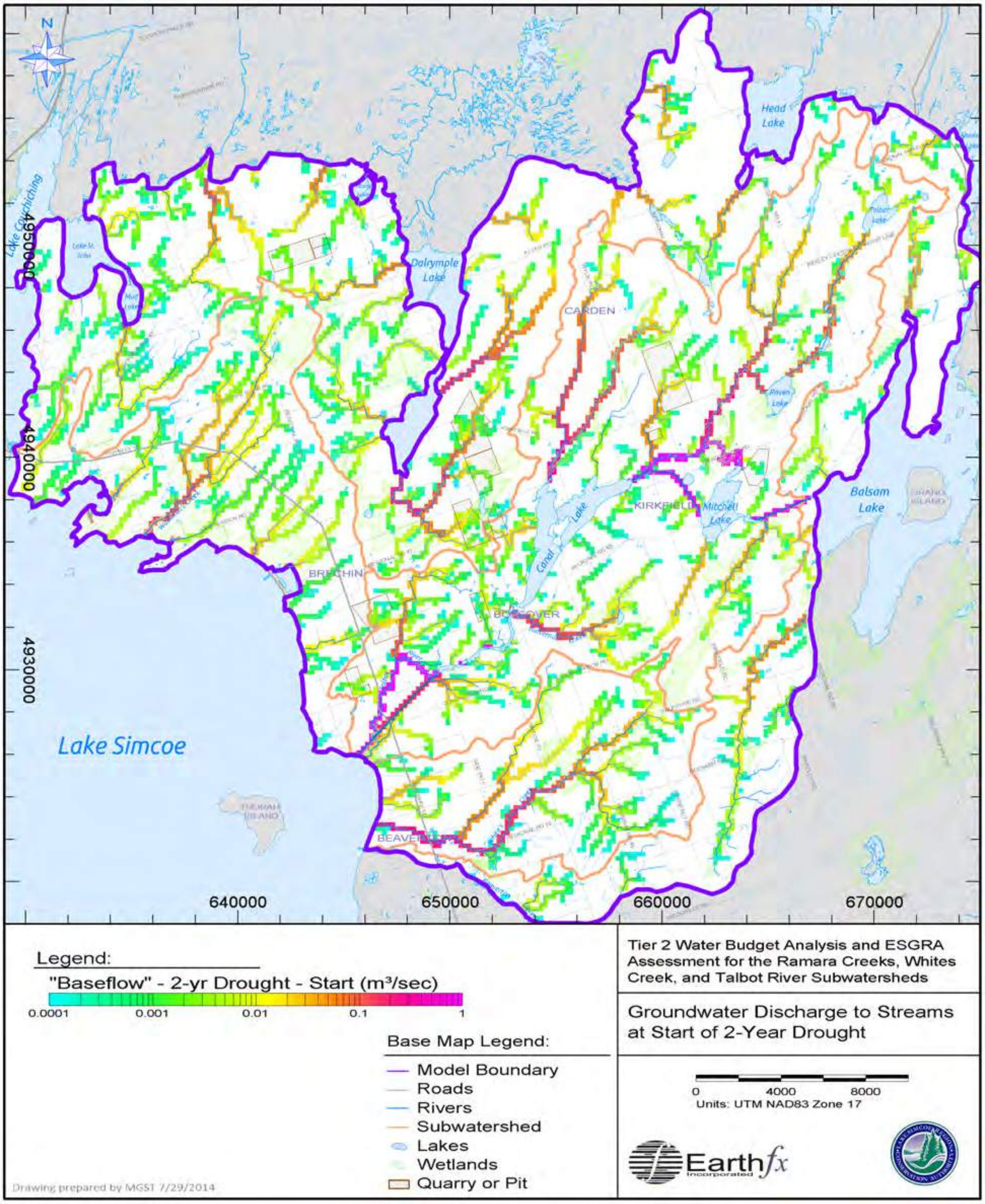


Figure 5 - 44: Simulated groundwater discharge to streams (baseflow) at start of two-year drought (current conditions) (Earthfx, 2014).

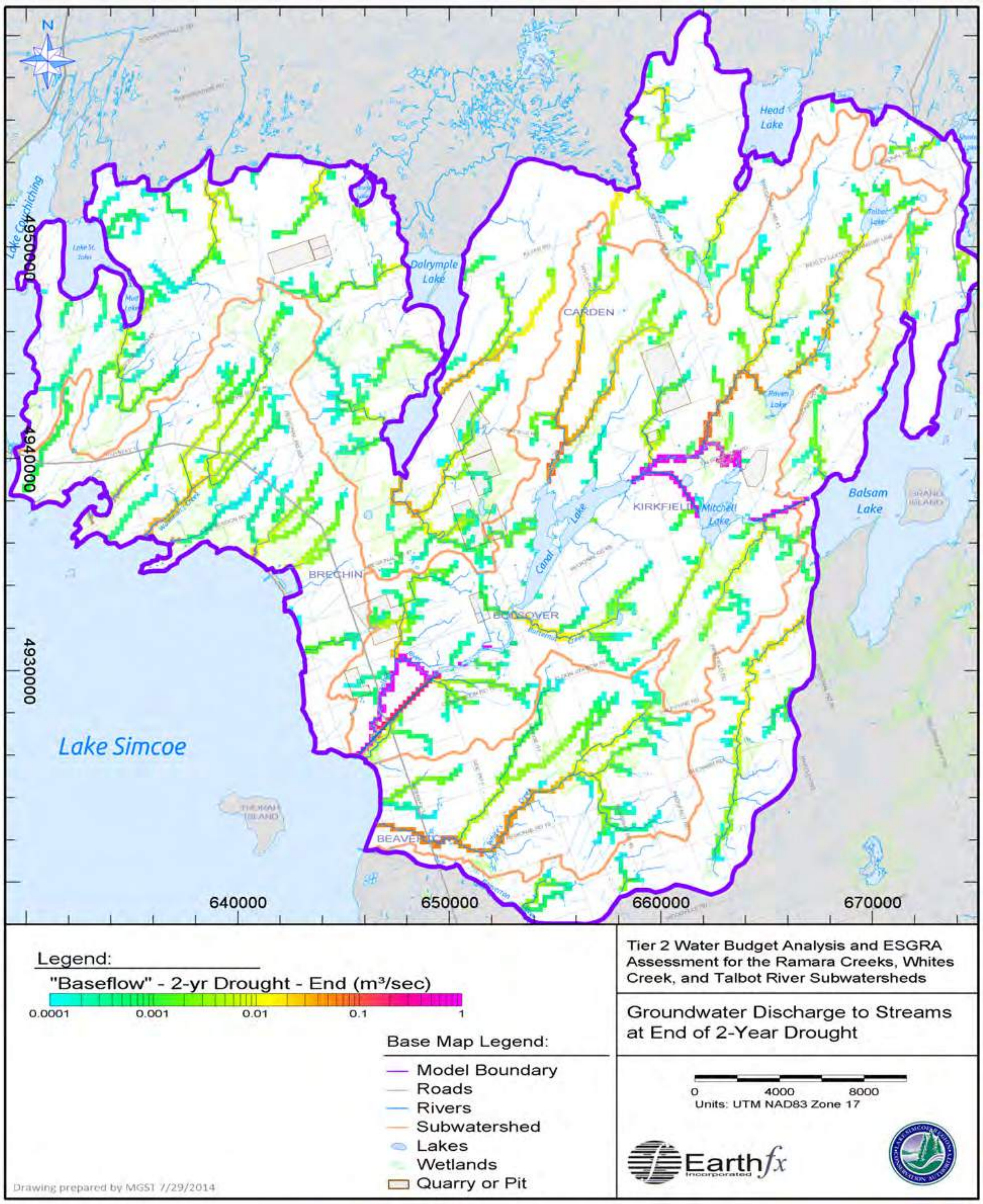


Figure 5 - 45: Simulated groundwater discharge to streams (baseflow) at end of two-year drought (current conditions) (Earthfx, 2014).

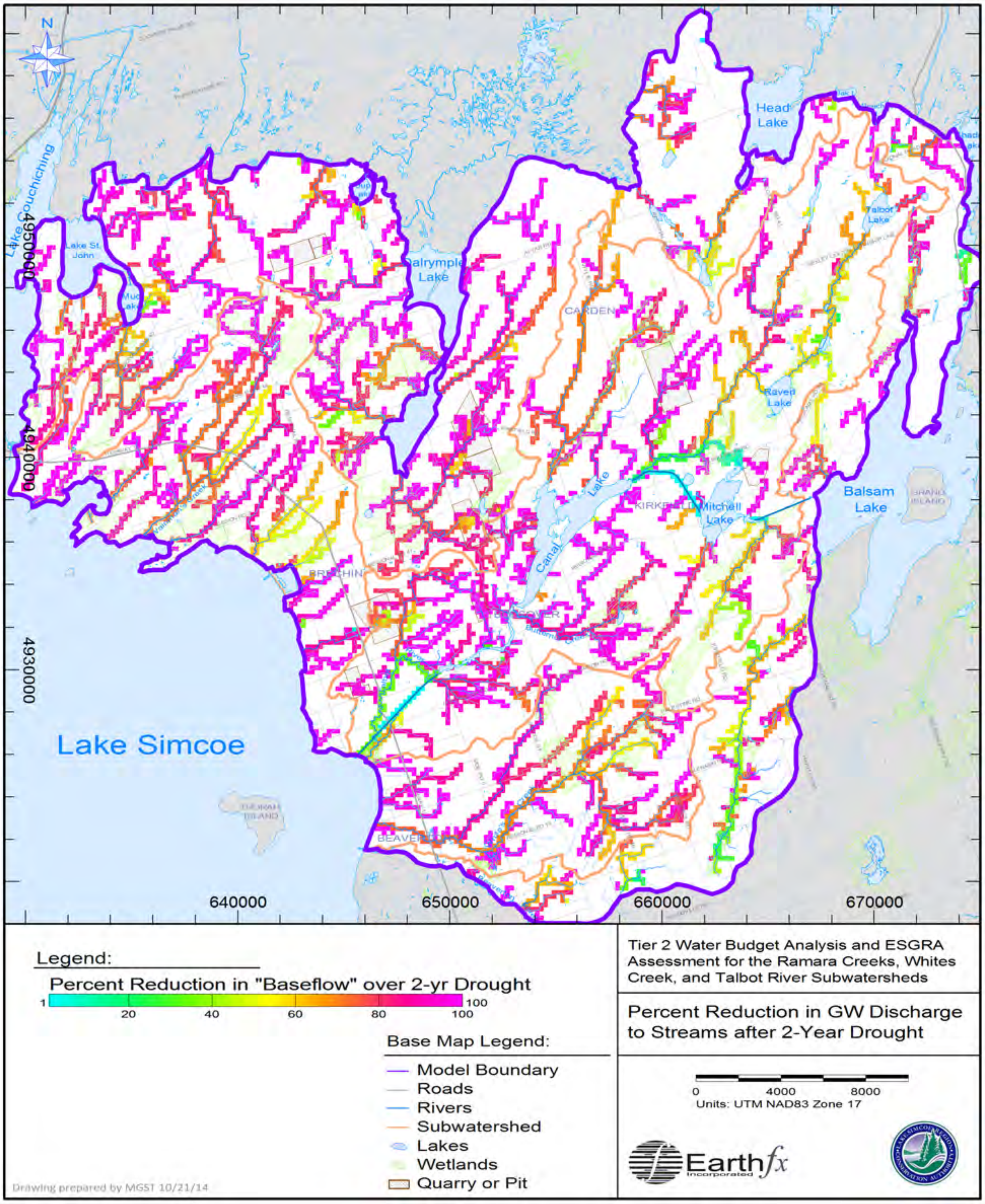


Figure 5 - 46: Percent reduction in baseflow at the end of the two-year drought (current conditions) (Earthfx, 2014).

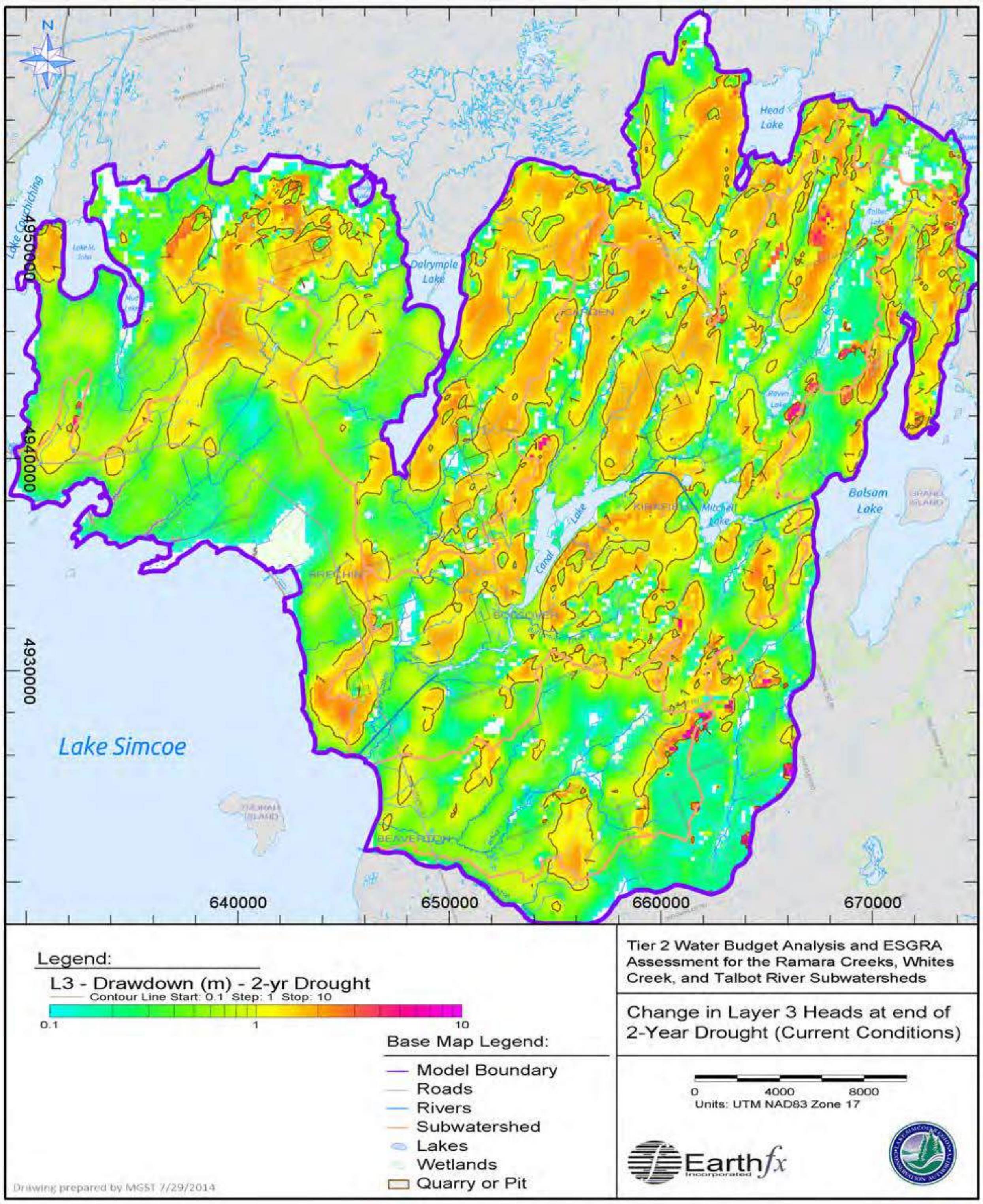


Figure 5 - 47: Change in Layer 3 heads after a two-year drought with no groundwater recharge (current conditions) (Earthfx, 2014).

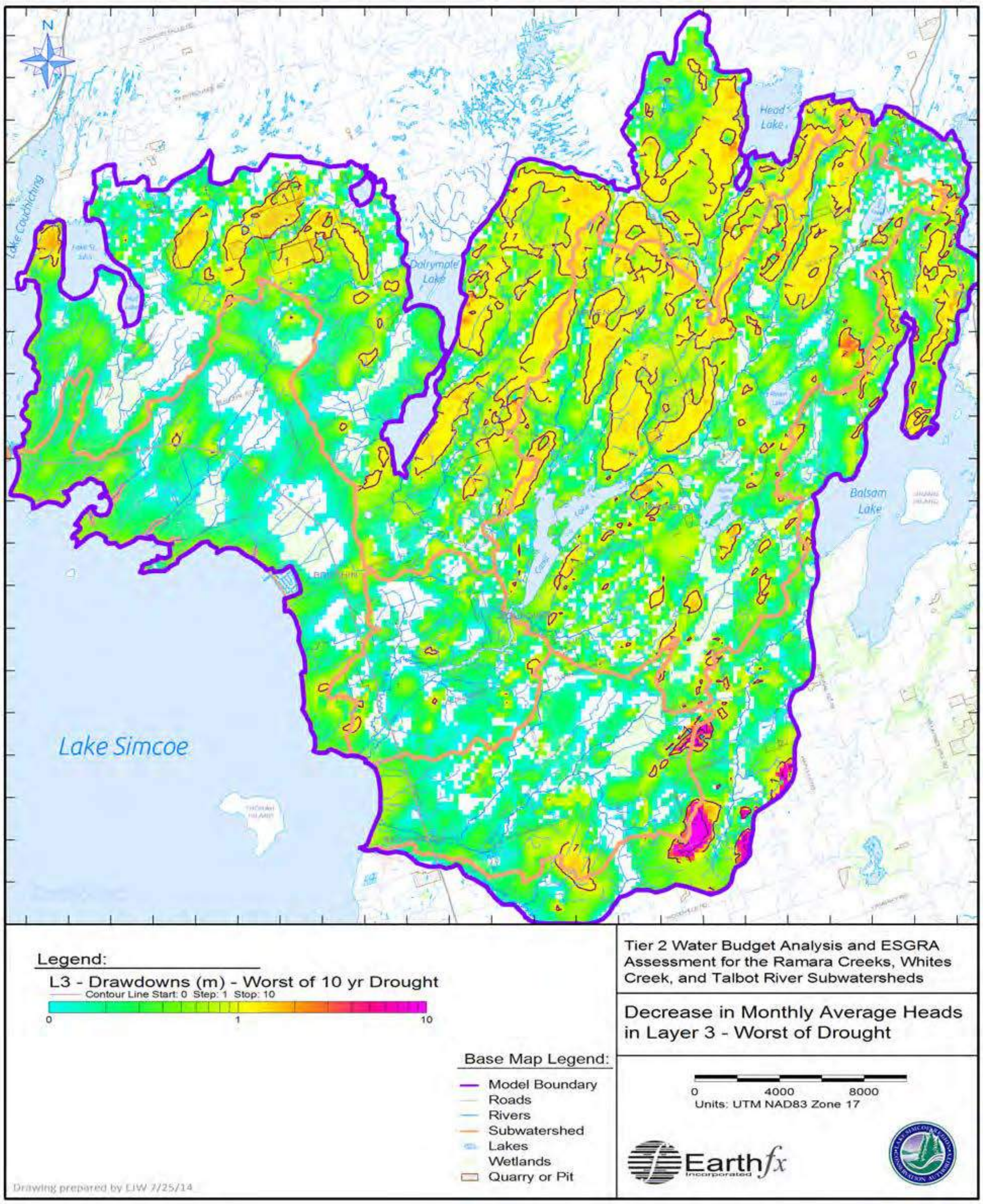


Figure 5 - 48: Decrease in simulated monthly average heads in Layer 3 at worst of drought (November 1964) (Earthfx, 2014).

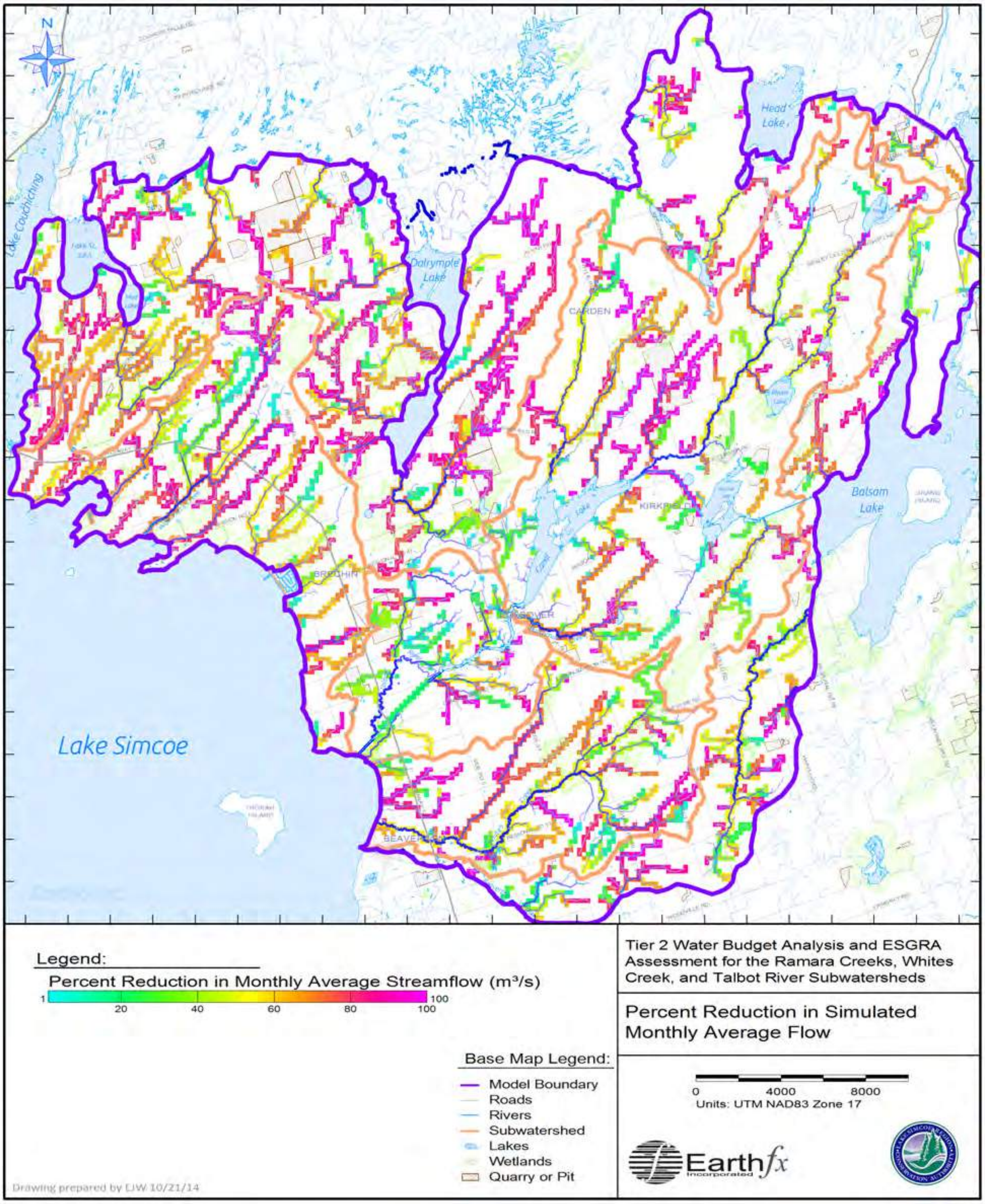


Figure 5 - 49: Percent reduction in simulated monthly average flow (July 1976 versus November 1964) (Earthfx, 2014).

5.4.4 Climate Change

The climate of the Whites Creek and Talbot River subwatersheds directly determines the quantity of surface and groundwater present in the system. When the spring melt occurs, a large volume of water is released. This water will first infiltrate the ground. When the soil becomes supersaturated the remaining water will flow overland until it reaches the tributaries and main branches of local rivers.

The temperature in the subwatershed can directly affect the quantity of water present in the system. In the cold winter months the water is frozen at the surface so the quantity of available water is reduced. In the hot summer months the water is flowing but an overall loss is occurring due to the high rates of evaporation.

Changes in climate trends have the potential to impact local water resources. An assessment of the effects of climate change on surface and groundwater resources in the Ramara Creeks, Whites Creek, and Talbot River subwatersheds was conducted using the integrated surface and groundwater model developed by Earthfx (2014). A detailed evaluation of the potential impacts of climate change on the hydrology and hydrogeology of the Whites Creek and Talbot River subwatersheds is further discussed below.

Changes in climate have the potential to impact local surface water and groundwater systems and the interactions between them. Predictions of projected changes in Ontario climate based on over 30 global circulation models indicate that total annual temperature will likely increase by 2 to 6% , while precipitation may increase by 2 to 4% by the 2050s over the Great Lakes Basin (Ontario Chapter of the Soil and Water Conservation Society, 2007). Changes in extreme warm temperatures are expected to be greater than changes in the annual mean temperature (Kharin and Zwiers, 2005), and the number of days exceeding 30 degrees Celsius is projected to more than double by the 2050s in Southern Ontario (Hengeveld and Whitewood, 2005), while heat waves and drought may become more frequent and longer lasting.

To evaluate the potential effects of climate change on groundwater and surface water systems on a subwatershed scale, Earthfx (2014) used the integrated surface and groundwater model in conjunction with transient global circulation model (GCM) datasets to simulate a number of climate change scenarios. In order to simulate the scenarios at a local scale, it was first necessary to downscale outputs from a selection of global circulation models. Outputs were downscaled using the Change Field Method – an approach recommended by Provincial Guidance, that involves the modification of baseline climate data by shifting the mean of observed climate data, and multiplying observed climate parameters by appropriate scale factors (e.g. a +2.5% increase in average daily temperature, and a +10% increase in total precipitation for January). The application of the Change Field Method yields a range of future climate data sets which can then be input into the local scale model to simulate future responses to climate change; these responses are then compared to baseline conditions for an overview of climate change impacts. For this study, a baseline period from 1971 -2000 and a future period representing 2041 – 2070 were utilized (Earthfx, 2014).

Before applying the change field method it was necessary to select the subset of global circulation models that would be downscaled and simulated for the climate change analysis, this was accomplished using the Percentile Method. In the percentile method, outputs of global circulation models, as sampled at a Ontario climate station, are ranked in ascending order, first based on their mean annual temperature change field, and then based on their precipitation change field – for this study the Orillia Brain climate station, located on the north shores of Lake Simcoe, was selected. A percentile is assigned to each climate scenario, and the 5th, 25th, 50th, 75th, and 95th percentiles are selected for modelling temperature and precipitation change (Earthfx, 2014). For this study, a total of nine unique climate scenarios were selected and simulated using the integrated surface/groundwater model. The subset of climate data sets used for the study as obtained from the Ministry of Natural Resources. The subset of climate data obtained was then adjusted based on the change field for each of the nine unique scenarios.

Figure 5 - 50 shows the range in monthly change fields used to scale the precipitation data for the nine climate scenarios presented as box-whisker plots. The zero line in the plot represents the baseline scenario. As can be seen, monthly precipitation increases in the majority of the climate change scenarios except for June and July, resulting in generally wetter falls, winters, and springs and drier summers (Earthfx, 2014). Figure 5 - 51 shows the range in monthly change fields used to shift the temperature data for the nine climate change scenarios. All the scenarios show an increase in temperature of at least one degree Celsius in all months, with winter and late summer/fall (August and September) having the highest increase (Earthfx, 2014).

The integrated surface/groundwater model was run to simulate each of the nine climate change scenarios. Analysis of model runs indicated that all components of the water budget are affected by changes in precipitation and temperature under the future climate scenarios. The results discussed in this section are presented in terms of monthly and annual average values over the model area.

Figure 5 - 52 shows the percent change in annual average net groundwater recharge under the climate change scenarios. When averaged over the year, recharge rates appear largely unchanged in the Whites Creek and lower Talbot subwatershed, with little to no increase occurring over the majority of the landscape, particularly in the till covered areas. However, in the Upper Talbot subwatershed, particularly on the alvar plain, annual average recharge is simulated to increase by as much as 40 - 60mm a year in certain portions of the subwatershed. This is likely due to the high hydraulic conductivity and low storage properties of the surficial geology associated with the alvar plains.

The effects of climate change on recharge rates are even more pronounced when observed on a monthly basis. As seen in Figure 5 - 53, median monthly groundwater recharge under climate change is predicted to increase significantly in the late fall and winter months and decrease during March and April. This indicates that although the net annual groundwater recharge may be largely unchanged over portions of the study area, there is a noticeable change in the magnitude and timing of seasonal recharge patterns that is likely to impact the hydrogeology across all of the study area subwatersheds.

To evaluate local groundwater response in significant hydrogeologic features under climate change, four inspection points were selected for analysis. The first inspection point is located near the Western Trent /Palmina municipal well field. This first inspection point was selected to observe groundwater responses to climate change in the municipal drinking water supply aquifer (the Shadow Lake aquifer). The second inspection point is located in the eastern portion of the Whites creek subwatershed, while inspection points 3 and 4 are located on the Carden plain alvar in the upper portion of the Talbot River subwatershed.

Under the climate change scenarios, groundwater levels experience an earlier and more prolonged response to the spring freshet, combined with less dramatic decreases in water levels over the winter months of January to March compared to the baseline scenario (Earthfx, 2014). This can be attributed to the wetter winters predicted by the global circulation models, which predict that a larger portion of winter precipitation will fall as rain rather than snow. Warmer temperatures predicted during the winter are also simulated to cause a reduction in average snowpack and ice coverage, which would otherwise serve to impede the movement of precipitation and runoff into the subsurface. The overall result of these climate change factors is an increase in groundwater recharge, which in turn is predicted to lead to higher groundwater levels throughout the winter months when compared to the baseline scenario (Earthfx, 2014). In addition, the increased proportion of rain (compared to snow) during the winter months was simulated to shift the spring freshet to earlier in the season, causing a lower magnitude increase in groundwater levels during the spring freshet, with the freshet occurring about a month earlier than under the baseline scenario.

Figure 5 - 54 to Figure 5 - 57 plot the average simulated monthly groundwater levels simulated for the four inspection points under each of the selected climate change scenarios. Figure 5 - 54 presents the climate change response of the deep Shallow Lake Aquifer near the Western Trent/Palmina wellfield, where the aquifer is well confined by the overlying bedrock aquitards. The impacts of climate change are generally muted, and predominantly fall within the same levels as the baseline scenarios, however, the impact of increased winter recharge is still visible in the monthly average groundwater levels for the months of January to May (Earthfx, 2014).

The impacts of climate change on groundwater discharge were also evaluated in the study area subwatersheds. The seasonal pattern of groundwater discharge to surface features echoes the previously discussed winter time response to climate change; since groundwater levels are anticipated to be higher during the winter months, the discharge into surface water features will also increase during these months (Earthfx, 2014).

Climate change impacts to streamflow were also evaluated at several locations within the model area including Rohallion Creek on the alvar plain, the upper Talbot River, Butternut Creek, the lower Talbot River near Lake Simcoe, and Whites Creek. Figure 5 - 56 to Figure 5 - 62 illustrate the average simulated monthly streamflow in each of the tributaries under baseline and climate change scenarios. Warmer winter conditions with higher average precipitation are simulated to cause higher winter streamflows from December through March in all modelled study area streams. Due to the warmer winter temperatures, precipitation that would be stored in the snowpack under baseline conditions is instead predicted to run off as streamflow during mid-winter melt and rain-on-snow runoff events (Earthfx, 2014).

Changes to the timing and magnitude of the spring freshet were also observed under the climate change scenarios. Predicted increases in winter temperatures and streamflow are expected to result in a decrease in the magnitude of spring freshet peaks. These winter temperature increases, and corresponding decreases in snowpack storage, are also expected to shift the timing of the spring freshet, by causing more water to move off study catchments earlier.

Shifts in freshet timing are predicted to result in a shift in the timing of spring recharge. Shifts in recharge rates from April to March produce a corresponding shift in the onset of low water periods. With longer summer low flow periods occurring earlier, the duration and severity of summer low flows increases (Earthfx, 2014). This is particularly true for stream catchments located in alvar areas, where the karstic nature of the landscape provides little recharge storage to support streamflow during the summer months (Earthfx, 2014). Overall, increasing temperatures, combined with a shift in the magnitude and timing of spring freshet and recharge events, are predicted to increase the stress placed on study area streams.

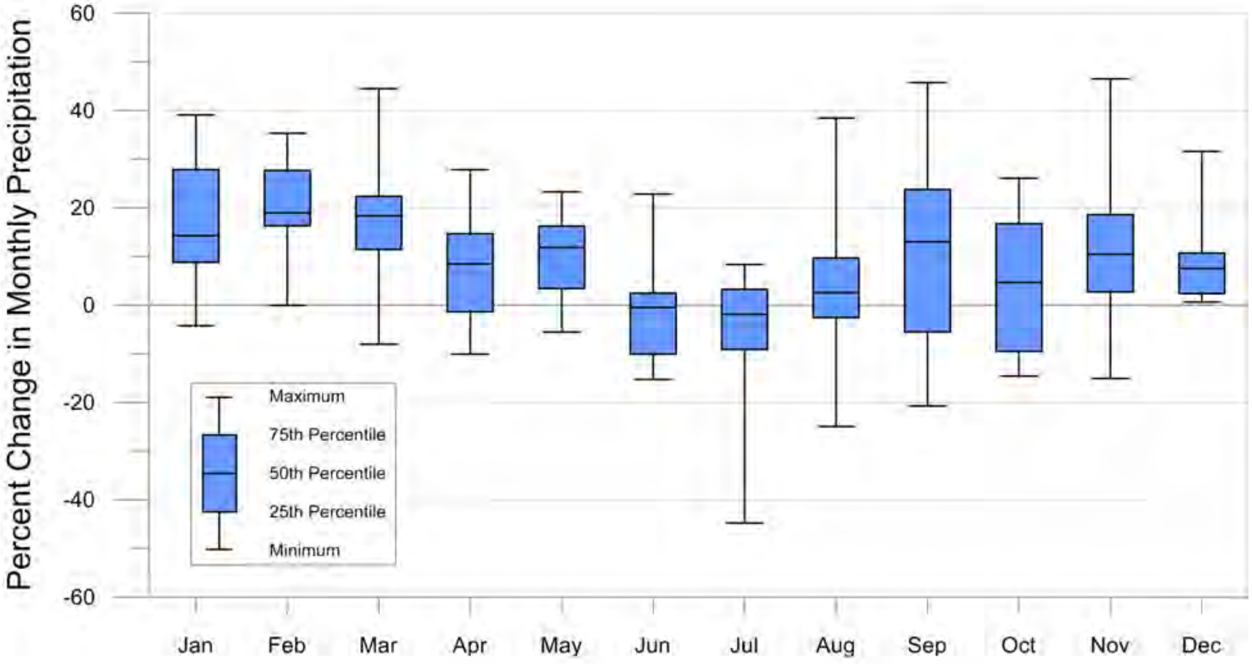


Figure 5 - 50: Monthly precipitation change field statistics for the climate scenarios selected for this studies (Earthfx, 2014).

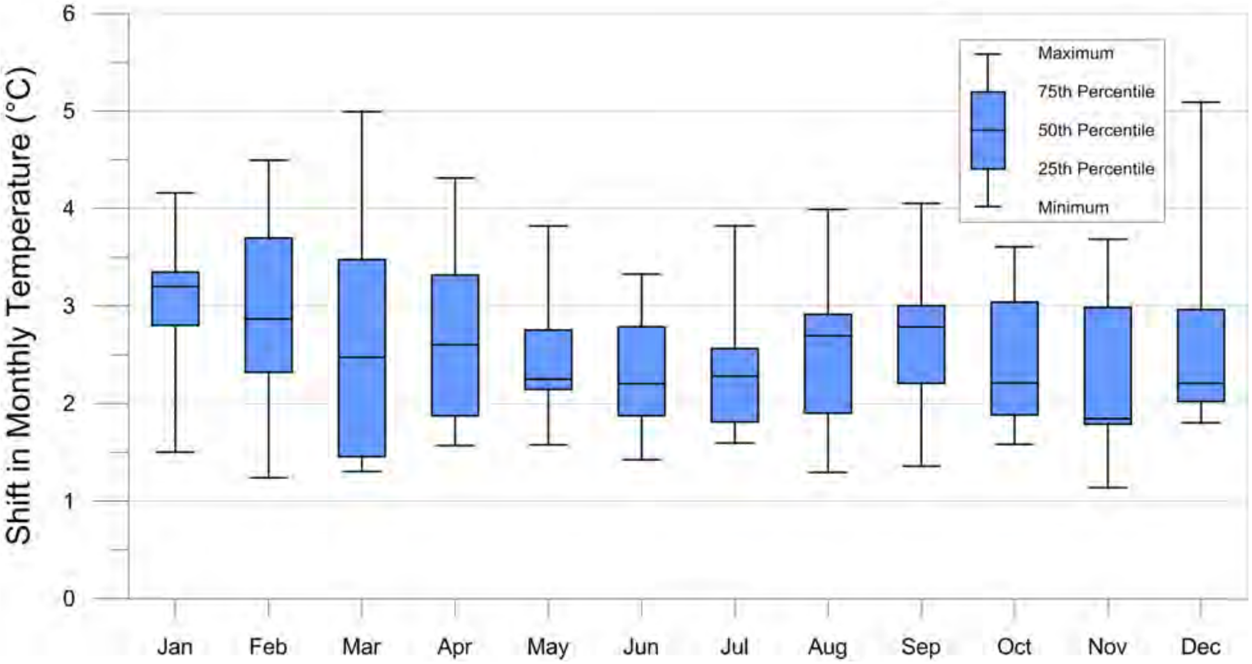


Figure 5 - 51: Monthly temperature change field statistics (Earthfx, 2014).

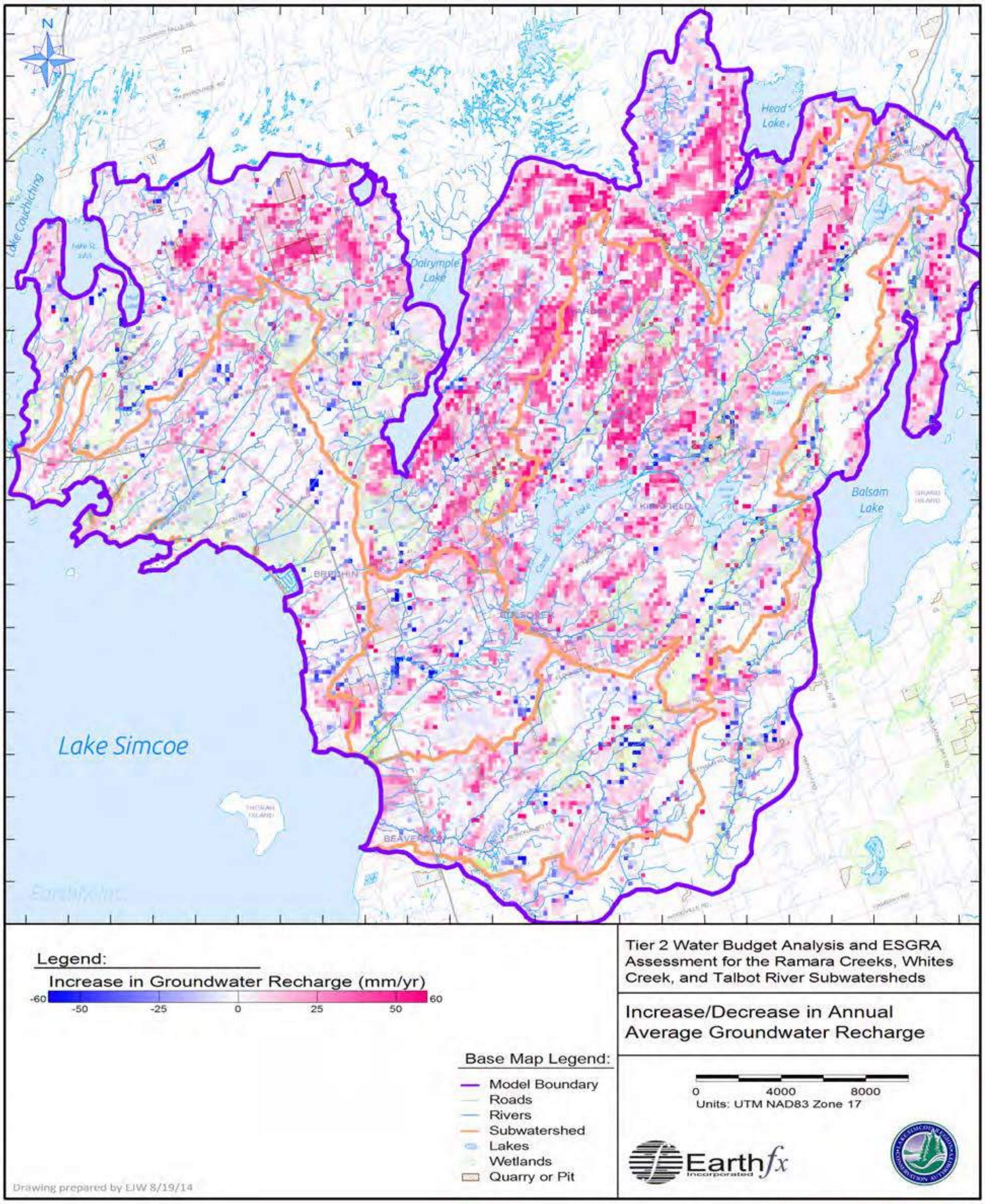


Figure 5 - 52: Change in annual average net groundwater recharge (Earthfx, 2014).

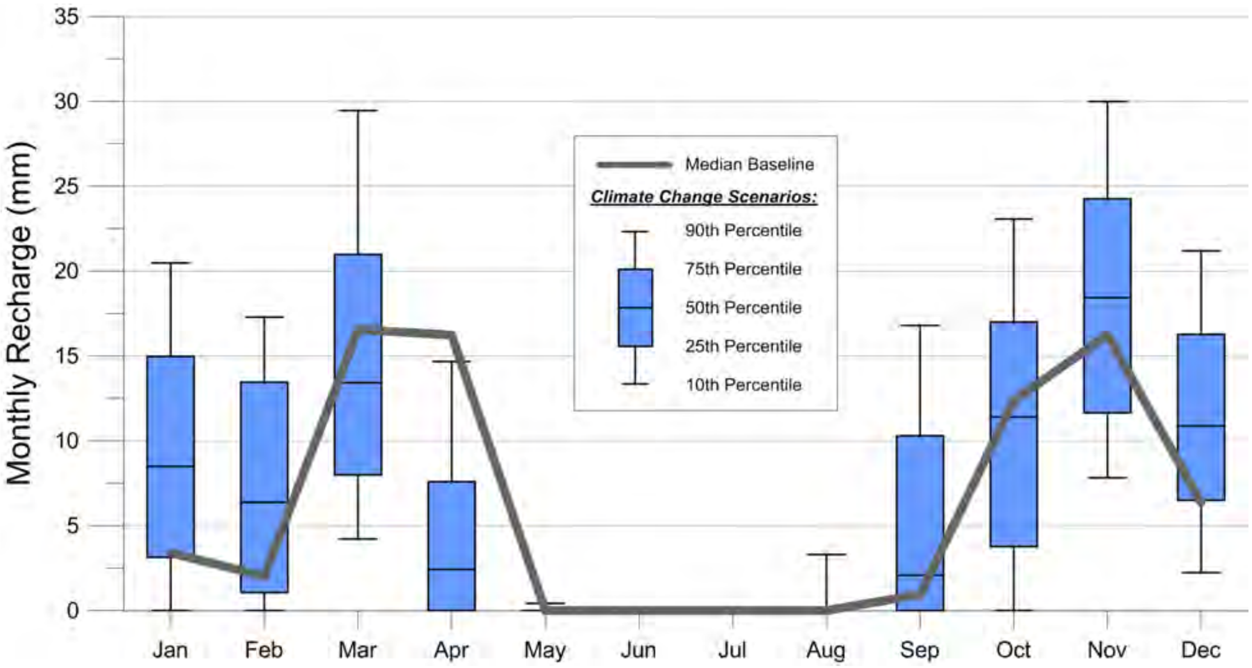


Figure 5 - 53: Monthly average groundwater recharge statistics for the study area (Earthfx, 2014).

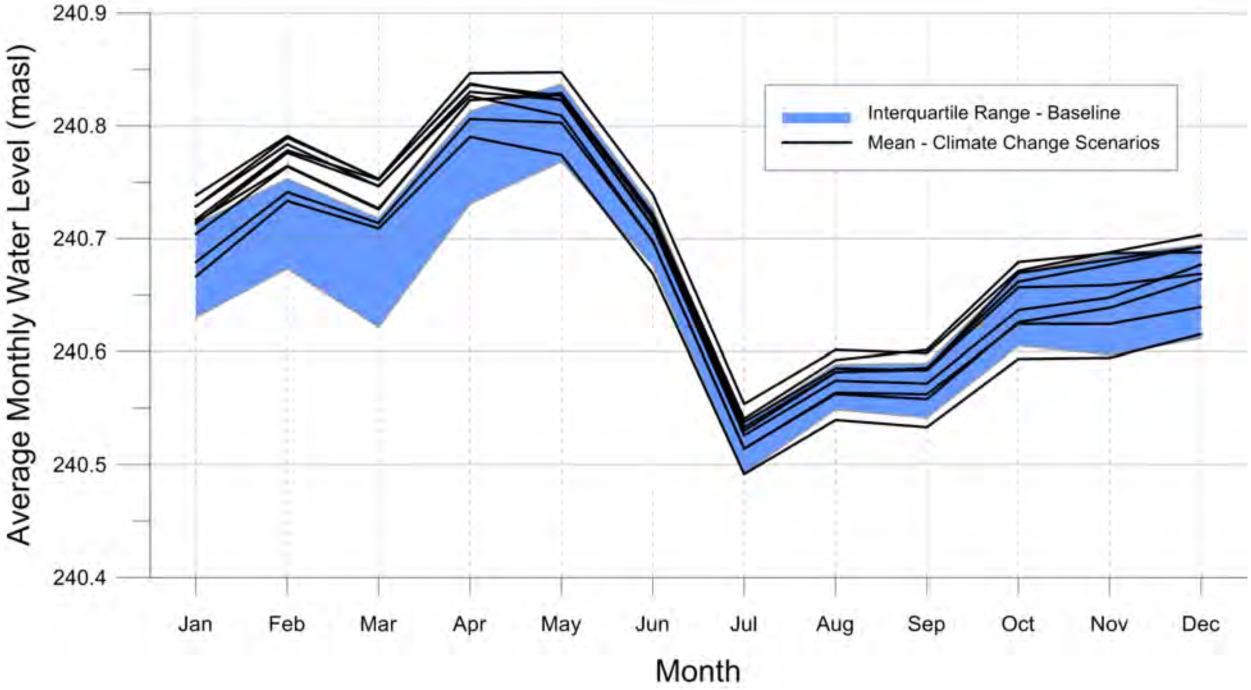


Figure 5 - 54: Average simulated monthly groundwater levels at Location C –Bolsover Wellfield (layer 7) (Earthfx, 2014).

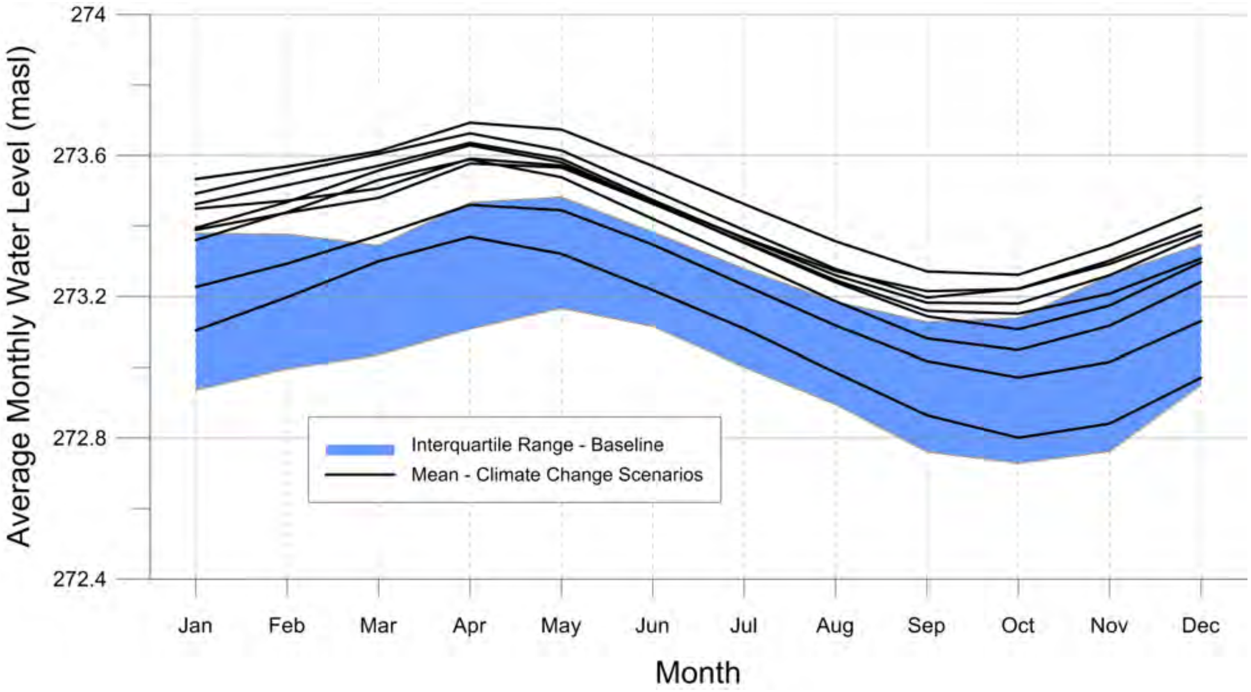


Figure 5 - 55: Average simulated monthly groundwater levels at Location D- Whites Creek and Prospect Rd. (layer 3) (Earthfx, 2014).

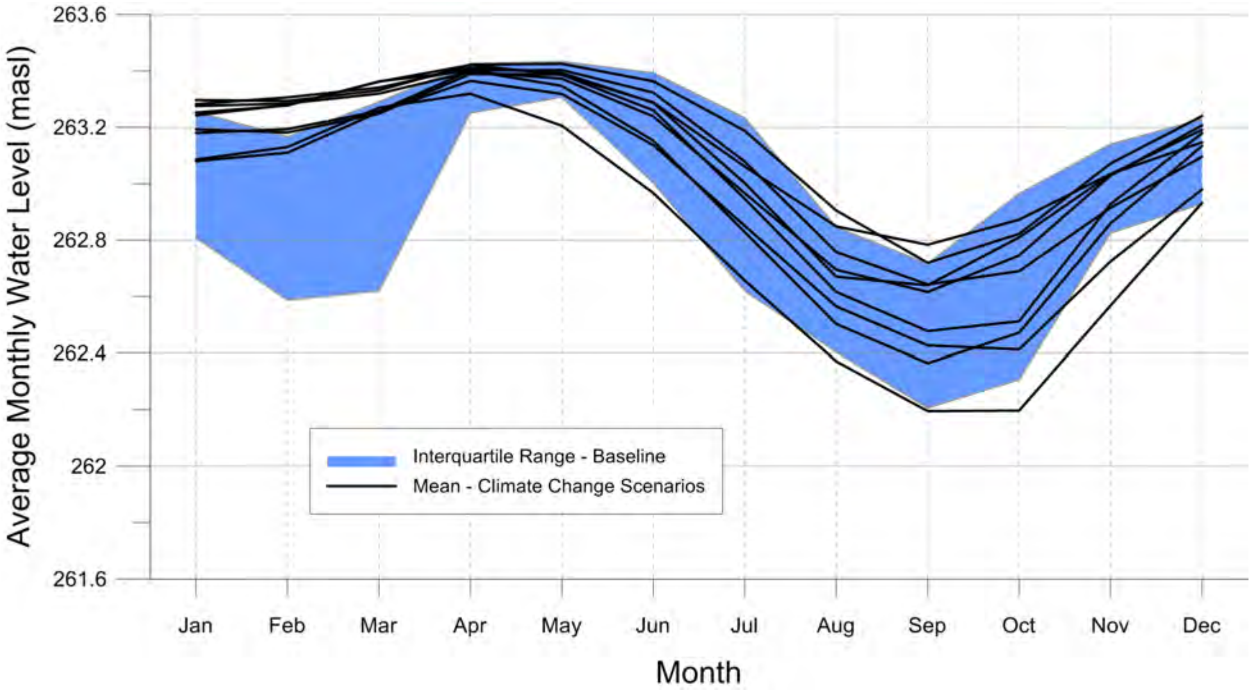


Figure 5 - 56: Average simulated monthly groundwater levels at Location E - Talbot Alvar (layer 3) (Earthfx, 2014).

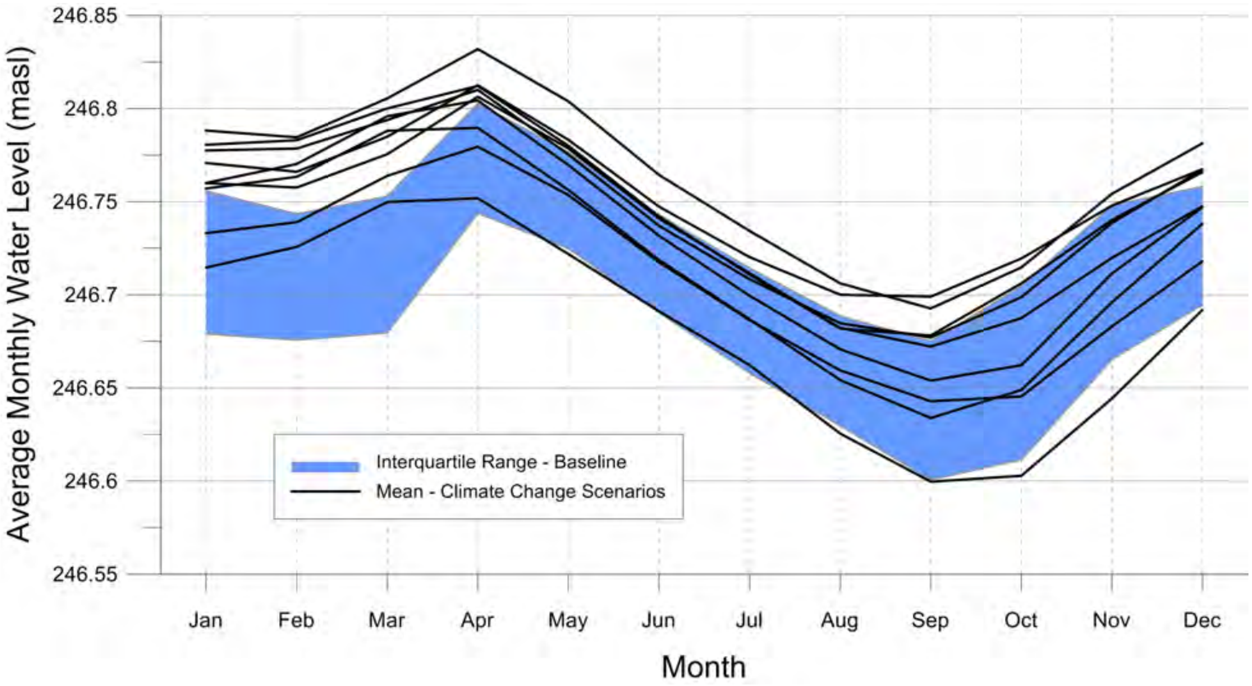


Figure 5 - 57: Average simulated monthly groundwater levels at Location F – Talbot Valley (layer 3) (Earthfx, 2014).

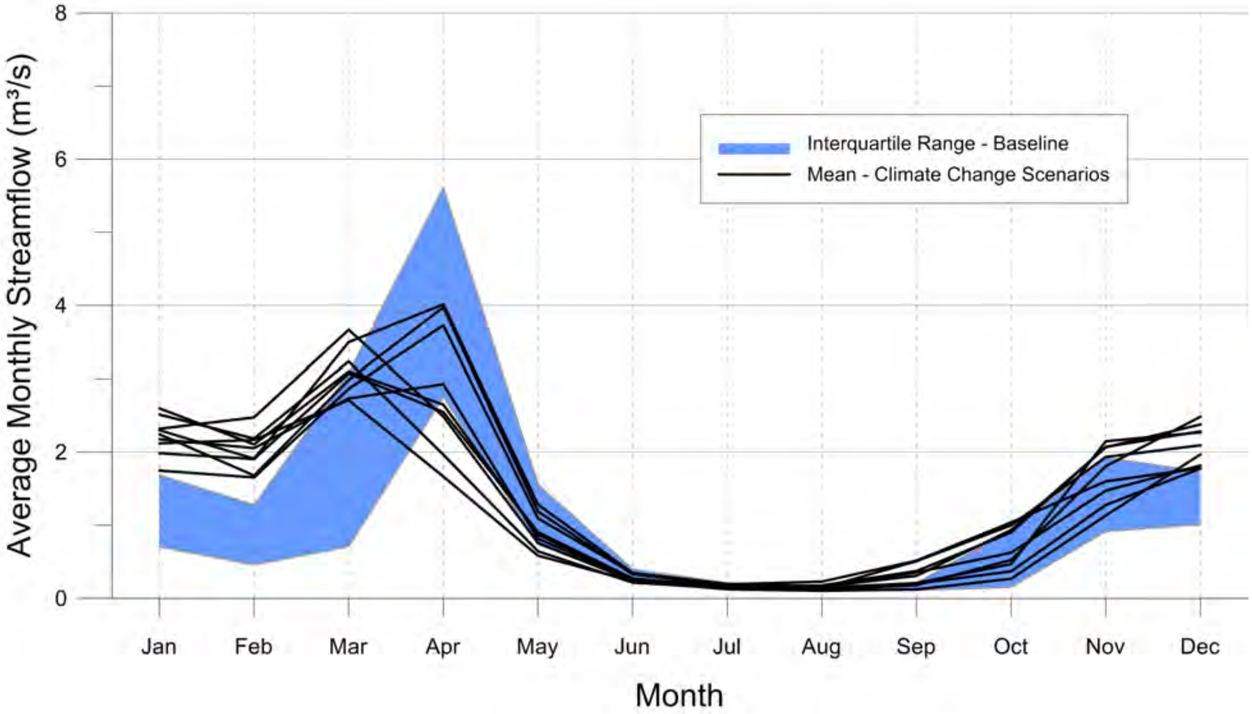


Figure 5 - 58: Average simulated monthly streamflow in Whites Creek (Earthfx, 2014).

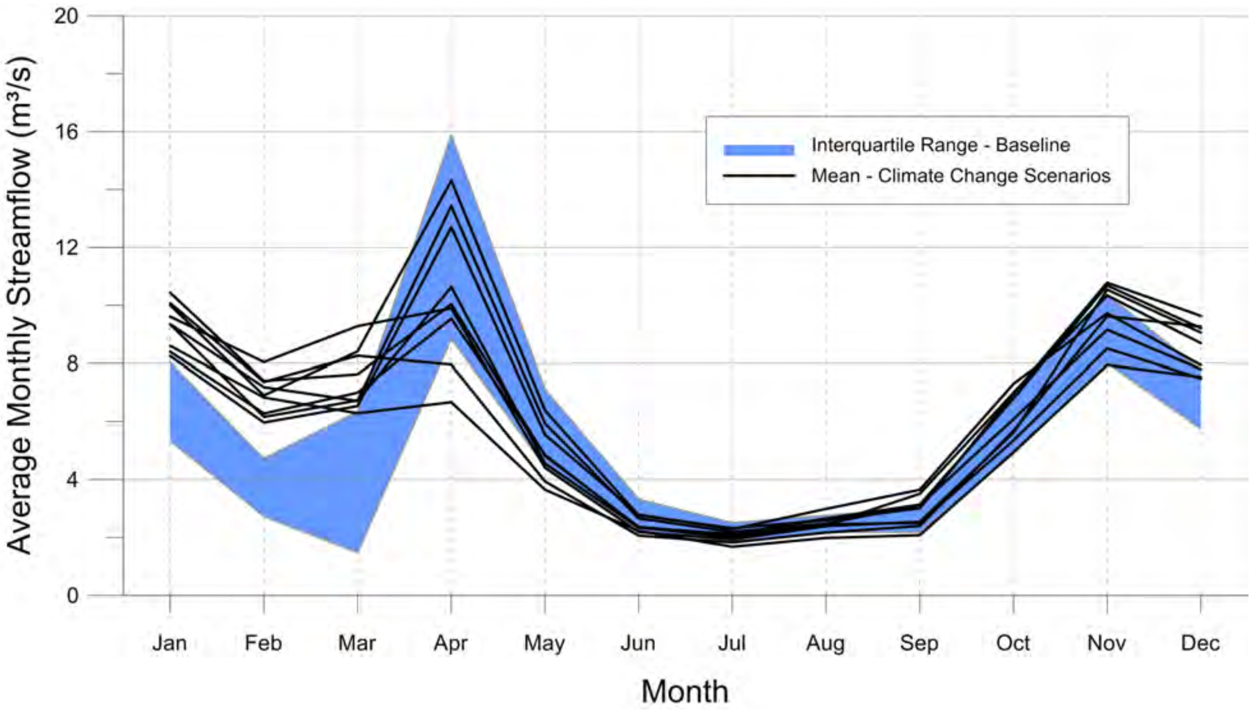


Figure 5 - 59: Average simulated monthly streamflow in the Lower Talbot River (Earthfx, 2014).

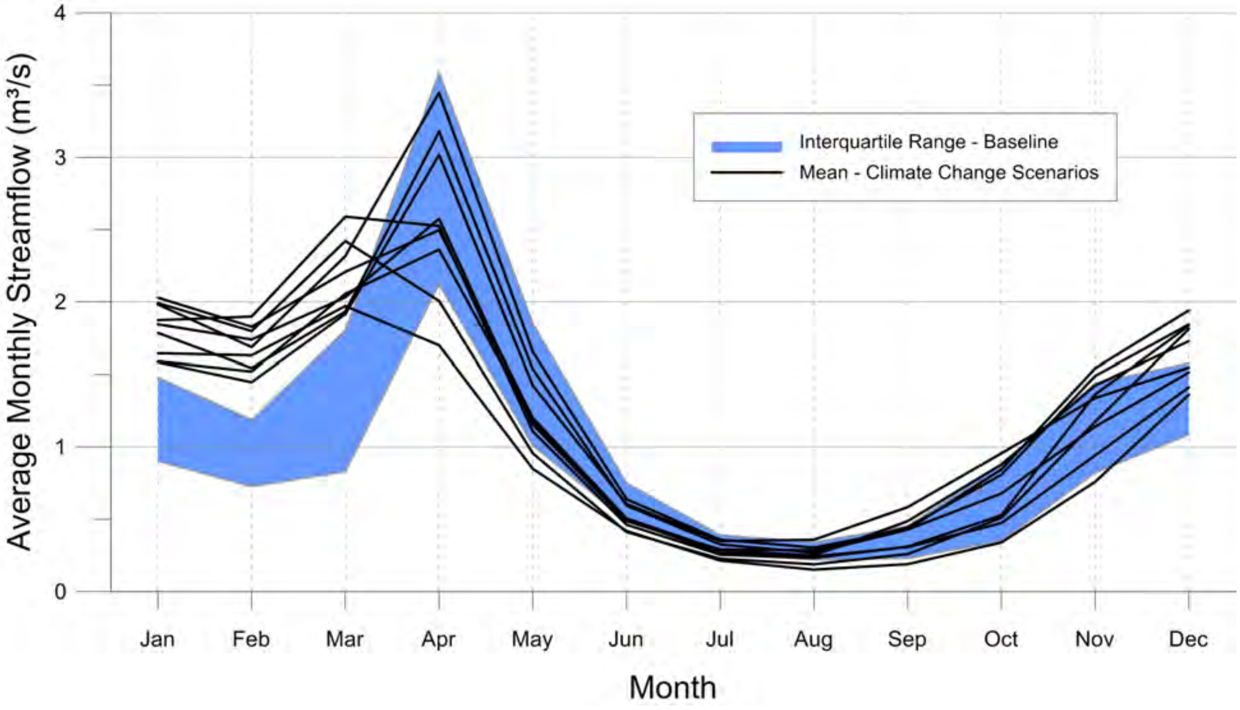


Figure 5 - 60: Average simulated streamflow in the Upper Talbot River (Earthfx, 2014).

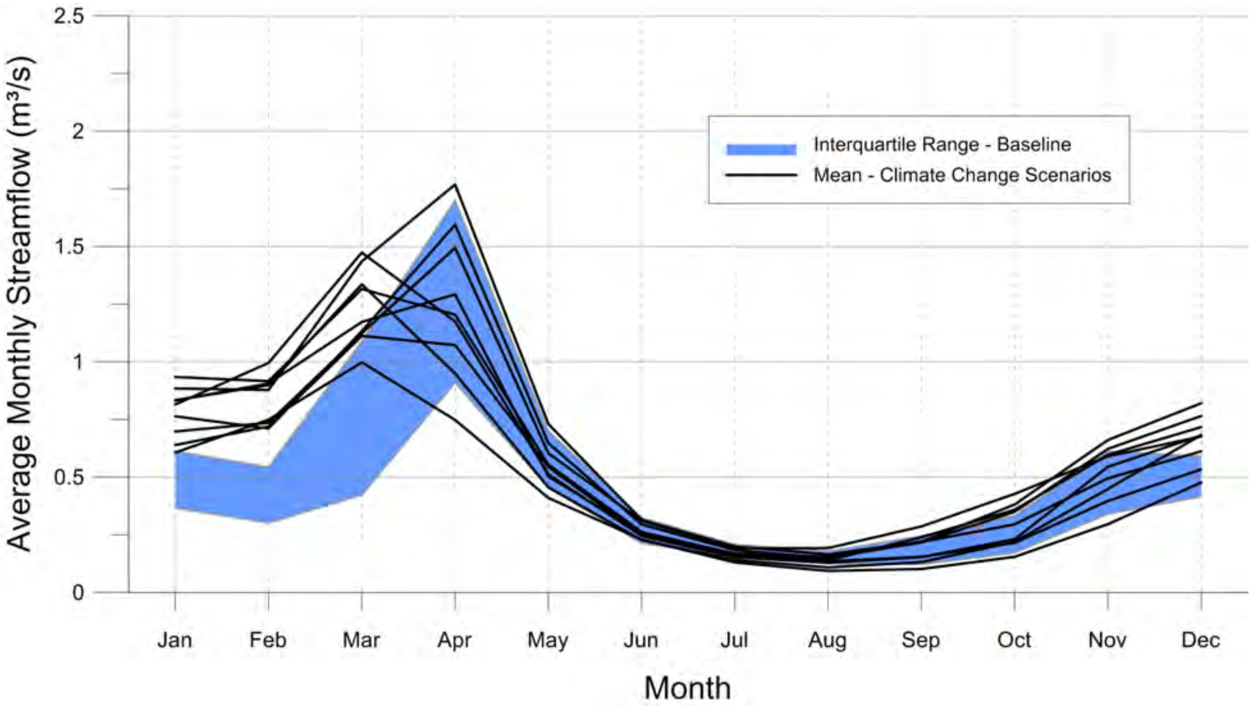


Figure 5 - 61: Average simulated monthly streamflow in Rohallion Creek (Earthfx,2014).

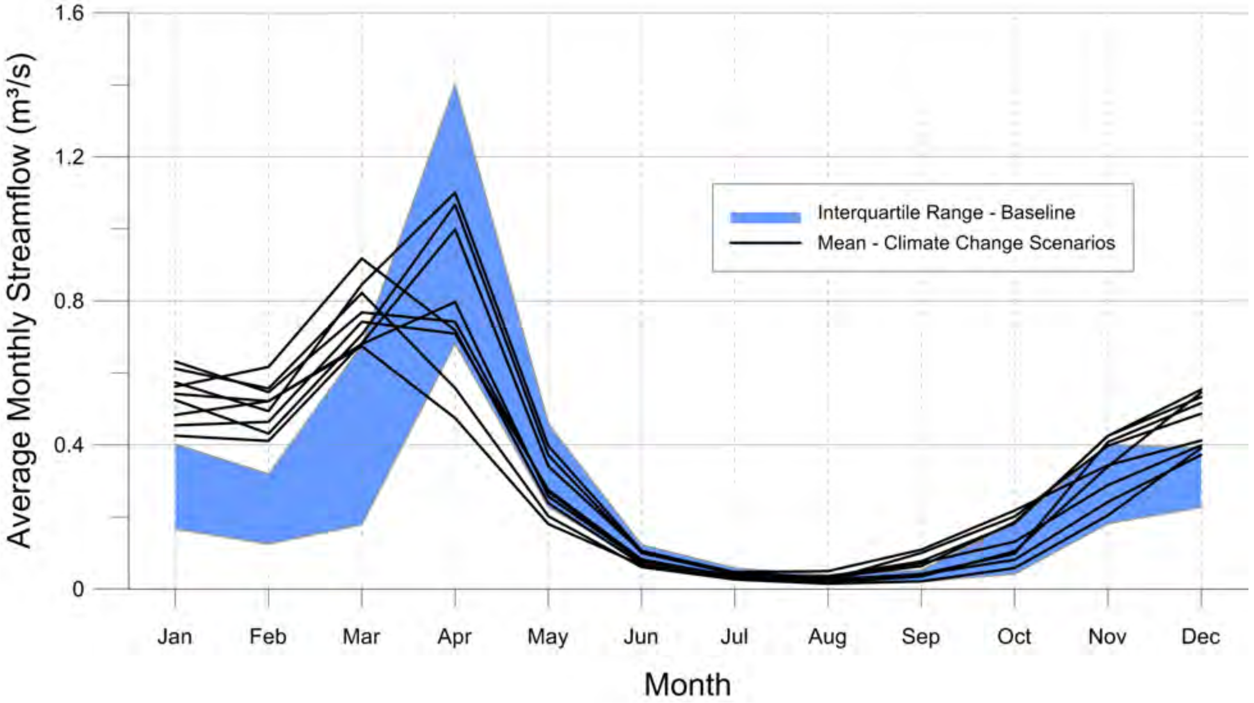


Figure 5 - 62: Average monthly streamflow in Butternut Creek (Earthfx, 2014).

Key points – Climate Change:

- A watershed scale integrated groundwater- surface water model was used in conjunction with 9 unique Global Circulation Model datasets to simulate the effects of climate change scenarios in the study area.
- Analysis of the climate change scenario outputs indicated that temperature in the study areas will increase by at least 1 degree Celsius in all months, with winter and late summer/ fall having the highest increases in temperature. Monthly precipitation is also generally expected to increase, except during the summer months. This is predicted to result in a wetter fall and winter, and a drier summer season.
- Warmer winter temperatures, increased winter precipitation, and reduced snowpack and ice pack coverage are predicted to increase groundwater recharge during fall and winter, and lead to higher groundwater levels throughout the winter months.
- Warmer winter conditions and higher average precipitation are also simulated to cause higher winter streamflows from December through March; this in turn, is will shift the timing, and decrease the magnitude, of spring freshet peaks, causing more water to move off study area catchments earlier.
- Shifts in freshet timing and spring recharge are predicted to produce a corresponding shift in the onset of low water periods. The onset of earlier summer low flow periods will increase the duration and severity of summer low flows.
- Stream catchments located in Alvar areas will be most affected by prolonged summer low flows; this is due to the karstic nature of the Alvar landscape, which provides little recharge storage to support streamflow during the summer months (Earthfx, 2014).

5.5 Current Management Framework

5.5.1 Protection and policy

There are numerous acts, regulations, policies and plans aimed at maintaining or improving water quantity. These include the Provincial Policy Statement, the Ontario Water Resources Act, the Growth Plan for the Greater Golden Horseshoe, the Lake Simcoe Protection Plan, and the Clean Water Act.

This management framework relates to many different stressors that can potentially affect water quantity, ranging from the urban development to the demand for water resources. Table 5 - 26 categorizes four such stressors, recognizing that many of these activities overlap and that the list is by no means inclusive of all activities. The legal effects of the various Acts, policies, and plans on the stressors is categorized as 'existing policies in place', or 'no applicable policies'. The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies, and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 5 - 26: Summary of current regulatory framework as it relates to the protection and restoration of water quantity

Stressor affecting water quantity	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Ontario Water Resources Act (1990)	Water Opportunities Act (2010)	Approved South Georgian Bay Lake Simcoe Source Protection Plan (2015)	LSRCA Watershed Development Policies (2008)	Simcoe County Official Plan (2007)	City of Kawartha Lakes Official Plan (2012)	Township of Brock Official Plan (2014)	Township of Ramara Official Plan (2003)
Impervious surfaces	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟥	🟥	🟩 6
Agricultural water demand	🟩	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟥	🟩 4	🟩 7
Commercial and residential water demand	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟩 2	🟥	🟩 7
Climate change	🟩	🟥	🟥	🟥	🟥	🟩 1	🟥	🟥	🟩 3	🟩 5	🟥

🟩 Restrictive policies in place

🟥 No applicable policies

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[1] No policies to prevent climate change, but policies include an assessment of possible impacts

[2] Requires commercial/industrial land use zoning for water extraction beyond personal use. Applicants for a PTTW under the OWRA shall be accompanied by a Water Budget that verifies no adverse effects on water systems and natural heritage features prior to consideration of the request zoning. Where a PTTW is not required, Council may require monitoring and a financial agreement to ensure that neighbouring drinking water supplies are not affected by water takings.

[3] General statement around recognizing potential implications of climate change and investigating potential mitigation and adaptation measures.

[4] Promotes farm practices that maintain and enhance natural resources; supports agri-business, encouraging to locate in urban areas, but will be permitted in rural area subject to meeting requirements that include an assessment of water and wastewater needs and an ability to provide the required services

[5] Policy specific to stormwater, requiring the consideration of potential impacts of climate change on the effectiveness of stormwater management works.

[6] General policy to minimize impervious surfaces

[7] General statement around sustainable use of water resources

As can be seen in Table 5 - 26, a number of Acts, plans, and policies already exist to protect surface and ground water quantity in the Whites Creek and Talbot River subwatersheds. Most of these policy tools are directed towards protecting and enhancing groundwater recharge and discharge, or promoting water conservation.

Under the Provincial Policy Statement, municipalities are required to restrict development and site alteration in or near vulnerable headwaters, seepage areas, recharge/discharge areas, springs, and wetlands in order to protect, improve or restore their hydrologic function. Under the LSPP, the Conservation Authority has to identified areas of ecologically significant groundwater recharge (i.e. areas where groundwater which eventually supports sensitive features such as wetlands or cold water streams, initially enters the system), and municipalities are to incorporate policies in their respective Official Plans to protect, improve, and restore the function of these, as well as significant groundwater recharge areas previously identified under the South Georgian Bay – Lake Simcoe Source Protection Plan.

The Environment goals in the City of Kawartha Lakes Official Plan include supporting water conservation, and protecting and/or enhancing ground and surface water resources. These goals are supported by policies including encouraging development and site alteration that maintains hydrological functions and minimizes alteration to groundwater flows; potentially requiring monitoring to ensure that commercial/industrial uses do not impact neighbouring drinking water supplies; encouraging the implementation of a hierarchy of source, lot-level, conveyance, and end-of-pipe controls for stormwater, as well as encouraging the use of innovative stormwater management measures. The OP also recognizes the importance of wellhead protection areas. The OP is consistent with the policies of the Lake Simcoe Protection Plan.

Under its Objectives for its Strengthening and Integrating Natural, Cultural, and Natural Heritage Resources, the Township of Brock's Official Plan notes the preservation, protection and enhancement of the significant features, functions, and attributes of the natural environment so that it will continue to sustain life, maintain health, preserve the visual landscape, and provide a high standard of living; and ensures that the relationship between the natural and built environments, and the principle of preserving resources and protecting the natural environment for future generations will form a basis for planning and development. Development applications are required to include documentation demonstrating how the quality and quantity of the groundwater will be maintained and protected, as well as how stormwater, erosion, and sedimentation will be controlled on site, and they stipulate that studies including hydrogeological assessments and Environmental Impact Assessments may also be required, depending on the application. In Hamlets, there are requirements for residential development that include an analysis of the hydrogeological regime to determine the availability and quantity of groundwater on a long-term basis, as well as assessments of the impacts of future development on existing groundwater and surface water quality and quantity, on the existing sources of drinking water and stormwater management. The Township's Open Space Objectives include improving water quality and quantity in streams, rivers, and Lake Simcoe. The Official Plan also includes policies consistent with the Lake Simcoe Protection Plan.

The Township of Ramara's 2003 Official Plan contains many policies around protecting and maintaining both surface and groundwater quantity. These include their objective to protect, conserve, and enhance natural area features and functions and encouraging private land stewardship. The natural resources objectives include ensuring that surface and groundwater resources used for existing and future uses are sustainable. There are a number of policies around protecting areas of groundwater recharge and discharge, as well as the promotion of innovative development techniques that strengthen and support natural areas objectives. The OP's stormwater policies note that facilities shall be designed to maintain groundwater and watercourse baseflow, and protect aquatic species and natural area habitat, and that development proposals should minimize impervious surfaces and maximize natural areas to achieve minimal surface water volumes. These policies will all help to ensure that the quantity of water resources is maintained.

Under the Lake Simcoe Protection Plan, an application for any development larger than four units (or individual units larger than $500m^2$) is required to be accompanied by a stormwater management plan that demonstrates consistency with the municipality's Stormwater Management Master Plan (as required under the LSPP), consistency with subwatershed plans and water budgets, an integrated treatment train approach to reduce reliance on end-of-pipe controls, and indication of how changes in the water balance (e.g. pre- vs. post-development) will be minimized, and how phosphorus loadings will be minimized.

Where the proposed development is within a Significant Groundwater Recharge Area the LSPP also requires that an environmental impact study to completed that demonstrates that the quality and quantity of groundwater in these areas and the function of the recharge areas will be protected, improved or restored.

Water conservation is promoted through regulatory restrictions, education programs, and municipal water use efficiency plans.

For example, under the Ontario *Water Resources Act*, any use of water which exceeds 50,000 litres per day requires a Permit to Take Water from the Ministry of the Environment. Under the LSPP, results of Tier 2 water budgets may provide background information for decisions made by the MOECC related to these Permits. The LSPP also directs the MOECC and MNRF to develop in-stream flow targets for water quantity stressed subwatersheds. When completed, these targets are to be used to inform future strategies related to water taking, which may include policies that identify how much water can be allocated among users in a subwatershed, including setting aside an allocation to support the natural functions of the ecosystem.

Results of these Tier 2 water budgets and instream flow targets are also intended to inform municipal water conservation plans, which the LSPP requires the Township of Ramara to prepare and implement. These plans are intended to establish targets for water conservation and efficiency, identify water conservation measures such as the use of flow-restricting devices and other hardware, and practices and technologies associated with water reuse and recycling, as well as methods for promoting water conservation including full-cost pricing for residents on municipal water supplies, and public education and awareness programs for rural residents not on municipal water systems.

Because the Talbot River as well as Canal and Mitchell Lake are part of the Trent-Severn Waterway, and water levels in the system are managed to maintain a navigable route, the hydrology of the these waterbodies, including water level, flow regime and channel morphology are controlled by the Trent Severn Waterway's water level management strategy.

Water conservation and stewardship is also to be promoted in the agricultural, recreational, commercial, and industrial sectors, through partnerships between government agencies and key private stakeholders.

5.5.2 Restoration and remediation

Although neither the Provincial government (through the Lake Simcoe Community Stewardship Program) nor the conservation authorities (through landowner grant programs) have funding for stewardship projects specific to issues related to water quantity, projects such as retrofitting on-line ponds and planting trees and shrubs which are supported to those programs will have benefits related to reducing evaporation, and increasing groundwater recharge. These projects are described in more detail in Chapters 3, 5 and 6.

The Environmental Farm Plan program, which is a partnership between the Ontario Ministry of Agriculture, Food and Rural Affairs, Agriculture and Agri-Food Canada, and the Ontario Soil and Crop Improvement Association does support projects specifically directed to managing water use on farms. Projects supported through the Environmental Farm Plan include infrastructure to support water use efficiency, including both in-barn and irrigation equipment, and support for establishing off-line irrigation ponds to reduce water taking demands on surface water features.

5.5.3 Science and research

As a result of the tragedy in Walkerton in 2000, and the subsequent Clean Water Act and Source Protection Planning process, the amount of research conducted on water quantity and ground water movement in the Lake Simcoe watershed increased exponentially.

The development of the South Georgian Bay – Lake Simcoe Source Protection Plan was supported by the establishment of a subwatershed-scale water budget, which described the movement of water among hydrologic elements in the watershed (e.g. wetlands, soils, aquifers), and the extractions of this water for human use. These budgets, and associated stress assessments also formed a significant part of the data used in drafting this subwatershed plan.

Another important component of the Source Protection Plan was the identification of 'Significant Groundwater Recharge Areas'. These areas are locations where surficial geology and hydraulic gradient tend to support a relatively high volume of water recharging into aquifers. The Lake Simcoe Protection Plan has directed the MOE MNR and LSRCA to follow up on this study and identify 'Ecologically Significant Groundwater Recharge Areas.' This new class of recharge area is to be identified based on ecological interactions, rather than volume of water. To identify these areas, reverse particle tracking models will be developed based on groundwater models created as part of the Source Protection Planning process, to identify areas which contribute groundwater to sensitive surface features such as wetlands and coldwater streams.

In order to support water budgeting and other watershed-scale modelling, LSRCA manages a network of 12 climate stations (including precipitation gauges), and 15 surface water flow stations (in partnership with the Water Survey of Canada). These stations provide monthly stream flow data, which can be used to monitor mean, median and baseflow conditions for many of Lake Simcoe's subwatersheds.

5.6 Management Gaps and Limitations

5.6.1 Water Demand

The Source Water Protection initiative addresses many potential concerns around water quantity, although these policies pertain to drinking water resources, and not the flows that are required to sustain healthy aquatic ecosystems within the subwatershed. The Lake Simcoe Protection Plan also contains a policy around maintaining adequate flows, with the development of in-stream flow targets for water quantity stressed subwatersheds. It does not, however, stipulate timelines for any subwatershed other than the Maskinonge, it is therefore not clear when this work and any associated limitations on water takings would be in place, or how they would be enforced and by whom. Another limitation in managing water demand is the Permit to Take Water process. These permits are only required when a user is taking more than 50,000 L/day, and are not required for most domestic and agricultural uses. This makes it difficult to track the cumulative use for a subwatershed, leading to the potential for stress at certain times of the year.

5.6.2 Land Use

There are few policies in the framework that deal specifically with the issue of impervious cover that accompanies development. The policies within the current planning framework around impervious cover generally do not require any concerted effort on the part of developers to move beyond traditional designs for developments and measurably reduce impervious surfaces, nor do they require the use of techniques aside from stormwater controls to increase infiltration.

With respect to water demand, the policies being developed through Source Water Protection will be most protective of the quantity of water resources within the subwatershed, although these policies will only pertain to drinking water resources. Currently, the Ontario Water

Resources Act is the main policy piece that considers water quantity. However, it only requires a permit for users taking greater than 50,000 L/day, and is not required for most domestic and agricultural uses. There is the potential for significant stress on a system due to the cumulative takings of both permitted and un-permitted users in a subwatershed, and these cumulative uses are generally not considered as part of the permitting process. This issue may be addressed through policies in the LSPP requiring the development of in-stream flow targets for water quantity stressed subwatersheds, which may lead to policies that require the development of targets for in-stream flow regimes, and set out how much water can be allocated among users in a subwatershed, including an allocation to support the natural functions of the ecosystem. The LSPP, however, does not define what constitutes a water quantity stressed subwatershed, nor does it specify timelines for the completion of this work with the exception of the Maskinonge River subwatershed. The LSPP also contains policies around reducing water demand by new and expanded major recreational uses, such as golf courses, through limiting grassed, watered and manicured areas; requiring the use of grass mixtures that require less water (where applicable); the use of water conserving technologies; and water recycling. As well, the LSPP contains policies aimed at undertaking stewardship activities with the agricultural community and other water use sectors, such as recreational, to encourage the implementation of best management practices to conserve water.

5.6.3 Climate

While it would be extremely difficult to account for variations in climate and their effects on water quantity within the policy framework, Source Water Protection and the LSPP have begun to consider the potential impacts of climate change on this important resource. Modelling undertaken for Source Protection has including drought scenarios, and the LSPP includes a section on climate change, including a policy to develop a climate change adaptation strategy for the Lake Simcoe watershed. The modelling undertaken for the Talbot River and Whites Creek subwatersheds includes an assessment of the risks of climate change impacts, however additional research is needed to better understand the impacts of climate change, the development of an integrated climate change monitoring program to inform decision making, and finally to develop adaptation plans. These are important first steps in what should now become a routine consideration for all activities.

5.6.4 Water Budget Estimates

While the water budget determined water taking rates to be broadly sustainable; however where low water issues occur the OWRA does enable Ministry of the Environment staff to limit takings through the PTTW process. This, however, is rarely done. This may be addressed through the LSPP's policies around developing targets for environmental flows.

5.7 Management Gaps and Recommendations

As described in the previous sections, there are a number of regulations and municipal requirements aimed at protecting water quantity of the Whites Creek and Talbot River subwatersheds already exist. Despite this strong foundation, there are gaps in the management framework that need to be considered. This section identifies some of the gaps in the existing protection of the water quantity in the Whites Creek and Talbot River subwatersheds, and outlines recommendations to help fill these gaps.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase

5.7.1 Water demand

Recommendation 5-1 - That the MOECC continue to improve the Water Taking Reporting System by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connecting those takings to wells / aquifers to facilitate impact assessment (i.e. the PTTW database needs to be connected to the WWIS database).

Recommendation 5-2 – That the MOECC and MNRF require the LSPP Tier 2 integrated model be used to simulate proposed dewatering activities associated with aggregate operations near the Whites Creek and Talbot River subwatersheds, and the impacts they would have on stream and wetland features in the subwatershed prior to issuing or renewing Permits to Take Water or aggregate permits. When reviewing aggregate applications, the MOECC is encouraged to collect the most up to date extraction, pumping, and groundwater level data, and use the data to update the integrated model.

5.7.2 Reducing impact of land use – groundwater recharge and discharge

Recommendation 5-3 – That the subwatershed municipalities, in the context of LSPP Policy 6.37-SA, adopt the 'Guidance for the protection and restoration of significant groundwater recharge area in Lake Simcoe' document. Further, that the municipalities utilize this document to incorporate policies around significant groundwater recharge areas into their official plans, as per LSPP Policy 6.38-DP.

Recommendation 5-4 – That the LSRCA provide updated mapping of significant groundwater recharge areas to the subwatershed municipalities and ensure they are updated periodically, at a minimum of every five years.

Recommendation 5-5 – That the subwatershed municipalities adopt the new stormwater volume reduction and quality control guidance provided in both the draft Lake Simcoe Watershed Model By-law and LID SWM Guidelines for Municipalities. Further, that the

Municipalities utilize these documents to incorporate policies around stormwater management into their official plans, as per LSPP Policy 4.7-DP.

Recommendation 5-6 – That the MOECC amend the Environmental Compliance Approvals application form and Guide to recognize the importance of protecting Significant Groundwater Recharge Areas.

5.7.3 Research and monitoring

Recommendation 5-7 – That the LSRCA and Kawartha Conservation, in partnership with Trent Severn Waterway, expand the surface water monitoring network to the manmade canal that connects the Talbot River watershed with the Balsam Lake watershed, and the canal that connects Mitchel Lake with Canal Lake in order to monitor water volume transferred between Great Lakes basins.

Recommendation 5-8 – That the Trent Severn Waterway initiate a surface water monitoring network to monitor surface and groundwater flows through the Talbot River.

Recommendation 5-9 – That the Trent Severn Waterway enhance flow monitoring and flow calculations where already exist and that the data collected be used to enhance subwatersheds water budgets.

Recommendation 5-10 –That the LSRCA expand the surface water monitoring network to the headwaters portion of the Talbot River subwatershed, and that the data collected be input into the integrated model to improve the understanding of surface and groundwater flows and interactions.

Recommendation 5-11 - That the MOECC, in partnership with the LSRCA and Kawartha Conservation, expand the PGMN network in the subwatershed to improve understanding of groundwater flows and levels in the deeper bedrock system; new wells should be screened in the deeper aquifer units and situated away from the influence of lakes, canals, and other pumping wells.

Recommendation 5-12 – That water quantity data from aggregate pits be made available to watershed municipalities and to the LSRCA and Kawartha Conservation for watershed management.

5.7.4 Climate change

Recommendation 5-13 – That the Trent Severn Waterway consider the possible impacts of climate change on fish spawning, and include mitigation considerations (e.g. the possibility of mimicking a natural freshet flow) in their annual water level management.

Recommendation 5-14 - That the LSRCA expand the environmental monitoring network to include a climate station in the Whites Creek and Talbot River subwatersheds; reliable meteorological baseline data will improve climate change predictions and allow for the improved identification of vulnerable areas.

Recommendation 5-15 - That the LSRCA and Kawartha Conservation, in partnership with the province and municipalities, develop management strategies to address the predicted impacts of climate change. Emphasis at this time should be placed on building ecological resilience in the Whites Creek and Talbot River subwatersheds through promoting recharge by increasing natural cover in the SGRAs/ESGRAs.

6 Tributary Health

6.1 Introduction - Overview of aquatic communities in the tributaries

To assess the environmental quality and the overall health of the aquatic system, the Lake Simcoe Protection Plan has provided indicators to determine how well the aquatic ecosystem is functioning. The indicators relevant to the Talbot River and Whites Creek subwatersheds and their tributaries are:

- Natural reproduction and survival of native aquatic communities;
- Presence and abundance of key sensitive species, and;
- Shifts in fish community composition.

To address these indicators, a number of analyses have been done on the stream systems. The following sections summarize these results.

6.1.1 Aquatic habitat

Habitat can be described as a place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic. All living things have a number of basic requirements in their habitats including space, shelter, food, and reproduction. In an aquatic system, good water quality is an additional requirement. In a river system, water affects all of these habitat factors; its movement and quantity affects the usability of the space in the channels, it can provide shelter and refuge by creating an area of calm in a deep pool, it carries small organisms, organic debris and sediments downstream which can provide food for many organisms and its currents incorporate air into the water column which provides oxygen for both living creatures and chemical processes in the water and sediments. Habitat features also frequently affect and are affected by other features and functions in a system. For instance, the materials comprising a channel bed can affect the amount of erosion that will take place over time; this in turn affects the channel shape and the flow dynamics of the water. The coarseness of the channel's bed load can also affect the suitability for fish habitat – some species require coarse, gravelly deposits for spawning substrates, while finer sediments in the shallow fringes of slow moving watercourses often support wetland plants that are required by other species.

All habitat features are impacted by changes in the system, both natural and anthropogenic in nature. There are numerous causes of stress in an aquatic environment. Any type of land use change from the natural condition will place a strain on the system, and can cause significant changes to the aquatic community. The conversion of natural lands such as woodland and wetland to agriculture or urban uses eliminates the functions that these features perform, such as improvement of water quality, water storage, and increasing the amount of infiltration to groundwater. This can result in impacts to water quality and a reduction in baseflow, resulting in watercourses that are unable to support healthy communities of native biota.

6.1.2 Fish Community

Studying the health of the fish community of the Talbot River and Whites Creek subwatersheds provides an important window into the health of the aquatic system as a whole. Fish are sensitive to a great number of stresses including water quality, temperature, flow regimes, and the removal of in-stream habitat. While they are able to move quickly in response to a sudden change in conditions (e.g. a release of a chemical into the system) and are therefore not a good indicator of these types of issues, prolonged stresses will eventually cause a shift in the fish community from one that is sensitive and requires clean, cool water to survive (e.g., coldwater species) to one that is more tolerant of degraded conditions (e.g., warmwater species). Long term monitoring will identify changes and trends occurring in the fish community, and will help to identify and guide restoration works.

The first step in analyzing the condition of a subwatershed's aquatic community is to undertake a general overview of the current fish communities to see what type of fish are at a site (cold water species[1], cool water species, warm water species[2], or no fish) and what the temperature of the creek is at the site (cold, cool, or warm water), as well locating any barriers to the movement of some or all fish species. This broad overview can show the general shifts in the fish communities; for example, as water temperatures rise, a coldwater fish community may shift to a warm water community, and where dams are present fish may eventually disappear from an area.

The water temperature of a system can dictate the composition of the fish community, as well as determine the way systems are managed. Figure 6-1 below illustrates the combination of maximum air temperatures versus water temperature at 4 p.m. (when water temperatures tend to reach their maximum) that makes a cold, cool, or warm water stream. Typically, the average maximum summer water temperatures for a cold water system is 14°C; this is generally due to inputs of cool groundwater, which ensure that air temperatures have little effect on the water temperature. Cool water is approximately 18°C and warm water systems have an average summer maximum daily water temperature of approximately 23°C (Stoneman and Jones, 1996). This temperature rating system has been used to classify the tributaries in the Lake Simcoe watershed.

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[1] Cold water species are indicators of cold water habitat.

[2] Warm water species are considered to be generalist species that are not coldwater indicators and can exist in warm, cool and coldwater sections of a stream.

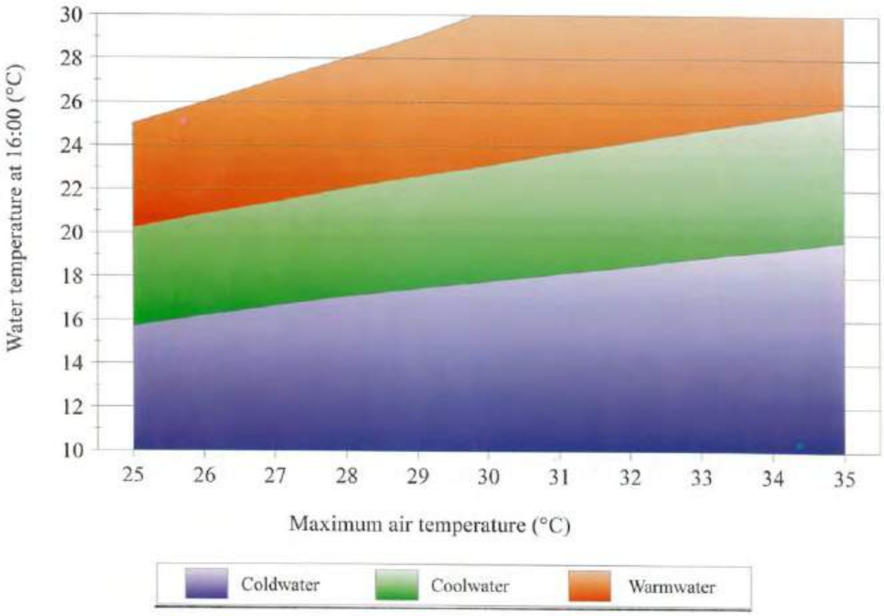


Figure 6-1: Cold, cool and warm water trout stream temperature ranges (Stoneman and Jones, 1996).

Field crew - electrofishing

Figure 6-2 shows the variation in temperature among the watercourses throughout the study area subwatersheds. This figure shows a wide variation in the temperature profile across the subwatersheds, with sites approximately evenly split as exhibiting warm water and cool water habitat conditions. Stream temperature data combined with fish community data, suggest that warmwater and coolwater conditions are dominant throughout the Talbot River and Whites Creek subwatersheds. However, cold water indicator species have been documented within the Whites Creek subwatershed. This is likely due to consistent cold water inputs from groundwater discharge areas.

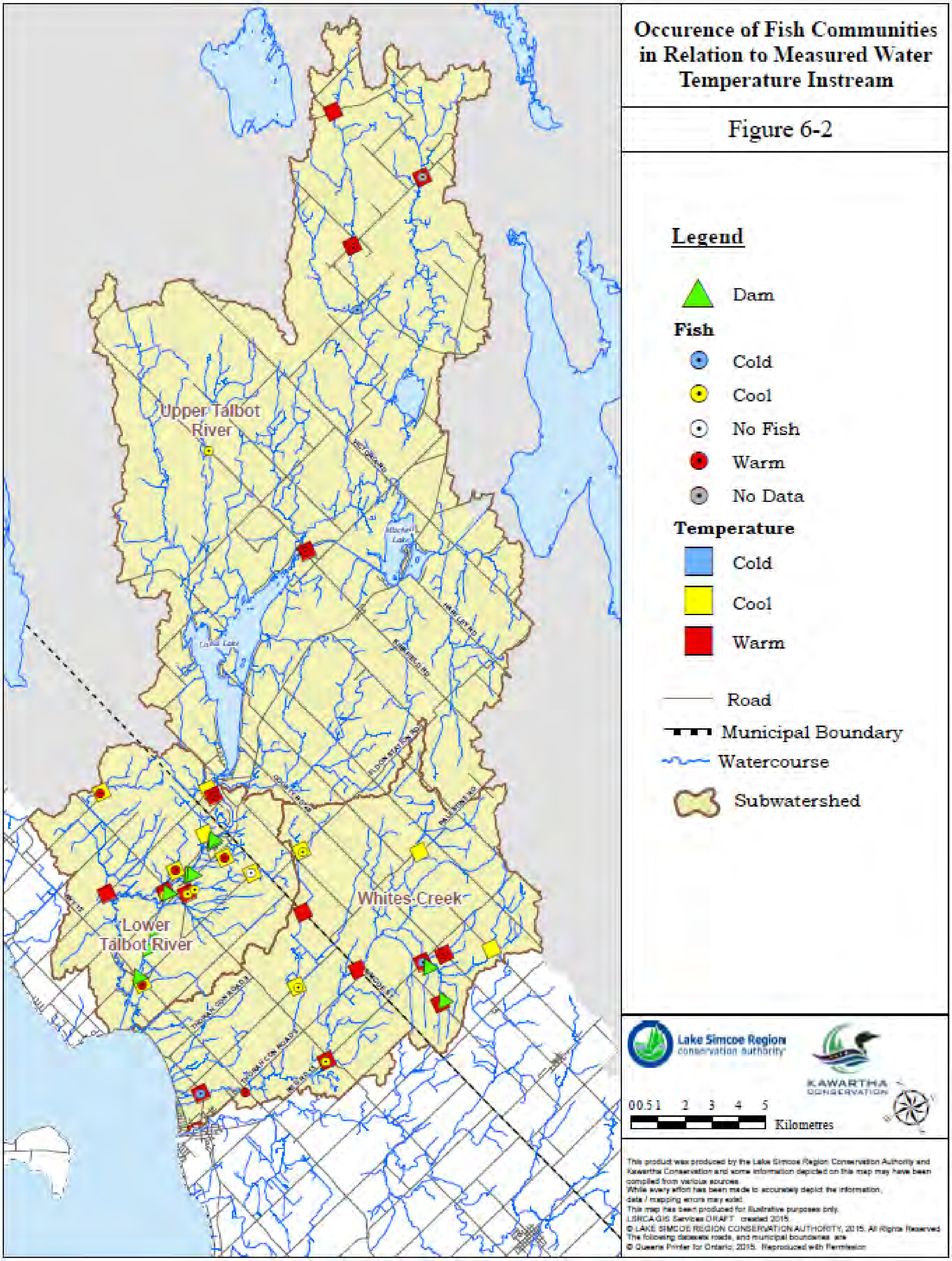
The map also shows where the major barriers to the movement of fish are located.

An Index of Biotic Integrity (IBI) was used to assess the ecological integrity of the creeks through an analysis of the composition of fish communities within the system (Figure 6-3). Fish population and community composition surveys are valuable tools for examining the health and stability of streams and rivers. Over time, shifts in composition along with the presence or absence of key species not only provides an indication of system health but can be used to help identify what ecosystem stressors, such as climate change and urbanization, are influencing aquatic habitats.

With this method there are five rankings that can be assigned to a site:

- Very good: Excellent diversity, top predators, trout present and high fish abundance
- Good: Average diversity, top predators present, trout present, average abundance
- Fair: Low/average diversity, some top predators, no trout, low/average abundance of fish
- Poor: Low diversity, no top predators, no trout, low abundance of fish
- No Fish: No fish were captured at these sites

Further analysis of the conditions of the fish community within the study area subwatershed can be found below.



Occurence of Fish Communities in Relation to Measured Water Temperature Instream

Figure 6-2

This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created 2015.

Figure 6-2: Occurrence of fish community in relation to measured water temperature in stream.

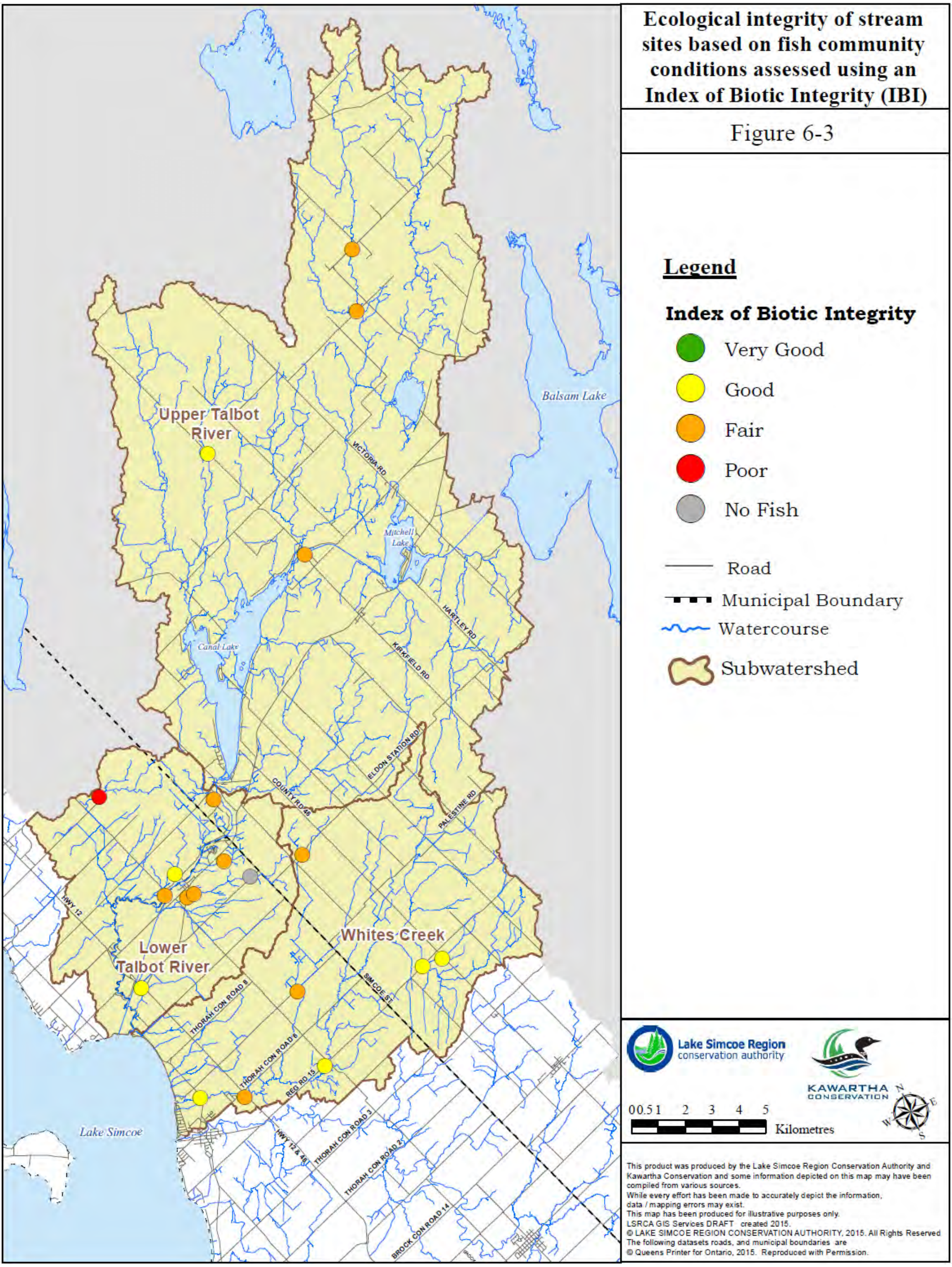


Figure 6-3: Ecological integrity of stream sites based on fish community conditions assessed using the Index of Biotic Integrity (IBI).

6.1.2.1 Talbot River

Forty species of fish have been captured from the Talbot River subwatershed (Table 6-1). Sampling has been completed by LSRCA, Kawartha Conservation, and the Ministry of Natural Resources and Forestry. For ease of analysis, and to highlight differences in habitat, the Talbot River has been broken into two sections – the Upper Talbot River, which is the area upstream of Canal Lake, and the Lower Talbot River, which is the area between Canal Lake and Lake Simcoe.

Table 6-1: Fish species captured in the Talbot River subwatershed.

Common Name	Scientific Name	Lower Talbot River subwatershed[+]	Upper Talbot River subwatershed[x]
Blackchin shiner	*Notropis heterodon*		*X*
Blacknose dace	*Rhinichthys atratulus*	X	*X*
Bluegill	*Lepomis macrochirus*	X	
Bluntnose minnow	*Pimephales notatus*	X	*X*
Brassy minnow	*Hybognathus hankinsoni*	X	*X*
Brook stickleback	*Culaea inconstans*	X	*X*
Brown bullhead	*Ameiurus nebulosus*	X	*X*
Central mudminnow	*Umbra limi*	X	*X*
Central stoneroller^	*Campostoma anomalum*	X	*X*
Common shiner	*Luxilus cornutus*	X	*X*
Creek chub	*Semotilus atromaculatus*	X	*X*
Emerald shiner	*Notropis atherinoides*	X	
Fathead minnow	*Pimephales promelas*	X	*X*
Finescale dace	*Chrosomus neogaeus*		*X*
Golden shiner	*Notemigonus crysoleucas*	X	*X*
Hornyhead chub	*Nocomis biguttatus*	X	*X*
Iowa darter	*Etheostoma exile*	X	
Johnny darter	*Etheostoma nigrum*	X	
Largemouth bass	*Micropterus salmoides*	X	*X*
Logperch	*Percina caprodes*	X	*X*
Longnose dace	*Rhinichthys cataractae*	X	*X*
Mottled sculpin	*Cottus bairdii*	X	*X*
Muskellunge	*Esox masquinongy*	X	*X*
Northern pike	*Esox lucius*	X	
Northern redbelly dace	*Phoxinus eos*	X	*X*
Pearl dace	*Margariseus margarita*	X	*X*
Pumpkinseed	*Lepomis gibbosus*	X	*X*
Rainbow darter	*Etheostoma caeruleum*	X	
River chub	*Nocomis micropogon*	X	
Rock bass	*Ambloplites rupestris*	X	*X*
Rosyface shiner	*Notropis rubellus*	X	

Common Name	Scientific Name	Lower Talbot River subwatershed+	Upper Talbot River subwatershedx
Round goby^*	*Neogobius melanostomus*	X	
Sand shiner**	*Notropis stramineus*	X	
Smallmouth bass	*Micropterus dolomieu*	X	
Spotfin shiner	*Cyprinella spiloptera*	X	
Spottail shiner	*Notropis hudsonius*		*X*
Walleye	*Sander vitreus*	X	
White sucker	*Catostomus commersoni*	X	*X*
Yellow bullhead	*Ameiurus natalis*	X	
Yellow perch	*Perca flavescens*	X	*X*
TOTAL (40)		37	*26*

^ = Not native to Lake Simcoe watershed

** = Invasive species*

*** = Unconfirmed (MNR, 2010)*

+= Sources of data used for this column: 1) LSRCA data from 2008 to present; 2) MNRF data from 1989, 1998, and 2010

x= Sources of data used for this column: 1) LSRCA data from 2015; 2) Kawartha Conservation data from 2014; MNRF ARA dataset accessed October 2015

Upper Talbot River

In the Upper portion of the Talbot River subwatershed, a total of 26 fish species have been caught, indicating that conditions are characteristic of a warm and cool water system. Common species captured include white sucker, central mudminnow, creek chub, and northern redbelly dace . One coldwater indicator species, mottled sculpin was documented, although at one site only. In addition, several game fish have been documented within tributary outlets near Canal and Mitchell Lakes including: muskellunge and largemouth bass. All fishes captured are considered to be relatively common within the region, and native to the Talbot River watershed, with the exception of central stoneroller. According to Holm et al. (2009), the range of this species is expanding in Ontario which is likely the result of climate change and introductions through bait buckets.

Overall, Figure 6-3 shows that the ecological integrity is relatively similar among samples across the Upper Talbot River subwatershed, with the sites being assessed as either Fair (three sites) or Good (one site). These results suggest that the watercourses are in a relatively healthy ecological state which is consistent with the findings from benthic invertebrate communities (discussed in a following section). This is expected because most of the sample sites exist within, and downstream, of large tracts of natural heritage areas with minimal disturbance. Even though the sampling effort within the Upper Talbot River subwatershed (i.e., four sites) is relatively low, particularly compared to the large sampling effort allocated to the Lower Talbot River subwatershed, the IBI results are likely similar among unsampled streams due to similar land use conditions within the subwatershed.

Lower Talbot River

A total of 37 fish species have been caught in the lower sections of the Talbot River, with species including game fish such as largemouth bass, muskellunge, northern pike, and yellow perch, as well as a number of smaller species. The influences on aquatic health in the lower portion of the Talbot River are numerous, and include the Trent-Severn Waterway at its core, with its associated cottage development; agricultural land use; and natural heritage features, many of which are concentrated in the south and south-east of the area. The influence of these land use features is outlined in the sections below.

Figure 6-3 shows some variability in the ecological integrity, with the sites in the upper and middle reaches draining into the main branch of the Talbot River being rated as Fair (five sites) or good (two sites). There is one site rated Poor, which is located in the north of lower section, near the border with the Ramara Creeks subwatershed. There was also one site, that nearest the border with Whites Creek, where no fish were caught when sampling was undertaken. There are a number of factors influencing the health of these sites. Many of those sites rated 'Fair' throughout the area just downstream of Canal Lake and midway to Lake Simcoe are immediately surrounded by natural features such as swamps, marshes, and thicket, but the predominant land use beyond these features often consists of low intensity and high intensity agriculture. Low intensity consists of mainly pasture and hay, while high intensity is generally row crop, sod farm, or market garden. Other common land uses that would affect the fish community include estate residential and rural developments. These land uses can all result in warming temperatures, and the inputs of sediment and nutrients into area watercourses. The site in the mid-reaches that received a rating of 'Good' is actually influenced by the presence of two online ponds in one of its upstream tributaries. Online ponds will generally limit the community that can live in an area due to their warming effects on stream temperatures, and the barrier to movement that they represent; however there appear to be mitigating features in the vicinity of this site that limit these impacts. The agricultural activities around this site are mainly low intensity, which may limit the potential impacts of this land use. The site nearest the outlet to Lake Simcoe received a 'Good' rating, likely due to the high levels of natural cover, including marshes, forests, swamps, and meadows, which would help to maintain stream health in this area.

While a number of the sites, regardless of their rating, had natural heritage cover in the vicinity of, and just upstream, only two received 'Good' ratings, and none were rated 'Very Good.' As discussed above, there are a number of factors influencing this. The lack of 'Very Good' ratings can likely be mainly attributed to the water temperatures, which are warm or cool. These temperatures are not able to support the most sensitive species of fish, such as brook trout or mottled sculpin, which would typically lead to a higher rating. The slower flowing waters of some of the marshes and through the swamp areas can, in some cases, limit the sensitivity of the species that can live in an area, due to warming. However, higher levels of natural cover, and wider natural buffers between the watercourses and anthropogenic land uses such as agriculture, roads, and estate residential development will generally result in higher IBI scores.

6.1.2.2 Whites Creek

Overall, Figure 6-3 shows that the ecological integrity varies spatially across the Whites Creek subwatershed, with the sites being assessed as 'Good' and 'Fair'. Important recreational species caught included smallmouth bass, largemouth bass, pumpkinseed, and yellow perch (Table 6-2). Those sites that are rated 'Fair', the two northern sites and the second site upstream from the outlet into Lake Simcoe, generally have areas of intensive and non-intensive agriculture adjacent and/or upstream of the site, alteration of the watercourse (straightening in the case of the northernmost site near the border with the Talbot River subwatershed), and often have a road crossing the watercourse just upstream of the sampling site. The natural heritage features located upstream of the sites can also have some influence, as areas with swamps and marshes can warm waters and potentially limit the species that can reside in that watercourse. Four of the subwatersheds sites are rated 'Good' according to the IBI. Characteristics of these sites include relatively high levels of natural features adjacent to and upstream of the site, though this is not always the case. For example, one of these sites is located just downstream of a road, with the area immediately upstream consisting primarily of agriculture and rural development, with only small areas of riparian buffer and small forested area approximately 1.5 km upstream. Sites such as this may be benefitting from inputs of cold water or stretches of quality instream habitat that help to support some of the more sensitive species

Table 6-2: Fish species captured in the Whites Creek subwatershed^{+}.

Common Name	Scientific Name
Blacknose dace	*Rhinichthys atratulus*
Blackside darter	*Percina maculata*
Bluegill	*Lepomis macrochirus*
Bluntnose minnow	*Pimephales notatus*
Brassy minnow	*Hybognathus hankinsoni*
Brook stickleback	*Culaea inconstans*
Brown bullhead	*Ameiurus nebulosus*
Common carp^*	*Cyprinus carpio*
Central mudminnow	*Umbra limi*
Common shiner	*Luxilus cornutus*
Creek chub	*Semotilus atromaculatus*
Fathead minnow	*Pimephales promelas*
Finescale dace	*Phoxinus neogaeus*
Hornyhead chub	*Nocomis biguttatus*
Johnny darter	*Etheostoma nigrum*
Largemouth bass	*Micropterus salmoides*
Longnose dace	*Rhinichthys cataractae*
Mimic shiner	*Notropis volucellus*
Mottled sculpin	*Cottus bairdi*

Common Name	Scientific Name
Northern redbelly dace	*Phoxinus eos*
Pearl dace	*Margariseus margarita*
Pumpkinseed	*Lepomis gibbosus*
Rainbow darter	*Etheostoma caeruleum*
River chub	*Nocomis micropogon*
Rock bass	*Ambloplites rupestris*
Rosyface shiner	*Notropis rubellus*
Round goby*^	*Neogobius melanostomus*
Smallmouth bass	*Micropterus dolomieu*
Central stoneroller	*Campostoma anomalum*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

^ = Not native to Lake Simcoe watershed

** = Invasive species*

+= Sources of data used for this table: 1) LSRCA data from 2003 to present, 2) MNR 1987, and 3) Beak, 1994

6.1.3 Benthic invertebrate community

Aquatic insects, or benthic invertebrates, are an ideal indicator of water quality as different species have different tolerances to factors such as nutrient enrichment, dissolved solids, oxygen, and temperature. The presence or absence of certain species is used to determine water quality at a given site. Of the indices developed to assess water quality in relation to benthic invertebrate communities, the Hilsenhoff Biotic Index (HBI) was selected as it provides a full spectrum of the different levels of organic pollution within a watercourse, which enables watershed managers to document declining watershed conditions by comparing years of data; whereas other indices (such as BioMAP) only provide an 'impaired' or 'unimpaired' rating (Jones et al. 2007).

Figure 6-4 is an assessment of the ecological integrity of the creeks through the composition of the benthic invertebrate communities within the study area. This composition is dependent on the quality of the water and the degree of organic pollution. With this method there are seven rankings that can be assigned to a site:

- Excellent: No apparent organic pollution
- Very good: Slight organic pollution
- Good: Some organic pollution
- Fair: Fairly significant organic pollution
- Fairly poor: Significant organic pollution
- Poor: Very significant organic pollution
- Very poor: Severe organic pollution

6.1.3.1 Talbot River

Upper Talbot River

The benthic community index scores range from 'Fair' (two sites), 'Fairly Poor' (one site) to 'Poor' (one site), indicating a more degraded ecological condition as compared to fish community Index of Biotic Integrity scores. However, sites that scored 'Fairly Poor' and 'Poor' appear to be influenced by the wetlands (one site within a marsh, the other within the swamp) in which they are located, rather than any anthropogenic influence. Warm, slow moving water is often not conducive to the establishment of the more sensitive benthic invertebrate communities. As such the fish community data are likely better representative of the current ecological state of the Upper Talbot River subwatershed.

Lower Talbot River

As with the fish community, the benthic invertebrate community index scores display a wide range of scores across the study area; ranging from 'Good' to 'Very Poor'.

The two sites rated 'Poor' in the Lower Talbot appear to be influenced by the marsh in which they are located, rather than any anthropogenic influence. Warm, slow moving water, as is found in marshes, is often not conducive to the establishment of the more sensitive benthic invertebrate communities. Just upstream of these sites is a site rated ‘Fairly Poor,’ which appears to be influenced by the presence of cultural meadow and swamps in its contributing area. Again, though these are natural areas, warm, slow moving water, and lack of shade can preclude some of the more sensitive species from inhabiting an area.

There is one site that received a ‘Good’ rating in the Lower Talbot, site TALBT-01, just upstream of the mouth. Upstream of this site, the watercourse flows through a small, low density urban area, in which a small riparian buffer has been maintained. Upstream of this area, the stream is surrounded by forested lands, with non-intensive agriculture being found just beyond the forested area. Two sites also received ‘Fair’ ratings, the first in the northern area of the Lower Talbot, which does have some influence of non-intensive agriculture along one side of the bank just upstream, but is otherwise surrounded by natural areas, including marsh, swamp, and thicket lands. The other ‘Fair’ site, located at centre of the Lower Talbot, drains into the main Talbot River. This stretch of watercourse is fairly wide at this point, with marshes and forests in the immediate vicinity, and a mixture of agriculture types and estate residential development beyond these natural areas.

The site rated ‘Very Poor’ is found just upstream of the river mouth near the Lake Simcoe shore. The land use influences around this site include rural development and natural heritage features in the immediate vicinity (swamps and forests), with agriculture beyond this. There is likely also a backwater effect from the lake, which may influence conditions at the site.

6.1.3.2 Whites Creek

The Whites Creek subwatershed has large areas of agricultural land use, which is likely the main influence on the benthic invertebrate community. The sites in this subwatershed vary from ‘Fair’ to ‘Poor’ ratings.

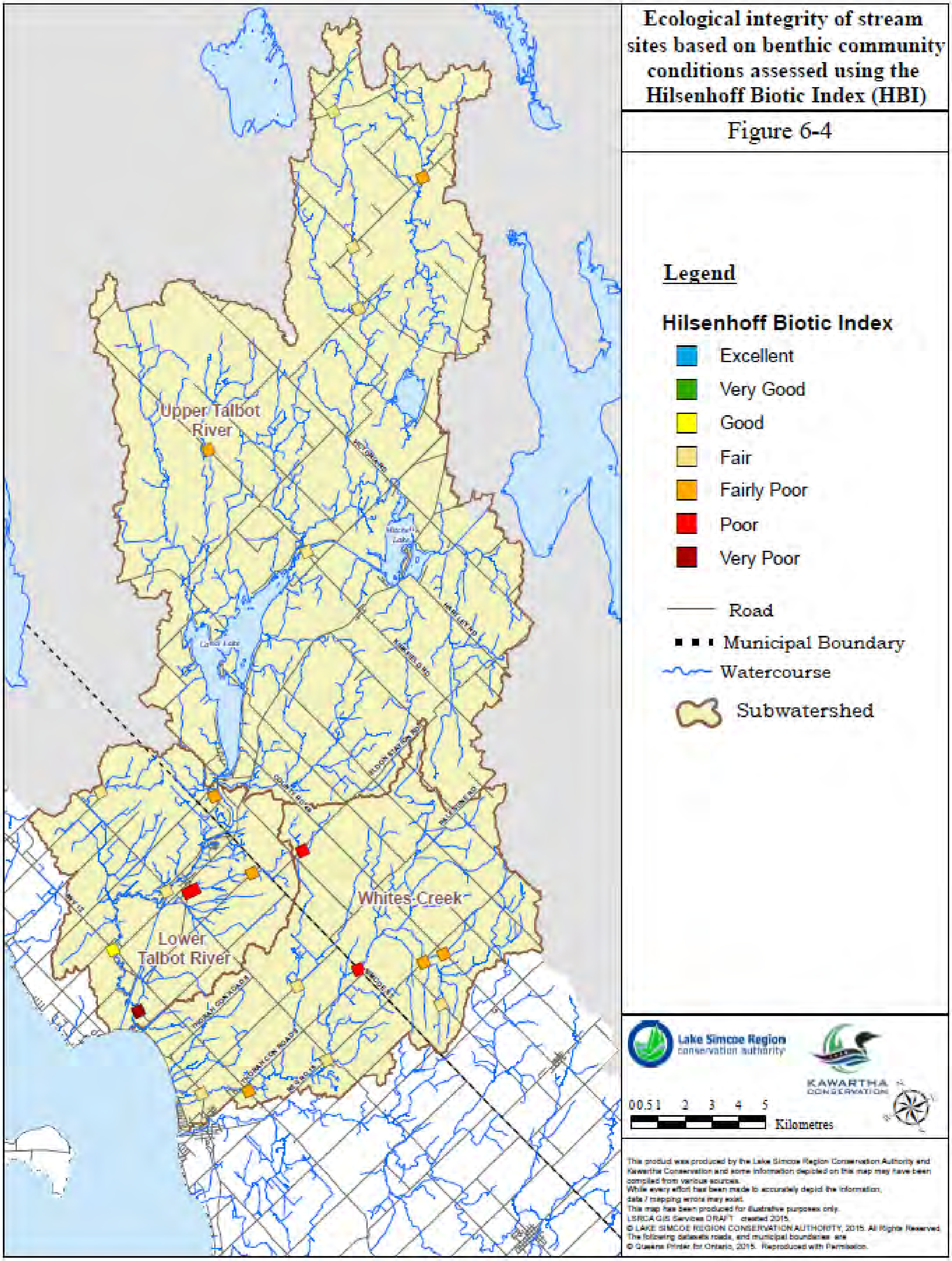
The only site rated ‘Poor’ in the subwatershed flows through a narrow band of swamp, which also comprises a fair amount of the land use immediately upstream, and is surrounded by agricultural land uses. Further upstream, some of the tributaries draining to this site have large amounts of agriculture (both intensive and non-intensive). The sites rated ‘Fairly Poor’ generally have intensive agriculture (much of this intensive), or urban or rural development, all of which would negatively influence the benthic invertebrate population. Those sites rated ‘Fair’ typically have a higher proportion of natural features in the adjacent and upstream areas though, as with other sites, the presence of agricultural areas is likely limiting the health of the benthic invertebrate communities at these sites.

Agricultural land use appears to be the most significant influence in the Whites Creek subwatershed. This can influence the communities in a number of ways: through the alteration of watercourses to accommodate crops and equipment; the removal of riparian buffers, which provide shade, habitat, and can help to filter out nutrients and sediment before they reach the watercourse; the increased nutrient and sediment loads, particularly during the spring and fall, when vegetation is not established to help hold the soil in place; and through the warming of stream water. Urban land uses can also have impacts such as warming, nutrient and sediment inputs, alteration of habitat, and the removal of riparian vegetation. Finally, even natural features can influence the types of communities that are found at a site; for example the location of the sampling site in a swamp is likely the most important contributing factor as mucky soils do not support the more sensitive benthic invertebrate species.

6.1.4 Rare and endangered species

None of the documented fish species within the Talbot River and Whites Creek subwatersheds are considered rare or of conservation concern (i.e., listed as Special Concern, Threatened, or Endangered) on a provincial or national level.

There has, however, been evidence of American eel (*Anguilla rostrata*; Endangered) in Lake Simcoe. This species is somewhat unique in its life history, in that it spawns in the Atlantic Ocean, and spends the rest of its life in freshwater systems. It is presumed to have travelled to Lake Simcoe via the Trent Severn Waterway.



Ecological integrity of stream sites based on benthic community conditions assessed using the Hilsenhoff Biotic Index (HBI)

Figure 6-4

This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created 2015.

Key Points - Current Aquatic Natural Heritage Status:

- Fish community and stream temperature data indicate that the Upper Talbot River, Lower Talbot River, and White's Creek subwatershed are characteristic of a warm and cool water dominated system, with localized areas of cold water habitat.
- The Upper and Lower Talbot River subwatersheds contain various large-bodied fishes of recreational significance such as: walleye, muskellunge, northern pike, largemouth bass, and smallmouth bass. Common small-bodied fishes within the subwatersheds include: creek chub, northern redbelly dace, central mudminnow, and brook stickleback. Whites Creek subwatershed supports several important recreational species caught included smallmouth bass, largemouth bass, pumpkinseed, and yellow perch
- All native fish species documented area relatively common throughout the Lake Simcoe basin. There are no documented occurrences of fish species of conservation concern (i.e., endangered, threatened, or special concern), however American eel may migrate through this area.
- The ecological integrity of the Upper Talbot River, Lower Talbot River, and White's Creek subwatersheds is in a fair to good state, as indicated by fish and benthic invertebrate biotic integrity scores. These results are reflective of the high amounts of natural heritage areas that remain on the landscape and along stream corridors. Healthy aquatic communities are generally associated with forested or wetland habitats.

6.2 Factors impacting status – stressors

There are a number of land uses, activities and other factors that can have an effect on the health of the aquatic community in the subwatershed. These include:

- Barriers,
- Bank hardening and channelization,
- Uncontrolled stormwater and impervious surfaces,
- Municipal drains,
- Removal of riparian vegetation,
- Water quality and thermal degradation,
- Invasive species, and
- Climate change.

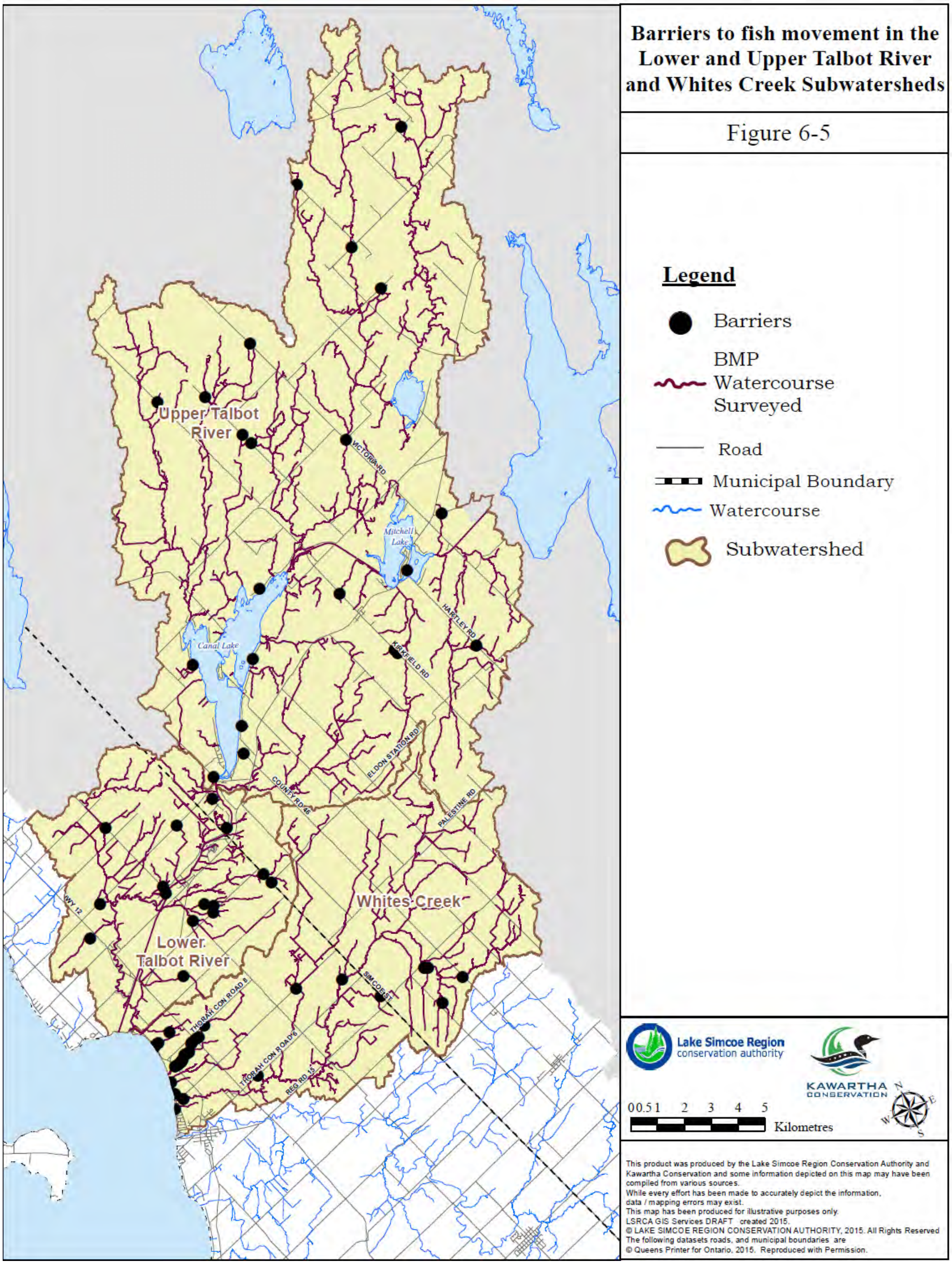
These factors are discussed in detail in the following sections.

6.2.1 Barriers

Barriers to fish movement in the form of dams, weirs, perched culverts, and enclosed watercourses serve to fragment the fish community by preventing fish from accessing important parts of their habitat. The impoundments created by dams serve to increase water temperatures, raise bacteria levels, and disrupt the natural movement of fish, benthic invertebrates, sediment and nutrients. The natural movement of each is imperative for a healthy aquatic system.

The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2014) looked at barriers to fish movement, which included dams, perched culverts, weirs, and other barriers such as online ponds, beaver dams, velocity barriers, and intermittent sections of stream. The BMP inventory covered 43% of the watercourses in the Talbot River subwatershed, including the shorelines of Canal and Mitchell Lakes, and 67% of the Whites Creek subwatershed.

The BMP Inventory has identified 43 barriers to fish movement in the Talbot River subwatershed (this does not include hardened sites found along Canal and Mitchell Lakes; these are discussed in Chapter 7 - Lake Health), and 39 in the Whites Creek subwatershed (Figure 6-5).



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT created 2015.

Figure 6-5: Barriers to fish passage

6.2.2 Bank hardening and channelization

In the past it has been common practice to straighten watercourses to accommodate various land uses, and to harden banks as a way to prevent stream bank erosion and increase 'developable' area. While we now know that these practices are harmful to the environment and can cause more issues than they resolve, there are several areas in the subwatershed where these practices have been utilized.

Water generally flows more quickly through a channelized section of stream, particularly during high flow events. This increase in flow can have several effects:

- Unstable banks in the channelized section (if they are not hardened)
- Flooding downstream of the channelized section (water is confined to the channel, which results in larger volumes of water flowing more rapidly than under natural conditions being conveyed to downstream sections)
- Changes to the migration patterns of fish (and wildlife)
- Bank erosion downstream of the channelized section
- Sediment deprivation in channelized section
- Sedimentation downstream of the channelized section where the flow of water slows

These effects result in the degradation of aquatic habitat. The riffle/pool sequences that occur in natural channels are lost in the channelized section as well as downstream. Much of the natural cover in the watercourse can be lost. Fluctuating flow levels can place stress on the aquatic biota, and in many cases can cause a shift from a more sensitive community to one that is better able to tolerate adverse conditions. Finally, the deposition of sediment as the water slows coming out of the channelized section can blanket the substrate, interfering with spawning activities and affecting the benthic invertebrate community.

There were 70 hardened sections of stream identified in the Talbot River subwatershed through the BMP Inventory (this does not include hardened sites found along Canal and Mitchell Lakes; these are discussed in the Lake Health chapter). Of these, 15 were considered to be failing, and would priorities for restoration works. An additional 42 sites were identified to have been straightened. In Whites Creek, 27 hardened sections of stream were identified through the inventory, with six of these considered to be failing. Another 17 sites have been straightened. All of these sites are depicted in Figure 6-6.

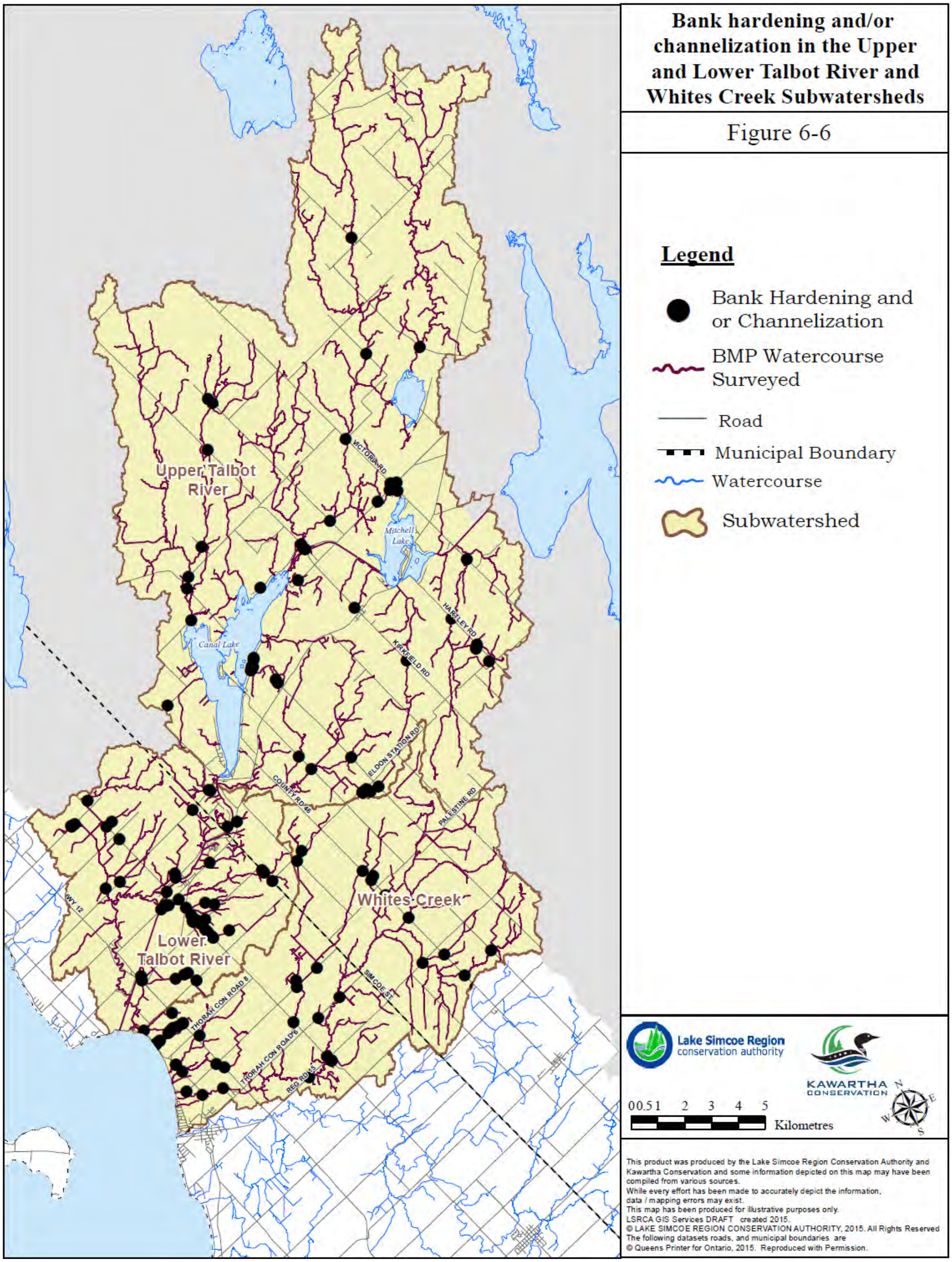


Figure 6-6: - Bank hardening and channelization

Figure 6-7: Examples of a weir, a failed bank hardening, and a perched culvert in the Whites Creek and Talbot River subwatersheds.

6.2.3 Uncontrolled stormwater and impervious surfaces

Urban stormwater runoff occurs as rain or melting snow washes off streets, parking lots and rooftops of dirt and debris, minor spills, and landscaping chemicals and fertilizers. In the past it was common practice to route stormwater directly to streams, rivers, or lakes in the most efficient manner possible. This practice typically has negative impacts on the receiving watercourse. Over the last two decades these practices have changed and efforts are made in urban centres to intercept and treat stormwater prior to its entering watercourses or waterbodies. However, in many older urban areas stormwater typically still reaches watercourses untreated. There are few areas of urban settlement within the study area.

One of the most significant impacts of stormwater runoff though, is to water quality (discussed in more depth in **Chapter 4 – Water Quality**). Problems with degraded water quality directly affect the aquatic ecosystem. This occurs in developed areas as pollutants are washed off of streets, parking lots, rooftops and roadways into storm drains or ditches which discharge to watercourses and lakes. Generally, concentrations of pollutants such as bacteria (e.g. *Escherichia coli*, faecal coliform, *Pseudomonas aeruginosa,* and faecal streptococci), nutrients (e.g. phosphorus, nitrogen), phenolics, metals, and organic compounds are higher in urban stormwater runoff than the acceptable limits established in the PWQO (MOECC, 1994). Other associated impacts include increased water temperature and the collection of trash and debris.

All of these changes can cause considerable stress to aquatic biota, and can cause a shift from a community containing more sensitive species to one containing species more tolerant of degraded condition. However, due to the extremely low coverage of urban areas within the Talbot River and White's Creek subwatersheds, there is minimal likelihood of any major ecosystem disturbances, excluding localized impacts from road infrastructure, resulting from impervious surfaces.

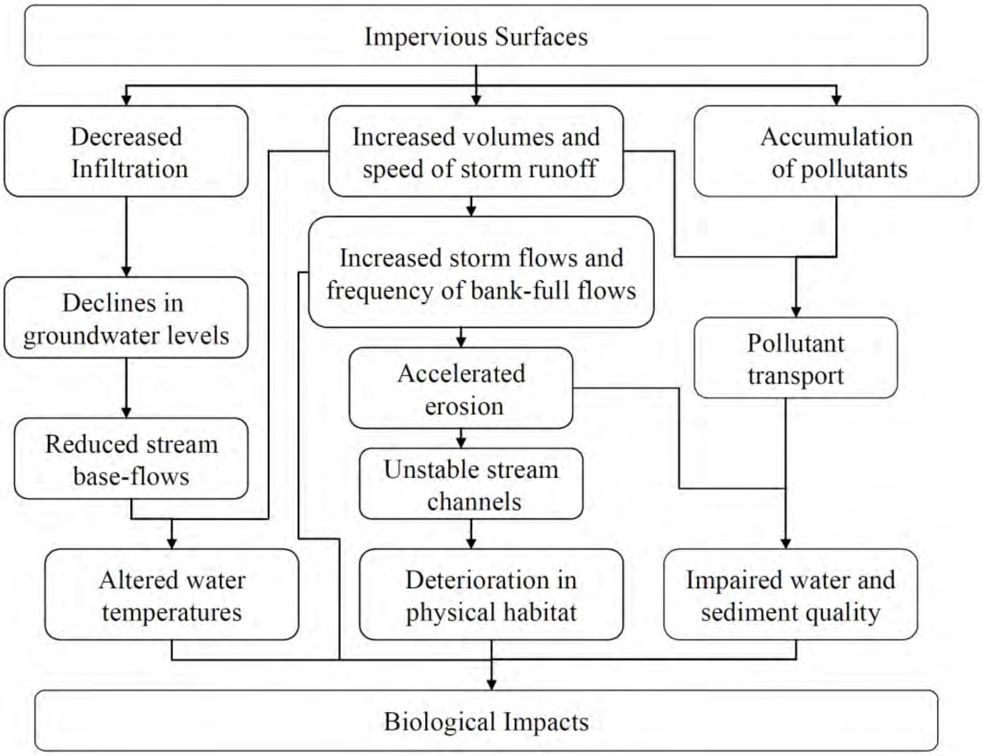


Figure 6-8: Pathways by which impervious surfaces may impact aquatic biological communities (ORMCP Technical Paper Series, #13).

6.2.4 Municipal drains

Municipal drains are generally located in rural agricultural areas and are intended to improve the drainage of the surrounding land. Typically they are ditches or closed systems (buried pipes or tiles) and can include structures such as buffer strips, grassed water ways, dykes, berms, stormwater detention ponds, bridges, culverts, and pumping stations. Currently, a number of creeks and small rivers have been designated as municipal drains (OMAFRA, 2001).

As these are direct links to watercourses, there are a number of impacts on the aquatic communities. The inputs into the drain consist of both overland flow and tile outlets and can carry contaminants, sediment, and debris into the drain. With little to no riparian vegetation, water temperature is increased and the drain therefore becomes a source of warm water in the watercourse system. Additionally, these drains come to be used as fish habitat. The issue with this is that municipal drains require maintenance to ensure they continue to work properly. While maintenance work is in progress, fish migration can be blocked and water quality can decline. The work itself may either negatively change or destroy fish habitat through altering or removal of the little riparian vegetation present, disrupting and changing bottom substrate composition and altering the width-to-depth ratio.

The construction and maintenance of municipal drains is regulated under the *Ontario Drainage Act,* while the protection of fish habitat is regulated under the federal *Fisheries Act*. To ensure that drains are properly maintained, while fish habitat is minimally impacted, Fisheries and Oceans Canada (DFO) developed a Class Authorization System. Drains are classified into six types (A, B, C, D, E, and F) based on the sensitivity of fish and fish habitat found in the drain and the type of work completed. Types A, B, and C are considered to contain fish and fish habitat more resilient to drain maintenance, while Types D and E have fish and habitat that are less resilient and maintenance work is determined on a case-by-case basis. Type F drains are intermittent and are usually dry for at least two consecutive months in the year. As fish habitat is not an issue here when dry, the only conditions for the maintenance work are that it be completed when dry and that soil is stabilized upon completion of work. There is one area with a number of municipal drains in the lower section of the Talbot River subwatershed, found in the area east of Hwy 12 to just west of Sideroad 5, and Concession Roads 1 and 3 to the south and north. These watercourses consist of Types C and F drains, and primarily drain agricultural lands (OMAFRA, 2015). However, there is a stretch of this drain that flows through an area of swamp land. The drain itself, as well as the maintenance activities, may have an impact on this feature; these potential impacts should be considered in planning drain maintenance.

6.2.5 Loss of riparian vegetation

While many policies now afford some protection to the riparian areas adjacent to the watercourses, this has not always been the case. In many instances, vegetation in the riparian areas of the subwatershed's watercourses has been removed to accommodate urban development and agricultural activities, leaving the bank vulnerable to erosion due to the removal of the stabilizing influence of the roots of the vegetation. This can result in inputs of sediment into the watercourse, which can settle and smother the substrate, thus eliminating important habitat used by fish for spawning and inhabited by benthic invertebrates. Sediment suspended in the water can also interfere with the feeding of those fish species that are visual feeders.

Riparian vegetation is also an important source of allochthonous material such as leaves and branches that serve as a food source for benthic invertebrates, and can also provide cover for fish.

In addition, riparian vegetation serves to enhance water quality – it filters the water flowing overland, causing sediment and other contaminants to settle out or be taken up prior to reaching the watercourses; and also helps to moderate water temperatures through the shade it provides. Removal of this vegetation can have an influence on the type of aquatic community able to inhabit the watercourse – a reach that may have been able to support a healthy coldwater community may no longer be able to do so, and the community may shift to a cool or warm water community containing less sensitive species.

Just over 51% of the area within 30 m of the watercourses in the lower portion of the Talbot River subwatershed are in natural cover; this number is approximately 53% in Whites Creek. These are among the lowest of Lake Simcoe's subwatersheds. This level of natural cover continues to decrease with increasing distance from the watercourses as the land use changes to agricultural. In contrast, 91% of the upper portion of the Talbot River subwatershed is in natural cover; this is consistent with the relatively natural state of this section of the study area. See section 6.2.4 – Riparian and Shoreline Habitat, for more information. The BMP inventory identified 208 sites in the Talbot River which had insufficient riparian cover (this does not include hardened sites found along Canal and Mitchell Lakes; these are discussed in the Lake Health chapter), and 77 sites in the Whites Creek subwatershed.

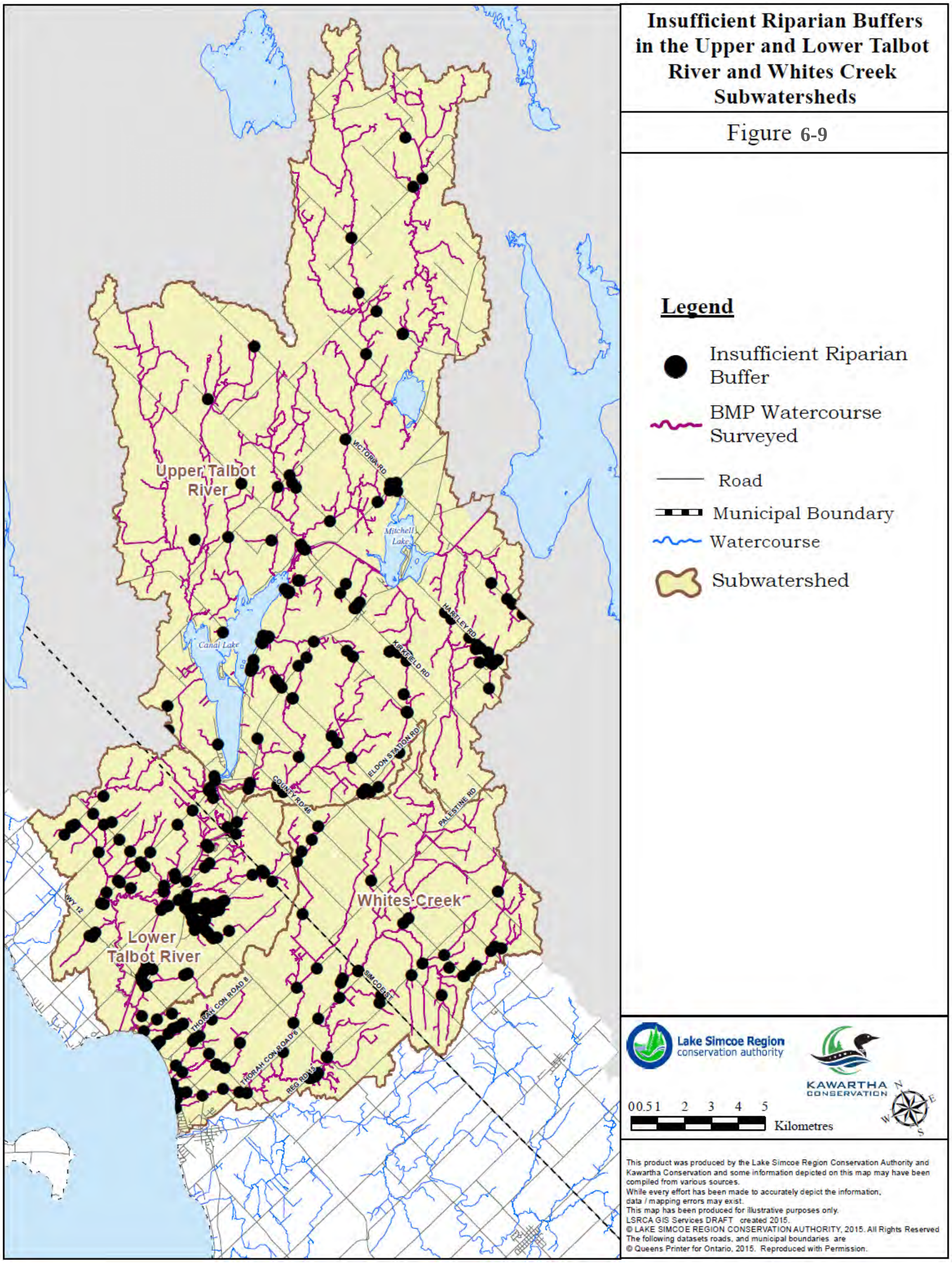


Figure 6-9: Areas of insufficient riparian cover

6.2.6 Water quality and thermal degradation

Inputs of contaminants, including high levels of chloride and suspended sediment, to watercourses can be harmful to many species of fish and benthic invertebrates, particularly the more sensitive species. It can force them to leave their habitats, inhibit their growth, or cause die-offs if concentrations of a contaminant get too high. Specific information on water quality issues pertaining to this subwatershed can be found in **Chapter 4 - Water Quality**.

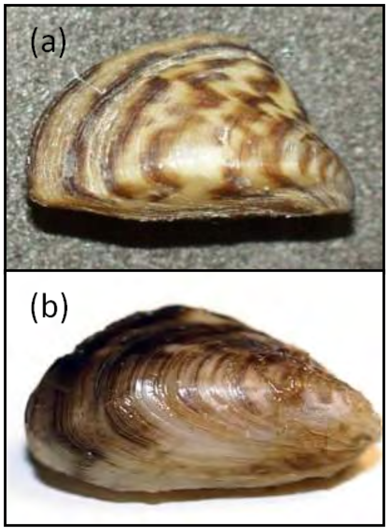
One of the issues that directly affects both water quality and aquatic habitat is livestock having direct access to streams. The issues associated with livestock in streams include streambank erosion, which results in the input of sediment and effects on riparian vegetation, and the direct input of nutrients and bacteria, as the waste from the cattle is deposited directly on, or in close proximity to, the watercourse. Streambank erosion can result in the input of nutrients and other sediment-bound contaminants, and the input of this sediment into the stream can blanket the stream bed, affecting important spawning habitat and populations of the benthic invertebrates on which the aquatic ecosystem depends. The BMP inventory identified 59 sites in the Talbot River and 28 in Whites Creek where cattle had unrestricted access to streams. Fencing of these areas to restrict livestock, and the installation of alternative water sources (such as a nose pump) are relatively simple solutions to this issue.

The MNRF has established warm water timing restrictions for in-water works on the upper portion of the Talbot River subwatershed and the upstream portion of the lower Talbot River. The remainder of the watercourses in the lower section have cool water restrictions. In the Whites Creek subwatershed, the headwaters through to the mid-sections of the subwatershed are subject to cold water timing restrictions, and the lower sections have warm water restrictions.

Stream temperatures should be maintained to help reduce shifts in tributary fish community composition. Thermal degradation of a system can be caused by a number of factors. The first is the removal of riparian vegetation and the shade that it creates. If large portions of a watercourse are shaded, these areas may be key in maintaining cold or cool water temperatures or may be a refuge for cool or cold water aquatic species during the hot summer temperatures. Runoff can also cause thermal degradation in a system. As impervious surfaces (such as pavement) heat up from the sun they easily warm any water running over them, creating a warm water source as the water drains into a watercourse, possibly rendering the surrounding waters uninhabitable for coldwater species. Lastly, the detention of water in a pond creates a source of warm water into a system as it increases the surface area of the water that is exposed to sunlight, and keeps it there for a prolonged period of time, leading to warming. Although online ponds are the greatest concern due to their direct impact on the watercourse, offline ponds (including stormwater ponds and detention ponds for irrigation) that discharge to watercourses are also a concern.

6.2.7 Invasive species

The traits possessed by non-native invasive species, including aggressive feeding, rapid growth, prolific reproduction, and the ability to tolerate and adapt to a wide range of habitat conditions enable them to outcompete native species for food, water, sunlight, nutrients, and space. This may result in the eventual reduction in the number and abundance of native species. The replacement of native species with invasive species affects the balance of the ecosystem, as species that relied on the native species for food, shelter and other functions now either have to move to another area with these species, or must utilize another source that is perhaps less desirable. This cycle reverberates throughout the ecosystem, and can be exacerbated by the introduction of additional invasive species. Ecosystems that are already under stress are particularly vulnerable to invasion by non-native species, as the existing ecosystem is not robust enough to maintain viable populations of native species as the invasive species become established. The process may happen more quickly in already disturbed systems than it would in a healthy community.



Two invasive mussel species in Lake Simcoe: (a) zebra mussel; (b) quagga mussel.

Two invasive fish species have been captured within the study area. The round goby (*Neogobius melanostomus*) is present in both the Talbot River and Whites Creek subwatersheds, and the common carp (*Cyprinus carpio*) has been found in the Whites Creek subwatershed. The round goby is an aggressive and fertile sculpin-like species that can out-compete native species, such as mottled sculpin, for space and food. This species is native to Europe, and were released into Canadian waters via ballast from international ships. In the Lake Simcoe watershed, they were first discovered in the Pefferlaw River in 2004 and, in spite of efforts to eradicate them, their populations have survived and rebounded, and they have spread to appropriate habitats throughout the watershed. These fish can also cause declines in populations of a number of sport fish, by eating eggs and young and competing for food sources. Common carp have a number of characteristics that make them detrimental to areas they are introduced to: they are prolific breeders, so their numbers can quickly shift the balance from native species; they feed by disturbing bottom sediment, which uproots vegetation, prevents new vegetation from becoming established, disturbs fish and amphibian nests, and causes the water to become cloudy; and their diets include, among other things, the eggs of other fish, as well as the invertebrates and plants that native species may use as a food source. The only invasive benthic invertebrate species that has been caught is the rusty crayfish, a species native to the Ohio, Kentucky, and Tennessee regions. It is thought to have been introduced in the 1960s by non-resident fishermen who used it as bait. Rusty crayfish have a number of characteristics that are cause for concern: they feed heavily on aquatic plants and other benthic invertebrates, thus disturbing the dynamics of the ecosystem; they are competition for native crayfish as well as juvenile fish; they aggressively chase native species from the best daytime hiding spots, leaving the native crayfish more vulnerable to predation; and they are also more aggressive when under attack by fish and are thus less likely to be preyed upon. In addition, they are able to mate with native species of crayfish, a process that may hasten the local extinction of the native species.

There have also been a number of invasive species identified in the study area that can impact the tributaries. These include:

- Eurasian watermilfoil (*Myriophyllum spicatum*),
- Curly-leaf pondweed (*Potomogeton crispus*),
- Spiny waterflea (*Bythotrephes longimanus*),

The LSPP includes a number of polices (7.1-SA to 7.10SA) to prevent the introduction of invasive species into the Lake Simcoe watershed. Of most importance is Policy 7.4-SA that requires that a “watch list” be developed and that response plans for those species on the list be prepared. These response plans will detail the actions that should be taken if the species are detected within the watershed. The following organisms are on the aquatic watch list:

- Fanwort (*Cabomba caroliniana):* A submersed freshwater perennial plant that is extremely persistent and competitive. Under suitable environmental conditions, it can form dense stands, crowding out previously well-established plants.
- European water chestnut *(Trapa natans):* Native to Europe, Asia, and Africa, *T. natans* is an invasive aquatic plant that can form dense mats of floating vegetation.
- Water soldier (*Stratiotes aloides):* An aquatic plant commonly sold in the aquarium and water garden industry. The plant is native to Europe and Central Asia, but has been identified in the Trent Severn Waterway near the hamlet of Trent River. Water soldier forms dense large masses of plants which crowd other aquatic plants.
- Asian carp: The term “Asian carp” refers to four invasive species (bighead, silver, grass, and black carp) that were brought to North America in the 1960s and 70s. Since then they have migrated north through U.S. waterways towards the Great Lakes, replacing native species in their path.
- Viral hemorrhagic septicaemia: A deadly infectious fish disease caused by the viral hemorrhagic septicemia virus. The virus can be spread from fish to fish through water transfer, as well as through contaminated eggs and bait fish from infected waters.

Figure 6-10: Invasive plant species on aquatic 'watch list': (A) Fanwort, (B) European water chestnut, and (C) Water soldier. (Photo Credits: Ontario's Invading Species Program)

6.2.8 Climate Change

Recent work from an MOECC Vulnerability Report for Lake Simcoe watershed wetlands, streams and rivers (Chu, 2011) suggests that climate change over the next 90 years will increase stream temperatures 1.3°C above current conditions, and 89% of the wetlands within the watershed will be vulnerable to drying and shrinkage. This prediction essentially threatens most wetlands in the study area.

In addition, as part of the Tier 2 Water Budget, Climate Change, and Ecologically Significant Groundwater Recharge Area Assessment for the Ramara Creeks, Whites Creek, and Talbot River Subwatersheds, Earth*fx* Inc. (2014) conducted a 10-year drought scenario and climate change assessment for the Talbot River and Whites Creek subwatersheds.

The drought analysis examined how the subwatershed would respond to conditions similar to a historic 10-year period of low rainfall. According to the model, the largest relative impact on streamflow occurs in the headwater streams; however, most of the areas within the subwatershed showed little response to the drought scenario, likely a result of a high groundwater storage capacity.

According to the climate change scenarios, warmer winter conditions, with higher than average precipitation and more coming as rain, will correspond to higher winter streamflow. Because less of the precipitation will be stored in the snowpack, there will be a lower peak for the spring freshet, and the timing will shift from April to March. In some areas, particularly those areas of the Upper Talbot fed by the Carden alvar, this will correspond to a longer summer low flow period, which will occur earlier in the year. Increasing temperatures will place added stress on these systems in the summer. The predicted groundwater discharge to the upper Talbot River and Rohallion Creek will decrease for the period from July to September. The lower Talbot River is expected to show less of an impact, because it is supported by the Trent-Severn system. There is little to no change indicated for the Whites Creek subwatershed with respect to groundwater discharge. Generally, these changes in flow regime and temperature can be expected to have an impact on the aquatic communities of the study area subwatersheds.

These studies highlight the importance of protecting and building more resilience to respond to climate change through the protection and maintenance of the current groundwater recharge-discharge system, as well as through activities such as instream rehabilitation, barrier removal, stream bank planting, the use of natural channel design during channel reconstruction, water quality protection in both urban and rural settings, and wetland protection. Long-term monitoring will be needed to assess the impacts of climate change to aquatic communities, where the key shifts are taking place and how they might be mitigated.

Key Points – Factors Impacting Aquatic Natural Heritage – stressors:

- Although the tributaries are in relatively good ecological state, as inferred from resident aquatic communities, there are several stressors to the aquatic natural heritage systems in the subwatersheds, including habitat alteration and fragmentation, invasive species, and climate change.
- Some of the most significant stressors include physical changes such as bank hardening, channelization, the removal of riparian vegetation, and barriers such as perched culverts and cement box culverts, and dams and locks.
- The BMP inventory covered almost half of the watercourses in the Upper Talbot River and Lower Talbot River subwatersheds, and identified 43 barriers to fish movement, 70 hardened sections of stream, and 208 sites which had insufficient riparian cover.
- The BMP inventory covered almost all of the watercourses in the White's Creek subwatershed, and identified 39 barriers to fish movement, 27 hardened sections of stream, and 77 sites which had insufficient riparian cover.
- Invasive species have invaded all subwatersheds (e.g., round goby, rusty crayfish, etc.), including the nearshore habitat (e.g., zebra mussels) of tributary outlets into Lake Simcoe. If populations of these invasive species increase, it is likely they will negatively affect native communities by occupying and/or destroying the habitat of native species and by out-competing them for resources.
- The emerging threat of climate change will interact with all of these threats, creating additional long-term stresses on the aquatic systems. Although research in this area is still emerging, initial predictions suggest that over the next 90 years stream temperatures will increase by 1.3°C above current conditions, and 89% of the wetlands in the Lake Simcoe watershed will be vulnerable to drying and shrinkage. Further, climate change scenarios indicate that median monthly groundwater recharge will increase in the fall and winter and decrease during the spring freshet, impacting processes such as stream flow and runoff.

6.3 Current Management Framework

Various programs exist to protect and restore aquatic natural heritage values in the Lake Simcoe watershed, ranging from regulatory mechanisms, to funding and technical support provided to private landowners, to ongoing research and monitoring.

Many of these programs already address some of the stresses facing aquatic systems in the Whites Creek and Talbot River subwatersheds, as outlined below.

6.3.1 Protection and policy

There are numerous acts, regulations, policies, and plans aimed at maintaining or improving aquatic habitat. These include the *Fisheries Act*, *Endangered Species Act*, the Lake Simcoe Protection Plan, and municipal official plans. This management framework addresses many of the stresses identified in this subwatershed. In Table 6-3 we categorize 12 such stressors, recognizing that many of these overlap and that the list is by no means complete. The legal effects of the various Acts, policies, and plans on the stressors is categorized as ‘existing policies in place’ (shown in green), or ‘no applicable policies’ (shown in red). The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 6-3: Summary of the current management framework as it relates to the protection and restoration of aquatic natural heritage

Stressor affecting aquatic habitat	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Endangered Species Act (2008)	Ontario Water Resources Act (1990)	Fisheries Act (1985)	Ontario Fisheries Regulations (1989)	Lakes and Rivers Improvement Act (1990)	LSRCA Watershed Development Guidelines (2015)	Simcoe County Official Plan (2007)	City of Kawartha Lakes Official Plan (2012)	Township of Brock Official Plan (2014)	Township of Ramara Official Plan (2003)
Site alteration in wetlands	🟩	🟥	🟩	🟩 4	🟥	🟩 5	🟥	🟥	🟩	🟩	🟩	🟩 11	🟩 13
Loss of riparian areas / shoreline development	🟩 1	🟥	🟩	🟩 4	🟥	🟩	🟥	🟩 6	🟩	🟩	🟩	🟩 11	🟩 14
Stream alteration (including enclosures and flow diversion)	🟩 1	🟥	🟩	🟥	🟥	🟩	🟥	🟩	🟩	🟩 10	🟩 11	🟩 11	🟩 15
Instream barriers	🟩	🟥	🟩	🟥	🟥	🟩	🟥	🟩	🟩	🟩 10	🟥	🟥	🟥
Bank hardening	🟩 1	🟥	🟩	🟥	🟥	🟩	🟥	🟩 7	🟩	🟩 10	🟥	🟥	🟥
Impervious surfaces	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩 16
Municipal drains	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟩	🟥	🟥	🟥	🟥
Uncontrolled stormwater	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩 9	🟩	🟩	🟩 11	🟩
Interference with groundwater recharge / discharge	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩 11	🟩	🟩
Degradation of water quality (including thermal impacts)	🟩 2	🟩	🟩	🟥	🟩	🟩	🟥	🟩 8	🟩	🟩	🟩	🟩	🟩 17
Introduction of invasive species	🟩 3	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟥	🟥	🟥	🟥
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟩 12	🟥

🟩 Existing policies in place

🟥 No applicable policies

[1] Regulations only apply to those areas outside designated Settlement Areas

[2] Only contains specific policies and targets about phosphorus reduction, none about other contaminants

[3] Discusses developing proposed regulations, conducting studies/risk assessments, developing response plans, education programs, but nothing banning use/etc

[4] Related to those features that are part of SARO listed species' habitat

[5] Restrictions apply only to direct or indirect fish habitat

[6] Not directly stated, but applicants who are applying for approval under the *Lakes and Rivers Improvement Act* need to be aware of the rights of riparian owners, and take into account the effect that the proposed work will have on the rights of riparian owners.

[7] Refers to channelization, including revetments, embankments, and retaining walls in rivers

[8] Not directly stated, but most of the policies would indirectly cover this

[9] Stormwater controls required, application must demonstrate every effort made to achieve pre-development hydrologic conditions

[10] References Fisheries Act (1985)

[11] Consistent with LSPP

[12] Consistent with LSPP, specific to consideration of stormwater management effectiveness

[13] If not PSW, requires proponent to demonstrate no negative impact on the feature or its functions

[14] Policies mainly relate to planning/building code issues; however one requires a 20 m setback, to protect from flood risk; another requires completion of assessment report for DFO, Simcoe County regarding development in fish habitat in Barnstable Bay

[15] Development proposals are to demonstrate that the natural condition of a watercourse will be maintained (but does not specifically address stream alteration)

[16] Township adopt guidelines for stormwater measures including maximum impervious area on individual lots – only applies in Shoreline Residential Areas

[17] There are policies related to water quality, although none specifically mention thermal impacts

Legislation and policy restrictions are the primary source of protection for aquatic natural heritage features in the Lake Simcoe watershed. However, some stresses are better suited to policy and regulation than others. For example, stressors such as climate change and invasive species are hard to regulate; however, activities related to the loss of habitat, or capture and killing of fish are much easier to define and enforce.

The new Federal *Fisheries Act* manages threats to fish that are part of or support commercial, recreational or Aboriginal fisheries with the goal of ensuring their productivity and ongoing sustainability. Under the Act, the Fisheries Protection Policy Statement applies to proponents of existing or proposed works, undertakings or activities that are likely to result in impacts to fish or fish habitat that are part of or support commercial, recreational or Aboriginal fisheries, including projects that have the potential to affect the passage of fish or modify the flow of watercourses.

The *Fisheries Act* is complemented by the Lake Simcoe Protection Plan, which (outside designated settlement areas) establishes restrictions to development or site alteration within 100 m of the Lake Simcoe shoreline (30 m in already built-up areas, subject to a natural heritage evaluation) (policies 6.1 and 6.2), or within 30 m of wetlands and watercourses, with natural heritage evaluations necessary for development proposed within 120 m of the feature (policies 6.22 – 6.25). Exemptions to these policies are provided for existing uses, municipal infrastructure, and aggregate operations. These activities will be required to demonstrate that they maintain or improve fish habitat in the watercourse, wetland, or riparian area.

Aquatic habitat is also offered some protection by municipal official plans. The City of Kawartha Lakes Official Plan states that the City's fisheries and fish habitat will be protected, enhanced and restored from any harmful alteration, disruption and/or destruction, and that increased setbacks from critical spawning areas and warm and cold water streams will be secured. In addition, a review of available information for development and site proposals for developments within 120 metres of a lakes, rivers, and watercourses is required to determine if the feature is fish habitat. If it is found to be fish habitat, an environmental impact study is required, in consultation with appropriate agencies. This Official Plan is also consistent with the Lake Simcoe Protection Plan, and the protections afforded through its policies.

Among the Strategic Directions for strengthening and integrating natural, cultural, and heritage resources, Township of Brock's Official Plan recognizes in its objectives that Lake Simcoe, and the associated rivers, streams and wetlands are essential to the quality of life in the Township and to its economic prosperity. Its Open Space policies recognize the importance of the preservation and protection of natural features and funcitons, hazard lands and man-made environments. In its Urban Areas and Shoreline Residential Areas policies, the Township requires (consistent with the LSPP) the preparation of an EIS that addresses, among other items, the increase or improvement of fish habitat in streams, lakes and wetlands, and any adjacent areas.

In the Official Plan for the Township of Ramara, Policy 5.2.3.7 of the Natural Area Framework outlines a limited number of uses permitted on lands of provincial, regional and local significance identified as fish habitat. Some of these uses include passive recreation, permitted agricultural activities, facilities for preservation and conservation of natural areas, and water supply, wastewater treatment, storm water management, and road, railway and utility infrastructure approved under applicable provisions. However, Policy 5.2.4.1 of the Township of Ramara's Official Plan states that, where it is demonstrated that there will be no negative impact on natural features and functions, development and/or site alteration may be permitted following consideration of an Environmental Impact Statement (EIS). Among other requirements, the EIS is to contain specified performance criteria, as outlined in the official plan. For example, with respect to fish habitat, development and/or site alteration proposed in areas within and/or adjacent to the features and functions of the natural areas shall satisfy, as a minimum standard, that the health of aquatic communities and fish habitat are not altered, disrupted or destroyed and there is no net loss of productive capacity.

Beyond the protection of aquatic habitat features themselves, processes related to groundwater flow (including both recharge and discharge) are also protected by a suite of policy mechanisms. The Lake Simcoe Protection Plan requires LSRCA (in partnership with MOECC and MNRF) to define and map Ecologically Significant Groundwater Recharge Areas (ESGRAs) throughout the watershed. ESGRAs are identified as areas of land that are responsible for supporting groundwater systems that sustain sensitive features like coldwater streams and wetlands. Once identified, municipalities are required to incorporate these features into their official plans together with policies to protect, improve or restore the function of the recharge areas.

Drainage works, such as those permitted under the Provincial *Drainage Act,* are exempt from many of the policy provisions provided under the Lake Simcoe Protection Plan and municipal official plans, but are not exempt from the requirements of the Federal *Fisheries Act* or the Provincial Regulation on development and interference with wetlands (O. Reg. 179/06). Maintenance of existing designated drains requires class authorization under the *Fisheries Act*.

For infrastructure or other works occurring in water, the Ontario Ministry of Natural Resources and Forestry is responsible for determining in-water work timing restrictions to ensure that fish and other aquatic life are permitted to carry out critical life processes undisturbed. These restrictions are based on the presence of warm and cold water thermal fish communities as determined by contemporary thermal regime and fisheries studies.

6.3.2 Restoration and remediation

There is a range of programs operating in the Talbot River and White's Creek subwatersheds to assist private landowners in improving the environmental health of its tributaries. Table 5-4 summarizes the stewardship projects completed between 2005-2015 through just one of these funding sources, LSRCA's Landowner Environmental Assistance Program (LEAP).

The LEAP is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which have traditionally been funded by the LEAP program include removing barriers from streams, adding bottom-draw structures to online ponds, and fencing and planting riparian areas, among others.

Table 6-4: Summary of stewardship projects completed between 2005 and spring 2015 in the Talbot River and Whites Creek subwatersheds under LSRCA's Landowner Environmental Assistance Program.

Project Type	Talbot River	Whites Creek
Clean water diversion	1	1
Cover cropping	0	1
Erosion streambank	3	2
Fencing	0	2
Manure storage	2	1
Milkhouse waste	0	1
Septic	4	4
Tree planting	1	1
Well decommissioning	3	1
Wellhead protection	0	1
Total	**14**	**15**

The Kawartha Lakes Farm Stewardship Fund is a new program at Kawartha Conservation, funded by the Ontario Ministry of Agriculture, Farming, and Rural Affairs. Agricultural landowners within the City of Kawartha Lakes may apply for assistance with a number of on-farm stewardship projects addressing nutrient and soil loss, cropland and shoreline erosion, manure storage runoff, livestock access to watercourses, sediments and contaminants entering water, and farm well management. Due to this funding's emphasis on Lake Simcoe, priority may be given to landowners within the Talbot River subwatershed, however projects with significant stewardship potential in other City of Kawartha Lakes locations will be considered. Information sessions are currently being scheduled for this Fund and applications are being accepted as of June 2015.

There are a number of other funding programs available to landowners who wish to undertake works on their properties. Several of these are described in the paragraphs below.

The Ontario Ministries of Natural Resources, Environment, and Agriculture, Food and Rural Affairs provide the Lake Simcoe Community Stewardship Program with financial and technical assistance for non-farm rural landowners in the Lake Simcoe watershed to implement projects such as shoreline stabilization, erosion control, and fish habitat improvements, among others.

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, streambank fencing, and nutrient management.

In 2008, 2009, and 2014, LSRCA field staff surveyed the majority of the watercourses throughout the watershed, including watercourses and shorelines in the Talbot River and Whites Creek subwatersheds, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. These inventories (LSRCA, 2010 and 2014) found over sites in the Talbot River subwatershed (this does not include hardened sites found along Canal and Mitchell Lakes; these are discussed in the Lake Health chapter) and 77 in Whites Creek where additional riparian planting could be introduced, 41 barriers in the Talbot River and 34 in Whites Creek that should be removed to improve fish passage, 59 sites in the along creeks in the Talbot River and 28 in Whites Creek that require additional fencing, and 70 locations in the Talbot and 27 in Whites Creek where the creek channel had been hardened, and an additional 42 and 17 sites were identified to have been straightened in the Talbot and Whites, respectively, which could be mitigated to improve fish habitat.

The forthcoming wetland and riparian area prioritization exercise, will identify and prioritize stewardship opportunities in these subwatersheds, specific to the shoreline and inland riparian and headwater areas, respectively.

6.3.3 Science and research

An ongoing commitment to applied science and research is necessary to improve our understanding of the extent, character, and function of the fish and other aquatic natural heritage values within the Lake Simcoe watershed. Ongoing monitoring programs led by the MNRF and the LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

The Lake Simcoe Region Conservation Authority and Kawartha Conservation monitor fish communities, benthic invertebrates, and temperature at a network of sites throughout the watershed. Some of these sites are visited only once, to describe the aquatic system, and some are visited annually to document changes in the health of the tributaries.

In addition to these ongoing monitoring programs, numerous scientific and technical reports have been published based on research conducted in the Lake Simcoe watershed. As a result of this combined focus, Lake Simcoe is one of the most intensively studied bodies of water in Ontario. The results of this research have been summarized, in part, in LSEMS (2008) and Philpot *et al.* (2010), and have informed the development of this subwatershed plan.

The Lake Simcoe Protection Plan commits the MNRF, MOECC, LSRCA, and others to continue to invest in research and monitoring related to aquatic communities of Lake Simcoe and its tributaries. Ongoing research is proposed to examine the biological components of the ecosystem, their processes and linkages; to build on existing knowledge; or address knowledge gaps (policy 3.5). The proposed monitoring program is intended to build on the existing monitoring described above, to describe the fish communities, benthic communities, macrophytes, and/or fishing pressure in the lake, its tributaries, and other inland lakes within the watershed (policy 3.6).

6.4 Management Gaps and Recommendations

(Note: It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.)

6.4.1 Stewardship implementation – increasing uptake

In addition to protecting existing aquatic habitat, programs which support the stewardship, restoration, or enhancement of aquatic habitat will be critical to meet the targets and objectives of the Lake Simcoe Protection Plan. To that end, Lake Simcoe Stewardship Network has been established to provide a forum that helps identify priorities and coordinate efforts between the multiple organizations undertaking stewardship in the watershed. The Stewardship Network includes the Ministry of Natural Resources and Forestry, Ministry of Environment and Climate Change, Ministry of Agriculture, Food and Rural Affairs, Ontario Federation of Agriculture, Ontario Soil and Crop Improvement Association, Lake Simcoe Region Conservation Authority, South Simcoe Streams Network and watershed municipalities.

Recommendation 6-1 – That the LSRCA and Kawartha Conservation, along with interested stakeholders and stewardship groups, develop an adaptive stewardship strategy to identify, implement and track stewardship projects in the study area subwatersheds. The development of this strategy should incorporate recommendations 6-2 through 6-12 as well as recommendations 8-16 through 8-21.

Recommendation 6-2 – That MNRF, MOECC, OMAFRA, LSRCA, and Kawartha Conservation continue to implement stewardship projects in the Talbot River and White's Creek subwatersheds, and encourage other interested organizations in doing the same.

Recommendation 6-3 – Governmental and non-governmental organizations should continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as existing networks (including Environmental Farm Plan coordinators), a simple web portal, or other, locally appropriate avenues.

Recommendation 6-4 – That MOECC, MNRF, LSRCA, Kawartha Conservation and other members of the Lake Simcoe Stewardship Network are encouraged to regularly compile and synthesize completed stewardship projects to allow efficient tracking, coordinating, and reporting of stewardship work accomplished.

Recommendation 6-5 –That the City of Kawartha Lakes, Simcoe County, and Region of Durham enhance existing funding to the LSRCA and Kawartha Conservation to ensure continued delivery of stewardship programs.

Recommendation 6-6 - That partnerships and funding opportunities with other organizations (e.g. Ducks Unlimited Canada, TD Friends of the Environment, Royal Bank of Canada, local businesses, etc.) be pursued to implement stewardship projects (eg. monitoring, pilot restoration projects, etc.).

Recommendation 6-7 – That the LSRCA create and/or publicize link to a website that provides information and contact information on available funding programs for stewardship works, and ensure that this site is kept current.

Recommendation 6-8 – That the MOECC, MNRF, OMAFRA, LSRCA, and Kawartha Conservation continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. local radio, Chamber of Commerce, 4H clubs, high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction, and/or including inserts in tax or utility bills). Results of these efforts should be shared with the Lake Simcoe Stewardship Network.

Recommendation 6-9 – That the MOECC, MNRF, OMAFRA, LSRCA and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in this subwatershed, and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 6-10 – That the conservation authorities work with organizations within the study area, including Couchiching Conservancy, Trent Matters, Farms at Work, the Kawartha Farm Stewardship Collaborative, and Ontario Soil and Crop, to better engage area residents and enhance uptake of available stewardship programs.

6.4.2 Stewardship implementation – prioritize projects

Stewardship programs play an important role in meeting the goals and objectives of the subwatershed plans. However, in order to ensure that they are both effective and efficient, stewardship projects should be selected in the context of the priority needs of the Lake Simcoe watershed, and its subwatersheds. An analysis of aquatic habitat has identified livestock and vehicle access to streams; bank hardening; barriers, particularly perched culverts; and insufficient riparian cover as some of the most important factors impacting instream habitat in the Talbot River and Whites Creek subwatersheds. Analogous to terrestrial natural heritage stewardship requirements, a tool has been developed to prioritize aquatic stewardship projects, taking into account: the most significant habitat stressors in the watershed; the use of best available datasets to identify potential restoration sites, such as the BMP inventory and riparian assessment; the expected improvements to aquatic habitat and therefore fish and benthic invertebrate condition, including improved water temperature, increased connectivity for movement within and between tributaries, enhanced riparian cover, and restored natural features within and along watercourses, including flow and channel design. A number of issues that are particularly prevalent in the study area are discussed in detail in the sections below; Recommendation 6-11 and 6-12 below discusses the implementation of all priority restoration areas.

Recommendation 6-11 – That specific focus be directed towards protecting and enhancing spawning habitat for species such as walleye within the lakes and tributaries of these subwatersheds.

Recommendation 6-12 – That the LSRCA and Kawartha Conservation, along with interested stakeholders and stewardship groups integrate the prioritized restoration areas identified through the recently developed tool into a stewardship plan that ensures prioritized restoration opportunities are undertaken as soon as feasible. This stewardship plan needs to incorporate the outcomes of recommendations to improve uptake identified in Recommendations 6-2 through 6-11. Further, that consideration be given to providing additional funding to projects deemed priorities, where feasible.

6.4.3 Habitat fragmentation

The fragmentation of habitat, and particularly the presence of numerous dams, perched culverts, weirs, and other barriers, are fragmenting the aquatic habitat through a number of sections of the study area. The locks located along the waterways of the Trent-Severn waterway also present a significant barrier to the movement of aquatic biota. Exploration of ways to mitigate barriers throughout the study area, while ensuring consideration of other issues that could potentially arise (such as the spread of invasive species), should be undertaken throughout the study area with a goal of providing aquatic biota with access to the maximum amount of habitat.

Recommendation 6-13 - That the study area municipalities, in partnership with the LSRCA and Kawartha Conservation, mitigate perched culverts through the design and implementation of routine road maintenance works.

Recommendation 6-14 - That the LSRCA, Kawartha Conservation, MNRF, and the Trent-Severn Waterway investigate the impacts of the Trent-Severn locks and other major barriers located in the study area to the movement of fish. Further that the partners explore the feasibility of mitigating these impacts, perhaps through the installation of fishways. Any potential mitigation activity would consider, at a minimum, the potential for the introduction and/or spread of invasive species.

6.4.4 Invasive species

Due to the significant impacts that invasive species can have on an aquatic ecosystem, such as habitat destruction, competition with native species for resources, and the direct consumption of the eggs and young of native species, it is important to prevent the introduction and spread of invasive species. This issue is of particular importance in the Talbot River subwatershed, where boats travel from different water bodies on the Great Lakes system, creating the potential for the spread of a wide variety of invasive species.

Recommendation 6-15 - That the MNRF, LSRCA, Kawartha Conservation, and the Trent Severn Waterway, in partnership with organizations such as the Ontario Federation of Anglers and Hunters (through its invading species awareness program) continue to implement strategies to prevent the introduction and spread of invasive species through the study area subwatersheds. This could include, but would not be limited to, the continuation of education and outreach works, and the development and distribution of additional materials as new species of concern arise; implementing measures such as boat and equipment sanitization, and conducting research on how the ecosystem responds to the introduction of invasive species.

Recommendation 6-16 - That the MNRF, LSRCA, Kawartha Conservation, DFO and the Trent Severn Waterway, examine ways of preventing the spread of novel invasive species between the Lake Huron and Lake Ontario basins via the Trent Severn Waterway.

6.4.5 Impacts to Hydrologic Regime

In addition to the stressors on aquatic habitat identified above (barriers, channelization etc), the condition of the fish and benthic communities in the subwatershed are also likely being impacted by stream hydrology, particularly from low flow condition. While water quantity and associated recommendations are discussed in detail within **Chapter 5**, the following recommendations are specific to aquatic habitat:

Recommendation 6-17 –That LSRCA, with assistance from MNRF and MOECC and in partnership with the Trent-Severn Waterway, establish ecological flows (instream) targets for each main tributary. These instream flow targets should be based on the framework established for the pilot project being undertaken in Lover’s Creek. Once these targets are established, a strategy should be established to achieve them. This strategy should also protect baseflow and location of upwellings in order to maintain thermal stability.

Recommendation 6-18 – That LSRCA and Kawartha Conservation work with the subwatershed municipalities, OMAFRA, and landowners to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using principles of natural channel design.

Recommendation 6-19 - That municipalities, in consultation with LSRCA, consider roadside ‘ditch cleanout’ practices which leave existing vegetation in place to increase water infiltration, reduce ditch maintenance costs, and reduce nutrient inputs into Lake Simcoe, against the increases in road maintenance costs associated with imperfectly draining road beds and other liabilities; further to develop a strategy to reach a balance between environment and roads maintenance, and construction costs and public liability on adjacent lands

6.4.6 Water Quality and Water Temperature

Based on the documentation of some relatively poor fish and benthic invertebrate community scores, there are a number of areas displaying water quality issues across the study area. Similarly, the assessment of fish Index of Biotic Integrity and water temperature indicate that the thermal regime of some watercourses is potentially being affected by factors such as loss of riparian cover, barriers, and an alteration of the flow regime. Recommendations addressing water quality are presented in **Chapter 4 – Water Quality.**

Recommendation 6-20 – That the MNRF, LSRCA, and Kawartha Conservation review and refine (as necessary) timing windows for proposals under the Fisheries Act in light of watercourse temperature data collected during this study.

6.4.7 Monitoring and Assessment

Long-term monitoring is required to identify changes and trends occurring in the aquatic community. These on-going annual surveys of fish, invertebrates, stream temperatures, water quality, baseflow and channel morphology are also intended to provide information that will direct future rehabilitation efforts. Additional environmental characteristics such as fish community surveys, field confirmation of groundwater inputs, algae/diatom sampling, lake/tributary interface assessment, as well as an expanded water quality and quantity network will need to be considered to provide the information to look at the system in an integrated and holistic way. A renewed need for regular reporting of the results and a systematic re-evaluation of the program is also required.

Recommendation 6-21 – That LSRCA and Kawartha Conservation, with support from the subwatershed municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish, benthic invertebrate and aquatic plant indicators. There is a particular lack of data noted for the upper portion of the Talbot River subwatershed; it is recommended that additional sites be added in this area, acknowledging that additional data would also be useful for the lower Talbot River and Whites Creek. Citizen science should be a pursued as a means for obtaining some of this data, as should partnerships with local groups, such as Couchiching Conservancy and Trent Matters.

Recommendation 6-22 – That LSRCA and Kawartha Conservation, in partnership with other Conservation Authorities, characterize fish-habitat and invertebrate-habitat relationships in central Ontario, and use that information to develop improved indices of aquatic system health.

Recommendation 6-23 – That LSRCA and its partners work to create a centralized location for reports and resources pertaining to Lake Simcoe and its watershed such that information can be accessed by all interested stakeholders.

7 Lake Health

7.1 Introduction

Canal and Mitchell Lakes are a part of a chain of lakes known as the Kawartha Lakes, and are part of the navigable route of the Trent-Severn Waterway system. The waters from these lakes flow through the Talbot River, discharging into Lake Simcoe. Canal and Mitchell Lakes, as part of the connected system that developed through the creation of the Trent-Severn Waterway, have a number of issues that have been identified by lake managers, users, and landowners. While some of these issues are similar to those found in the river and stream systems, many are found only in the lake system, and require different analyses and management actions to other parts of the study area. This chapter, which is unique among other subwatershed plans developed throughout the Lake Simcoe watershed, has been created to examine the unique characteristics of these lake ecosystems, the stressors that influence them, and their importance for area residents, First Nations, seasonal visitors, and local businesses. This analysis has also included the development of lake-specific management recommendations.

7.1.1 Background

Canal Lake is a small, man-made lake, which was created due to flooding during the construction of the Trent-Severn Waterway. Originally this area was wetland and forest; the remnants of the trees were harvested following the first few years of flooding when it was deemed unsightly by canal superintendent J.H. McClellan. The lake was constructed during the Balsam Lake to Lake Simcoe phase of the water system, which was completed in approximately 1904, and was designed to store water for the canal system. Due to the reserve of water in Canal Lake, and the lack of hydro-electric dams in this part of the Trent-Severn waterway, there has never been a shortage of water in the western portion of the system. Currently, Canal Lake is surrounded by agricultural land, several quarries, and urban development, with a golf course on the southwestern shore.

Similar to Canal Lake, Mitchell Lake is also a small, man-made lake; it was formerly Grass River and wetland, and was flooded to build the Trent-Severn waterway and lift lock system, during the same phase in which Canal Lake was created. Currently, Mitchell Lake is surrounded by natural vegetation interspersed with agricultural land.

Figure 7-1 and Figure 7-2 show lake depths (bathymetry). The average depth of Canal Lake is 3 metres, and maximum depth is 4 metres. Mitchell Lake is shallower, having an average depth of 1.4 metres and maximum depth of 1.8 metres.

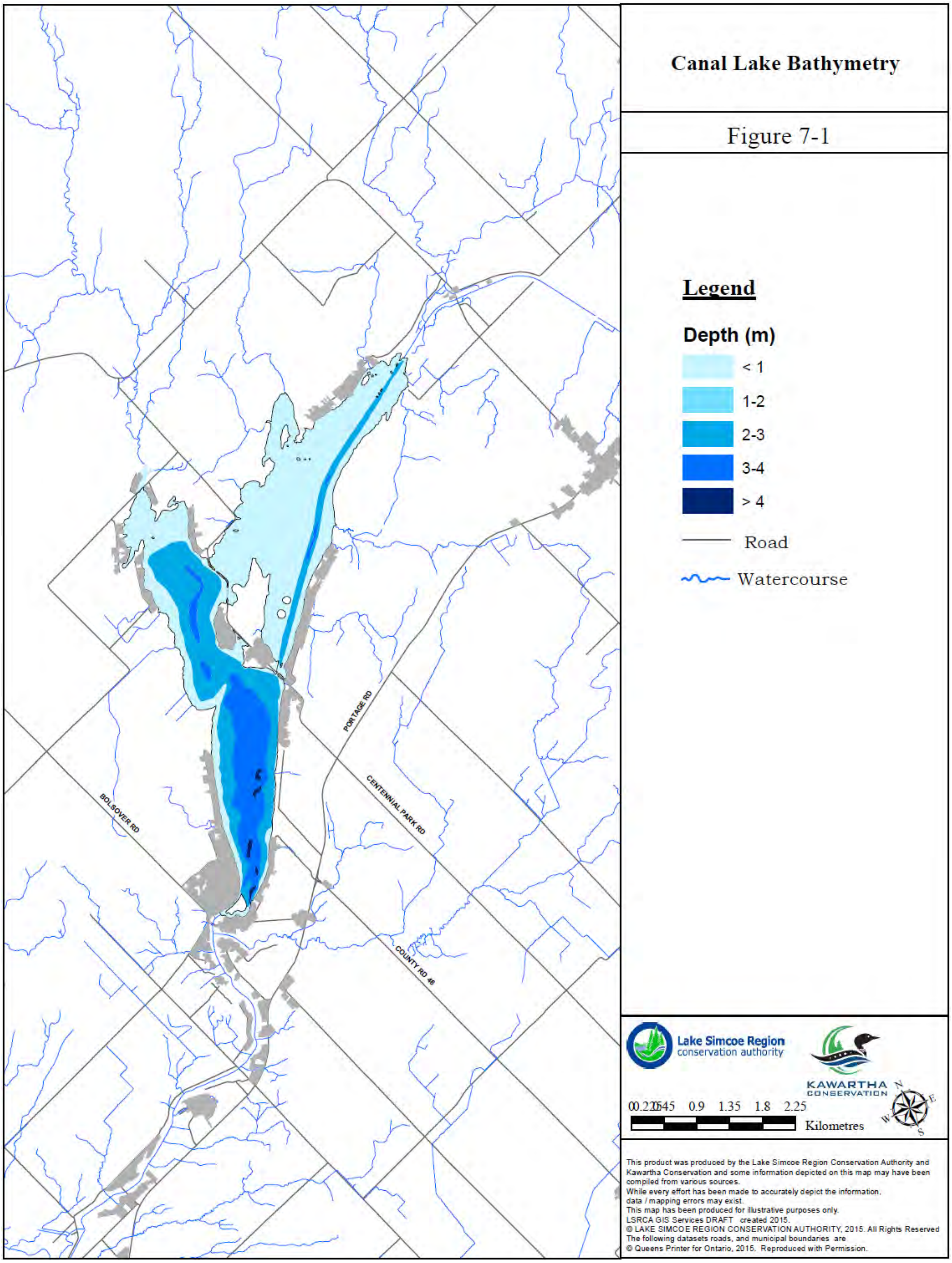
7.1.1.1 <u>Land Use</u>

An analysis of the portion of the Talbot River subwatershed that drains into Canal and Mitchell Lakes has been undertaken. It found that the majority of the 29,455 ha of lands within this area are comprised of natural heritage features (84.5%). Intensive agriculture comprises close to 9% of the land area, and non-intensive agriculture accounts for just over 3%. The remaining lands consist of a mixture of urban (just over 1%), roads, aggregate operations, and golf courses. The natural heritage features are comprised of a mixture of meadows/grasslands (39% of natural heritage area), forested areas (28%), wetlands (27%), and open water (6%).

7.1.1.2 Shoreline Characteristics

The shoreline of Canal Lake is approximately 40 kilometres in length, while that of Mitchell Lake is approximately 23 km. The length of the Lake Simcoe shoreline along the Talbot River subwatershed is just over two km (or 0.8% of the total length of the Lake Simcoe shoreline), and along Whites Creek is 6.3 km (or 2.4% of the total shoreline length).

Much of the shorelines of both Canal and Mitchell Lakes remain in a natural state. In Canal Lake, close to 76% of the shoreline is considered to be ‘natural’, with 71% being comprised of vegetation, and 5% being comprised of other natural materials such as cobble, boulders, and sand. The remaining 24% of the shoreline has been developed to some extent, with dock structures; flagstone, concrete, riprap, steel, or gabion basket reinforcements, or manicured lawns up to the water’s edge. Mitchell Lake has a somewhat lower percentage of developed shoreline, at 16%. Approximately 78% of the shoreline has natural vegetation, and the remaining 6% contains natural materials such as cobble and boulders. The shoreline of Lake Simcoe along the Talbot River subwatershed is comprised of a thin band of urban land use directly adjacent to the shoreline, with non-intensive agriculture (such has hay or pasture) and a large wetland complex beyond this. Much of the area directly along the shoreline of Lake Simcoe on Whites Creek consists of a thin band of manicured open space, or parks, with an urban community found along the shoreline at the south end. Beyond this, there are small patches of natural heritage features, but agricultural land uses occupy much of the area near the shoreline. According to a mapping study conducted by MNRF in 2014, 90% of the Lake Simcoe shoreline within the Talbot River subwatershed is currently developed; in the Whites Creek subwatershed, 53% of the shoreline is developed.



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
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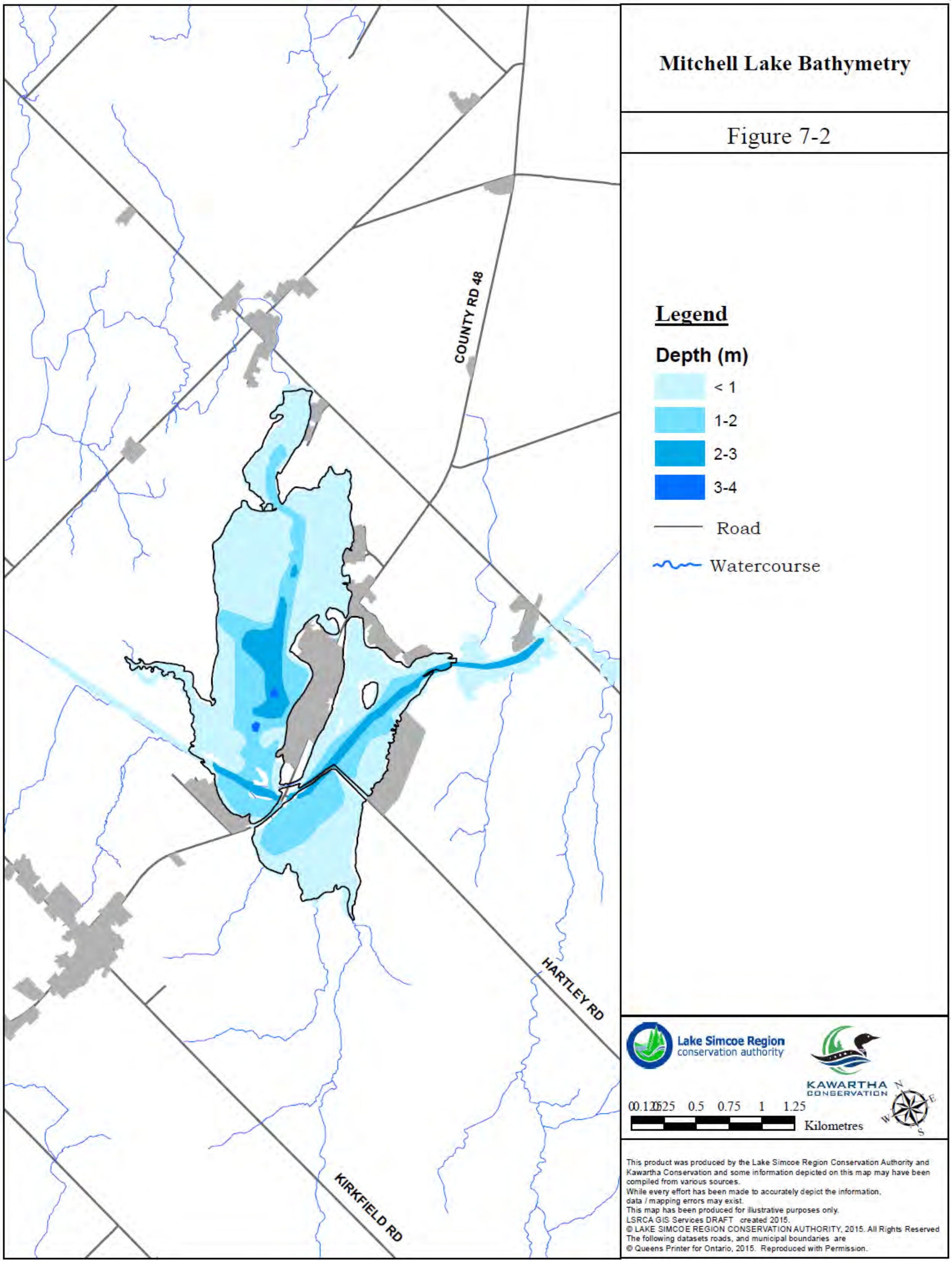
LSRCA GIS Services DRAFT created 2015.

Figure 7-1: Canal Lake bathymetry



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LSRCA GIS Services DRAFT created 2015.

Figure 7-2: Mitchell Lake bathymetry

7.1.1.3 Tourism and recreation

Tourism and recreation are significant activities on all three lakes. All are popular fishing destinations, with Canal and Mitchell Lakes offering warm water species such as largemouth bass, smallmouth bass, northern pike, muskellunge, and walleye, as well as smaller species such as pumpkinseed, yellow perch, and white sucker. Lake Simcoe offers a variety of both cold and warm water species due to its numerous habitat types. These include cold water species such as lake trout and whitefish, as well as smallmouth and largemouth bass, yellow perch, northern pike, and a number of species of panfish.

The lakes are also popular for boaters, particularly due to their location on the Trent Severn Waterway, which offers access to a number of different lakes. The presence of areas of dense aquatic plant growth in all of these lakes provides habitat for fish, but can become an impediment to boat travel as plant growth progresses later into the summer months. The use of non-motorized watercraft is also popular.

The shorelines of all three lakes are developed to a large extent with cottage properties. While many of these were built strictly as seasonal recreational properties, there has been a trend over the past number of years to convert these properties to year-round residences. This can place additional strain on the lakes by a number of means: under sized septic tanks not designed for year-round use can input extra nutrients; increased development of existing lots and/or expansion of cottages can be detrimental to natural heritage features; and more landscaping of lots, including the removal of natural vegetation, mowing grass to the water's edge, fertilizer use, etc. may be undertaken as the property becomes less of a 'cottage' and more of a 'home'.

Other popular activities include swimming at area beaches such as Centennial Park on Canal Lake; bird watching; and golfing.

7.2 Current Status

There has been extensive monitoring work undertaken on Lake Simcoe, Canal Lake, and Mitchell Lake by the LSRCA, Kawartha Conservation, and the MNRF's Kawartha Lakes Fisheries Assessment Unit. The LSRCA's work is undertaken through its Lake Simcoe Science Research and Monitoring Program. On Lake Simcoe, this includes surveys of the vegetation growing in the lake, sediment and water quality, and the benthic invertebrate community, with particular emphasis on the invasive zebra and quagga mussels. In Canal and Mitchell Lakes, monitoring work has included obtaining water quality samples, survey of the biomass and distribution of aquatic plants, and the collection and analysis of sediment cores which, as will be described below, contain microscopic organisms called diatoms that can be extremely descriptive of the change in condition of a lake over time. Kawartha Conservation and the LSRCA undertook a survey of the shoreline along both Canal and Mitchell Lakes, to see how much of the shoreline was in natural cover and how much had been altered, and to observe what those alterations were. Further, the Kawartha Lakes Fisheries Assessment Unit has undertaken fisheries and lake-habitat surveys on Canal Lake in 2002, 2008, and 2013 through Nearshore Community Index Netting and Broad-scale Monitoring programs, and aerial surveys of angler activity in 2009 and 2010.

7.2.1 Aquatic habitat

As mentioned above, the aquatic habitat of the three lakes has been monitored through a number of programs, and to varying degrees in each of the three lakes. This section will focus on the results of the nearshore monitoring program in Lake Simcoe, and the sediment core and diatom studies in Canal Lake and Mitchell Lake. These are described below.

Canal and Mitchell Lake Studies

As discussed above, work done in Canal and Mitchell Lakes related to aquatic habitat has included analysis of the plant biomass and distribution and sediment core samples, all of which was undertaken in 2013. This information is supplemented by the Kawartha Lakes Fisheries Assessment Unit, which has undertaken surveys in Canal Lake in 2002, 2008, and 2013; and in Mitchell Lake in 2009.

Lake Simcoe Studies

The nearshore zone for Lake Simcoe is from the shoreline to when the depth reaches 15-20 m. This is an important fish feeding, migration, and nursery area; and is also an area that has undergone significant environmental change, including the introduction of a number of invasive species (including zebra and quagga mussels, plants, and zooplankton), changes in the aquatic plant communities, and the impacts of shoreline development and hardening. Part of the mandate of the LSRCA Lake Science Research and Monitoring Program is to assess the environmental status of Lake Simcoe and track any ecological changes; the collected data is being used to set public policy, advise lake managers, and verify environmental guidelines. Included in this mandate are three areas of interest: aquatic plants, sediment phosphorus, and invasive species.

Overall, the goal of the LSRCA Lake Science Research and Monitoring Program is to monitor for environmental changes in Lake Simcoe, fill existing data gaps, target emerging environmental issues, and understand linkages between current ecological stressors. In terms of the aspects highlighted within this section, the use of biological indicators highlights a holistic ecosystem approach to lake management. This approach, using diatoms as a rapid assessment tool, evaluates the nutrient runoff to Lake Simcoe from individual tributaries and allows management strategies to be specifically applied. Monitoring of benthic invertebrate and fish communities not only allows the evaluation of ecosystem health in these habitats, but also their development as biological indicators for oxygen levels, contaminants, and nutrients. Nutrient flux from the land to the tributaries to Lake Simcoe is reflected in both the plant biomass and sediment phosphorus levels (higher nutrient supply from tributaries equals more phosphorus in sediments and more plant biomass). In addition, the work with zebra and quagga mussels not only provides monitoring of these invasive species but suggests how they are impacting Lake Simcoe (high amounts of zebra mussels equals high filtering of particles from the water column, allowing greater light penetration and in turn more plant biomass and more offshore nutrients pulled to shallow water habitats).

7.2.1.1 Sediment core studies

In response to a lack of long-term environmental monitoring data, paleolimnological methods have been used in many areas to accurately assess and track the timing of environmental changes. These studies can provide ecological context, including a history of pre-impact conditions, a measure of natural background variability, in addition to using biological indicators to infer the timing of changes and probable causes of disturbance. Therefore, sediment cores were used to reconstruct the environmental history of both Canal and Mitchell lakes from the time of flooding when the Trent-Severn Waterway was constructed to present day conditions. This study provides a historical context in which to better understand the current monitoring data, and can help to set mitigation and management targets.

Diatoms (Bacillariophyta) are widely-used environmental indicators for a variety of reasons: they are the dominant algal group in many aquatic systems, they have a well-described and broad range of environmental optima and tolerances, respond rapidly (less than 24 hours) to changing environmental conditions, and are well-preserved in most lake sediments. Therefore an analysis of diatom species present in both Canal and Mitchell Lakes was carried out to investigate changes in the lake ecosystems from initial flooding to present day conditions.

Canal Lake

The diatom species found at the bottom of the sediment core (which represents ~1904), are indicative of early lake formation, with pioneering species being present. These species are dominated by stalked or attached benthic species. The species then begin to transition to larger and more motile species. This change in species indicates a change in habitat availability and trophic regime in Canal Lake. Shading from macrophytes favours motile, or free-floating species of diatoms, which can move to better light conditions and habitat freely. An increase in macrophytes is also indicative of increased nutrients and a more productive lake; this also shows the effects of zebra mussel colonization in the early 1990s, with a nutrient-rich system dominated by macrophytes rather than algae. Changes in the species assemblage include an increase in both *Achnanthidium minutissimum* and *Cocconeis placentula*; these species are again more tolerant of shading, as well as disturbance. There is also an increase in *Fragilaria crotonensis* towards the very top of the core (representing the last 10-15 years). This taxon is known to be very nutrient tolerant, and is often cited as an indicator of nutrient enrichment in lake systems. This lake is beginning to show the effects of urban development and nutrient enrichment in the current diatom assemblage (Figure 7-3).

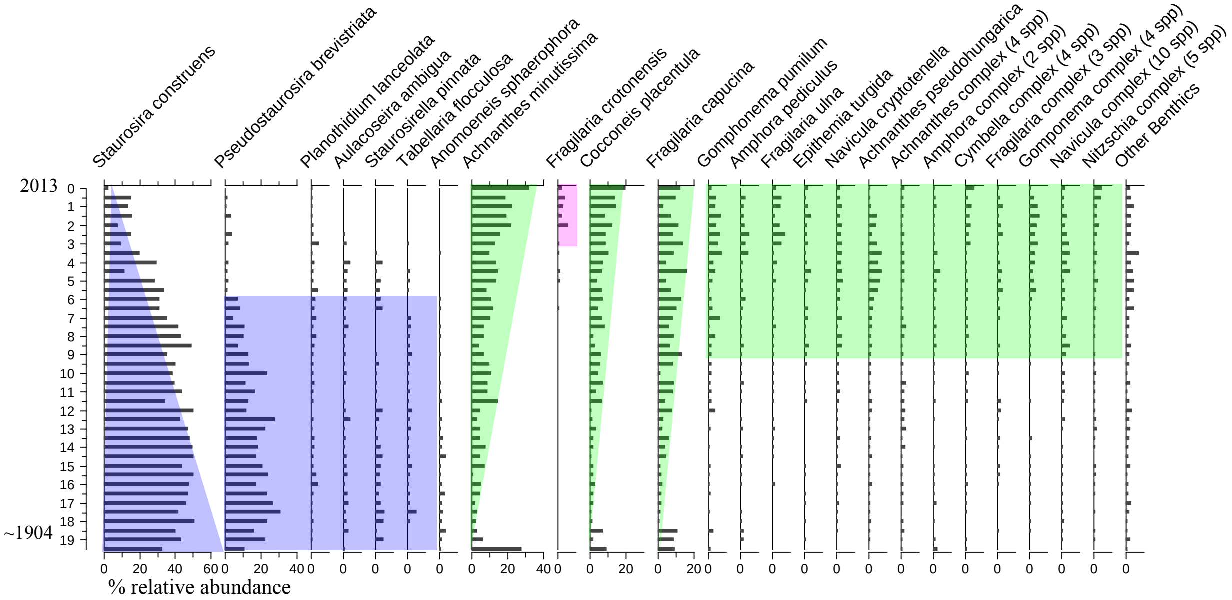

Figure 7-3: Canal Lake diatom assemblage, blue and green triangles/rectangles highlight changes in the assemblage with depth (cm), red rectangle indicates more nutrient tolerant taxa.

Mitchell Lake

As in Canal Lake, the diatom species present at the bottom of the core are indicative of early lake formation, with similar pioneering species. A similar change in species is also noted in Mitchell Lake, beginning around the 1960s. The shift from attached/stalked species to motile or free-floating species is consistent with that of Canal Lake, and again is indicative of a change in habitat quality or availability, such as an increase in shading from aquatic plants, increased nutrients, and the invasion of zebra mussels in the early 1990s.

Sediment core samples and diatom analysis have not been taken in Lake Simcoe near the outlet of the Talbot River and Whites Creek subwatersheds.

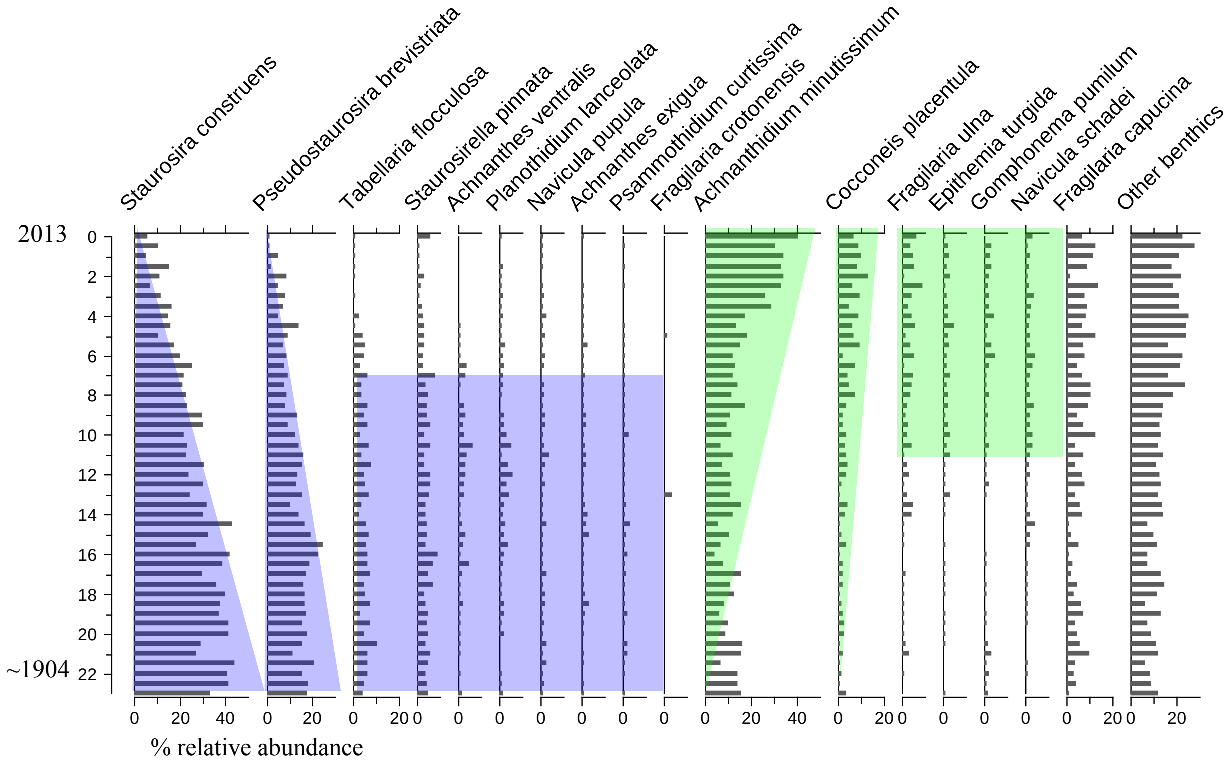

Figure 7-4: Mitchell Lake diatom assemblage, blue and green triangles/rectangles highlight changes in the assemblage with depth (cm)

7.2.1.2 Aquatic vegetation

Submerged aquatic plants are an important biological component of a lake ecosystem and have an important role in stabilizing sediments, buffering shorelines from wave action, and providing important habitat (living, feeding, and nursery space) for warmwater fish species such as perch, pike, bass, and sunfish. Aquatic plants also have an important role in cycling nutrients (particularly phosphorus) in the lake, uptaking as much as 97% of their phosphorus requirement from lake sediments and re-distributing it through the lake through plant decomposition and movement of plant material following plant die-back in autumn. Decomposition of this plant material provides an important food source for benthic invertebrates that are, in turn, food for recreationally important warmwater and coldwater fish species.

Despite these important roles of aquatic plants in the lake ecosystem, under conditions of increased nutrient inputs to a lake, particularly when combined with increased water clarity from filter-feeding invasive species such as zebra and quagga mussels (such as in Lake Simcoe), aquatic plants can achieve dense growths that are considered a nuisance by lake users, impairing recreational uses such as swimming, boating, and fishing, or forming unaesthetic wash-ups of dead / decomposing plant material on shorelines located downwind of areas with high growths of plants.

Aquatic vegetation can be indicative of various aspects of the health of a lake system, and changes in the composition and distribution of the aquatic plant community over time can tell us a great deal about changes that have occurred in the system.

Canal and Mitchell Lakes

While long-term monitoring of the aquatic plants in Canal and Mitchell Lakes has not been undertaken, a survey was conducted in support of this subwatershed plan in 2013. Surveys of the extent of aquatic plant growth were completed twice in each lake, once in June to capture the early season growth, and once in September, to observe the growth at its peak. The plant communities in the two lakes are quite different, with a relatively biodiverse community of native pondweeds found in Mitchell Lake, while Canal Lake is almost entirely dominated by the invasive Eurasian water milfoil (*Myriophyllum spicatum*) (Table 7-1).

As can be seen in Figure 7-5, the vegetation in Canal Lake is already rather extensive during the June survey, and has spread to much of the southern portion of the lake by September, with other areas also displaying high biomass. Over the course of the summer, the composition of aquatic vegetation within the lakes changes as well, with a general decrease in diversity and increase in the presence of a few dominant competitors (Table 7-1). The plant density is relatively lower in Mitchell Lake during the June survey, but is quite extensive during the September survey. Certain shoreline communities along Canal Lake and Mitchell Lake have expressed their concern that the abundance of aquatic vegetation impedes their use of the lakes. Both native and invasive plants contribute to this abundance, which is a result, in large part, to the presence of favourable growing conditions (e.g., shallow water, clear water, productive substrates, low-energy environments, etc.). The expansion of aquatic vegetation, in particular wild rice and Eurasian watermilfoil, within the last decade has changed the character of certain sections of the lakes, which is of concern to several waterfront communities. These issues can affect the enjoyment of a property as well as long term property values; however, large tracts of aquatic plants are beneficial to the aquatic ecosystem and certain communities, such as local First Nations, who value wild rice for cultural purposes and who have traditional rights for harvesting it. Active harvesting of wild rice occurs on Mitchell Lake.

Table 7-1: Aquatic plants found in Canal and Mitchell Lakes (summer 2015), expressed as percent of total biomass

Scientific name	Common name	Mitchell Lake		Canal Lake	
		June	September	June	September
Ceratophyllum demersum	Coontail	7.9	27.7	0.9	12.5
Chara spp.	An alga				2.2
Elodea	Canada	16.2	2.3	3.4	2.3

Scientific name	**Common name**	**Mitchell Lake**		**Canal Lake**	
		June	**September**	**June**	**September**
canadensis	waterweed				
Elodea nutallii	Western elodea			0.5	
Lemna trisulca	Star duckweed			0.5	0.2
Myriophyllum sibiricum / verticillatum	Water milfoil			0.2	
Myriophyllum spicatum	Eurasian water milfoil		1.1	93.4	70.8
Najas flexilis	Slender naiad	0.5	14.5	0.01	0.1
Nitella spp.	An alga				1.6
Potamogeton amplifolius	Large-leaved pondweed	22.0			0.1
Potamogeton pusillus	Small pondweed	10.4		0.6	
Potamogeton richardsonii	Richardson's pondweed	28.5		0.2	
Potamogeton strictifolius	Straight-leaved pondweed	1.0		0.3	0.2
Potamogeton zosteriformis	Flat-stem pondweed	9.4	9.5		7.0
Spartina pectinata	Prairie cordgrass	1.1			
Vallisneria americana	Tape grass	2.8	39.6		3.1
Zizania palustris	Wild rice		5.3[1]		

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[1] Wild rice occurs more extensively in Mitchell Lake, but was selectively under sampled, in order to minimize economic impacts on harvesters

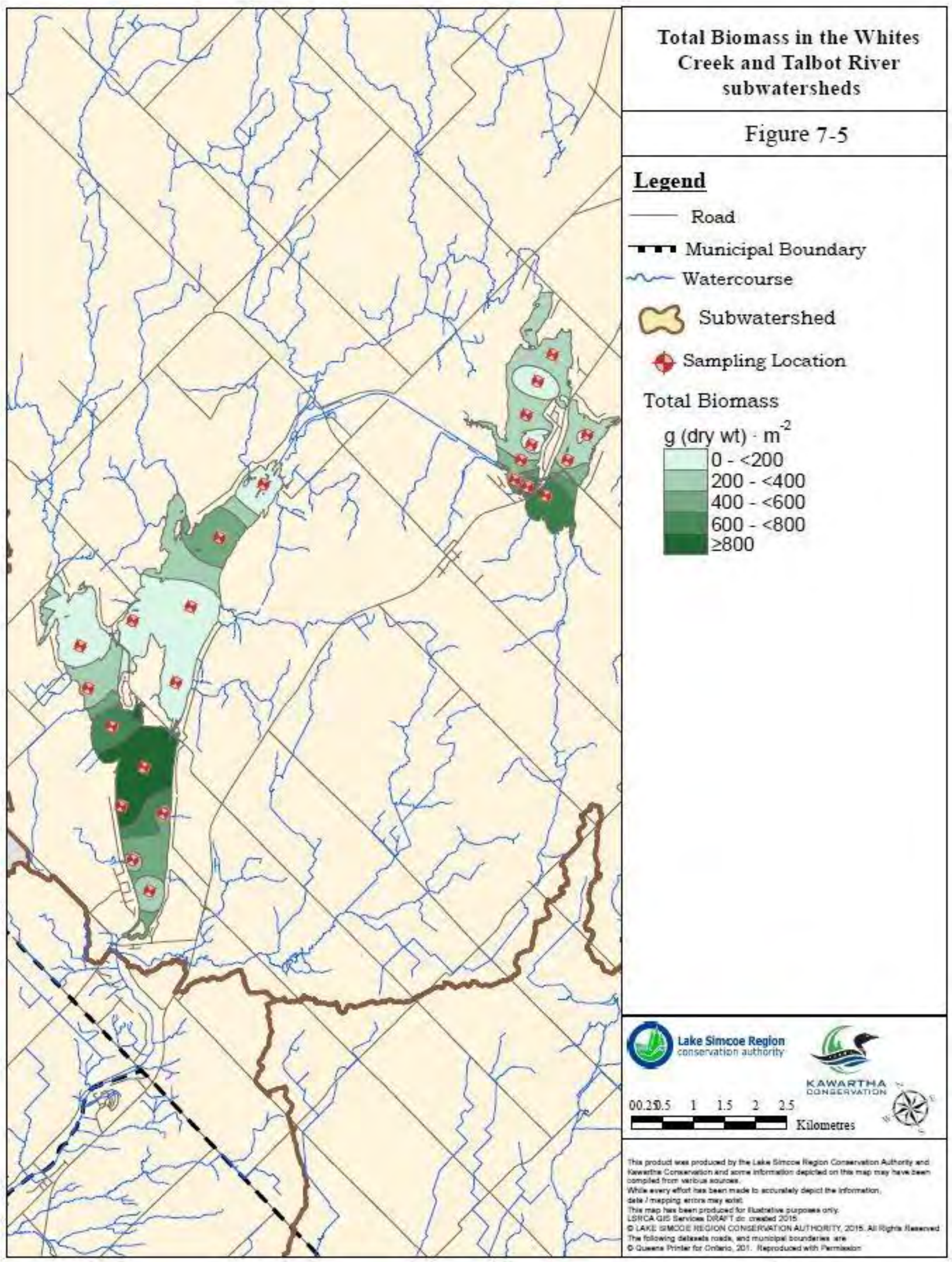


Figure 7-5: Aquatic plant biomass in Canal and Mitchell Lakes

Lake Simcoe

The LSRCA has carried out two comprehensive, lake-wide, surveys of the Lake Simcoe aquatic plant community in 2008 and 2013. In 2008, a total of 16 species were recorded. In 2013, 22 species were recorded. Three submerged aquatic plant species in Lake Simcoe are invasive: Eurasian watermilfoil (*Myriophyllum spicatum*), first reported in 1984; curly-leafed pondweed (*Potamogeton crispus*), also reported in 1984, and starry stonewort (*Nitellopsis obtusa*), first recorded in 2009.

Based on the analyses, there were five areas of high aquatic plant growth in Lake Simcoe, one of which is located between the discharge of the study area subwatersheds and Thorah Island (Figure 7-6). Excess nutrient runoff into Lake Simcoe, soft substrates, the shelter from the wind provided by the island, and the high light transparency of the water provide optimal conditions for plant growth. If the aquatic plant community changes in this area correspond to those in Cook's Bay, then the biomass of aquatic plants has increased three-fold since the 1980s as well. This is likely due to zebra mussels (*Dreissena polymorpha*) clearing the water and creating ideal habitat for plant growth.

The biomass of aquatic plants in Lake Simcoe near the Whites Creek and Talbot River is similar to levels found in Canal and Mitchell Lake, where plant abundance is relatively high (≥80 g/m^2) (Figure 7-6). This area is one of the five zones of high aquatic plant growth observed in Lake Simcoe in 2013. These areas of high plant growth are related to four, closely related, environmental factors: (1) water depth and clarity, the maximum depth of plant growth is 10 m and has increased from 6.5 m before invasion by zebra and quagga mussels; (2) presence of soft (mud and silt, or sand) lake bottom that provides stable attachment for rooted plants and have higher nutrient (phosphorus) concentrations; (3) higher phosphorus concentrations in water and sediment that provide nutrients for plant growth; and (4) proximity to larger subwatersheds that provide higher amounts of phosphorus to Lake Simcoe.

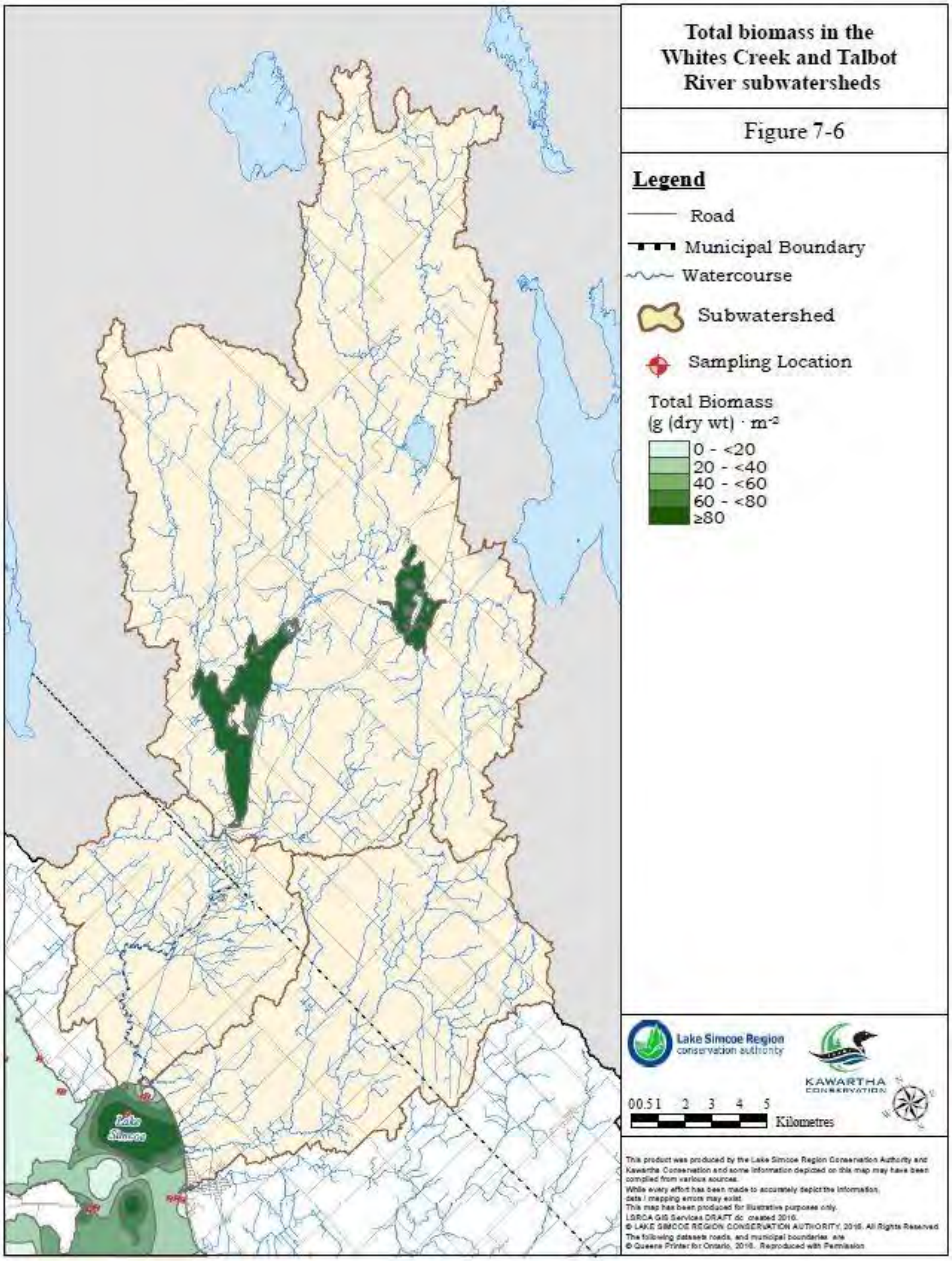


Figure 7-6: Aquatic plant biomass in Lake Simcoe, offshore of the Whites Creek and Talbot River subwatersheds compared to Canal and Mitchell Lakes (data from 2013)

7.2.1.3 Fish communities

Formal assessments of fish communities within Canal Lake have been conducted on three occasions (2002, 2008, and 2013) by the Ontario Ministry of Natural Resources and Forestry. There are no whole-lake fish community data available for Mitchell Lake at the time of this report. The Kawartha Lakes Fisheries Assessment Unit (KLFAU) is the lead department of the OMNRF that is responsible for fisheries science within Canal Lake, as well as Mitchell Lake and the Kawartha Lakes. On Canal Lake, assessments were conducted in 2002 following Nearshore Community Index Netting (NSCIN) protocol, and 2008 and 2013 following Broad-scale Monitoring (BsM) protocol. NSCIN is a provincial standard trap netting program designed to assess fish species that inhabit the nearshore zone of the lake in the late summer and early fall (i.e. the so-called warmwater and coolwater fish communities of temperate lakes). The BsM is a provincial standard gill netting program conducted when surface water is over 18^{o}C, a time when fish are distributed across the lake habitat.

Canal Lake’s fish community composition reflects its cool/warmwater thermal regime and mesotrophic nutrient status. Approximately 16 fish species have been formally documented within Canal Lake from OMNRF 2002-2013 netting programs (Table 7-2). Due to sampling gear selectivity the species list in Canal Lake is dominated by large-bodied fishes, many of which are important top predators (e.g., Muskellunge, Walleye, Largemouth Bass, etc.) that contribute to the recreational fishery. Canal Lake’s fish species are similar to those found in other Kawartha Lakes due to similar habitats (e.g., relatively shallow, warm/cool waters) and the interconnectedness of lakes along the Trent-Severn Waterway system. Little is known about the status of smaller-bodied species within Canal Lake; however records from other Kawartha Lakes and their tributaries indicate the potential for a diverse community.

According to most recent netting data (BsM 2013), yellow perch are most abundant (6.99 fish/net) and contribute to 40% of the relative abundance of all fish caught (Figure 7-7). Yellow perch, combined with golden shiner, bluegill, pumpkinseed, and brown bullhead contribute to over 85% of the relative abundance of all fish caught. The remaining fishes captured comprising 15% of the relative abundance include: largemouth bass, northern pike, black crappie, rock bass, Lepomis sp., white sucker, walleye, bowfin, and smallmouth bass.

Comparing 2013 BsM data to 2008 BsM reveal potential changes in fish community composition, although the top five abundant species do remain the same (Figure 7-7). In 2013, the relative abundance of all fish captured was 17.5 fish per net, a value higher than in 2008 by approximately 30%. Increases in relative abundance of various fishes were observed and was most pronounced in black crappie, golden shiner, and bluegill. Decreases were recorded by almost 50% for white sucker, and no muskellunge and yellow bullhead were caught. Due to the limited number of years of data (i.e., only two), these trend observations should be interpreted with caution because these values may simply reflect natural annual population variations within the lake. However, population increases for several panfish species (including bluegill and black crappie) have been documented over a similar time period in several lakes within Kawartha Lakes including neighbouring Balsam Lake (Kawartha Conservation, 2015), which seems to corroborate these data for Canal Lake. Similarly, the trend for muskellunge may reflect population decline due to the relatively recent colonization of northern pike, a non-native fish that has the potential to outcompete native muskellunge. Northern pike were first confirmed in Canal Lake in the 1980's, and have since expanded their range into Balsam Lake (OMNR, 2008).

Recreational angling activity is significant on Canal Lake and is comparable to other Kawartha Lakes. Estimations of angler activity on Canal Lake have been assessed by OMNRF in summer 2009 and winter 2010 through aerial observations of vessel activity (Figure 7-8). Although these are limited data, it indicates that vessel activity on Canal Lake in the summer, as expressed as a density (number per square kilometre) is equivalent to the average summer activity on any given lake within the entire Fisheries Management Plan Zone 17 (FMZ 17; includes all Kawartha region lakes) and is slightly higher than lakes in the FMZ 17 region of similar (i.e., small) size. Winter angling activity is approximately 35-45% less than the average activity within all FMZ 17 lakes and lakes within FMZ 17 of similar size.

Table 7-2: Fish species found in Canal Lake based on recent observations from MNRF (Nearshore Community Index Netting (NSCIN), and Broad-scale Monitoring (BSM)).

Common Name	Scientific Name	NSCIN 2002	BsM 2008	BsM 2013
Black Crappie	*Pomoxis nigromaculatus*	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X
Bowfin	*Amia calva*			X
Brown Bullhead	*Ameiurus nebulosus*	X	X	X
Emerald Shiner	*Notropis atherinoides*			X
Golden Shiner	*Notemigonus crysoleucas*		X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X
Muskellunge	*Esox masquinongy*		X	
Northern Pike	*Esox lucius*	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X
Rock Bass	*Ambloplites rupestris*	X	X	X
Smallmouth Bass	*Micropterus dolomieu*	X	X	X
Walleye	*Sander vitreus*	X	X	X
White Sucker	*Catostomus commersoni*	X	X	X
Yellow Bullhead	*Ameiurus natalis*	X	X	
Yellow Perch	*Perca flavescens*	X	X	X
TOTAL (16)		**12**	**14**	**14**

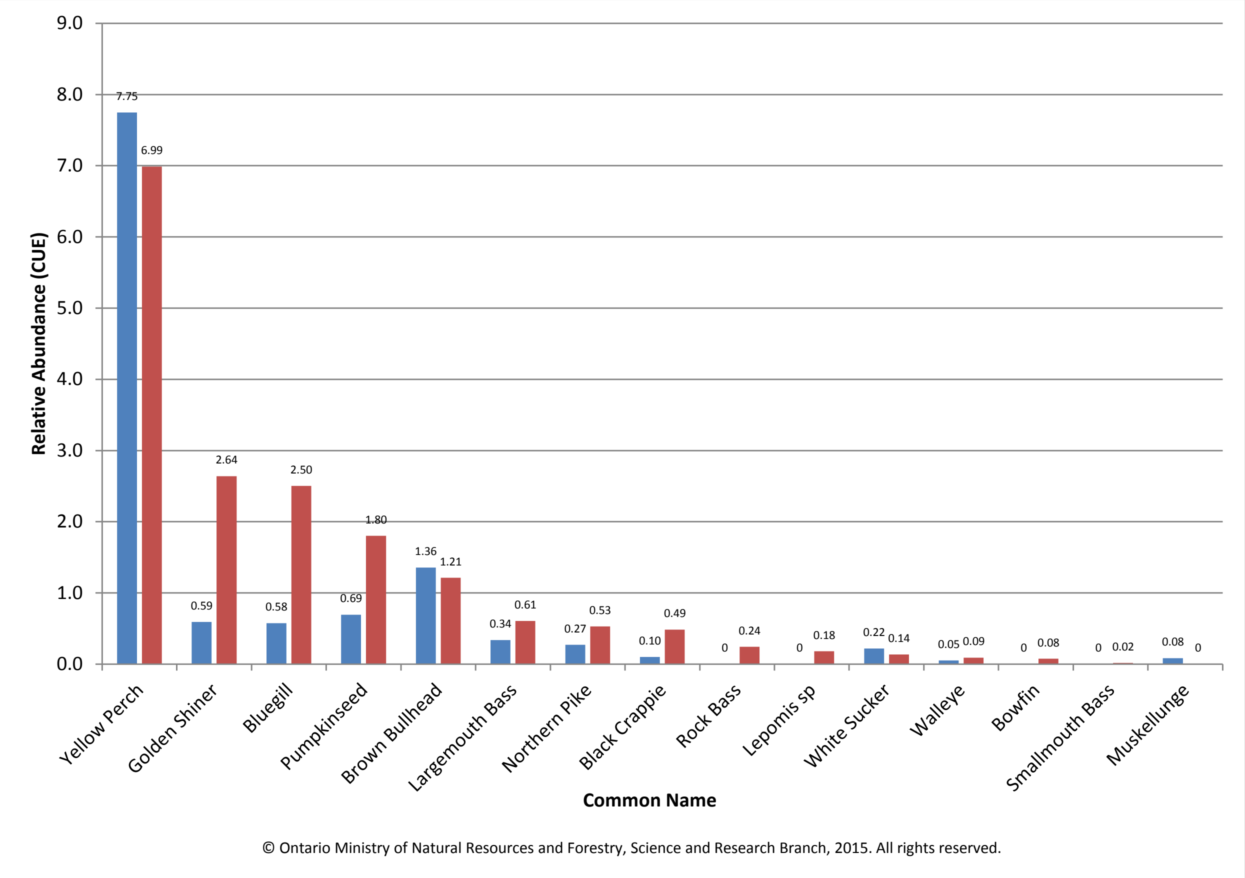


Figure 7-7: **Area weighted Relative Abundance (CUE) of species caught in large mesh gill nets during the Canal Lake Broad Scale Monitoring Survey, 2008 (blue bars) and 2013 (red bars)**

Note: Surveys conducted by the Ontario Ministry of Natural Resources and Forestry, Science and Research Branch. The survey is conducted when surface water is over 18oC, a time when fish are distributed across the lake habitat.

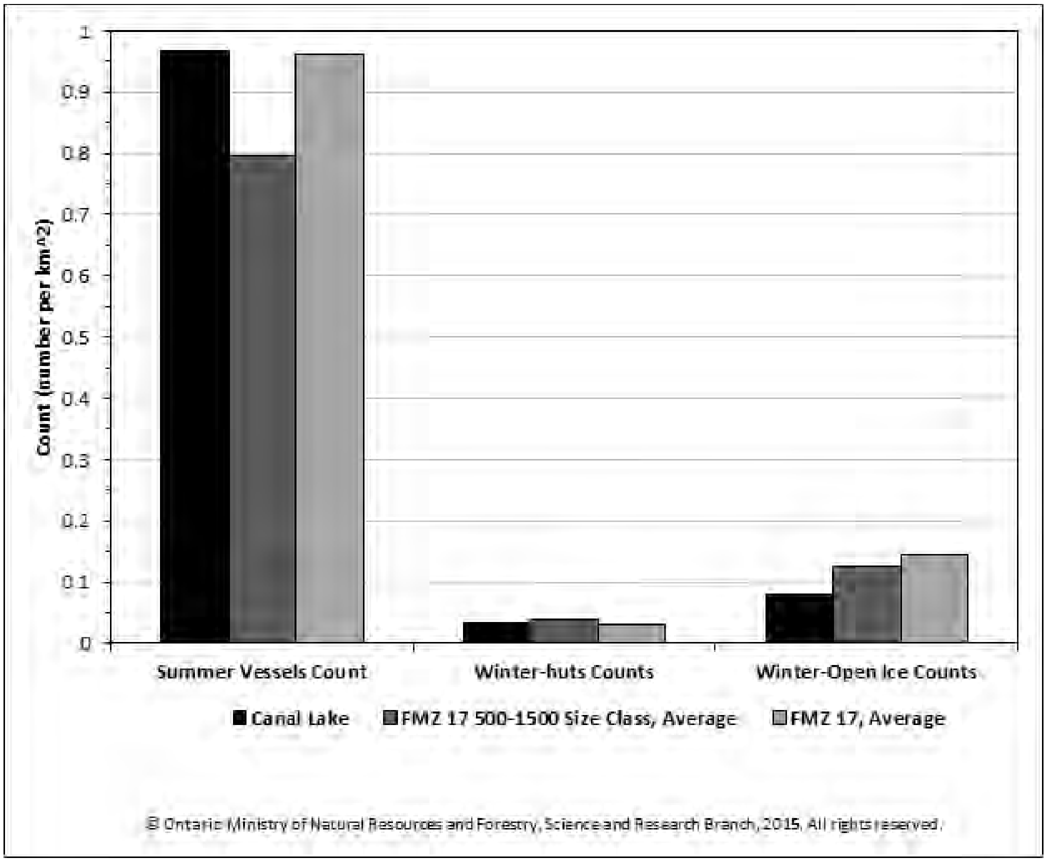


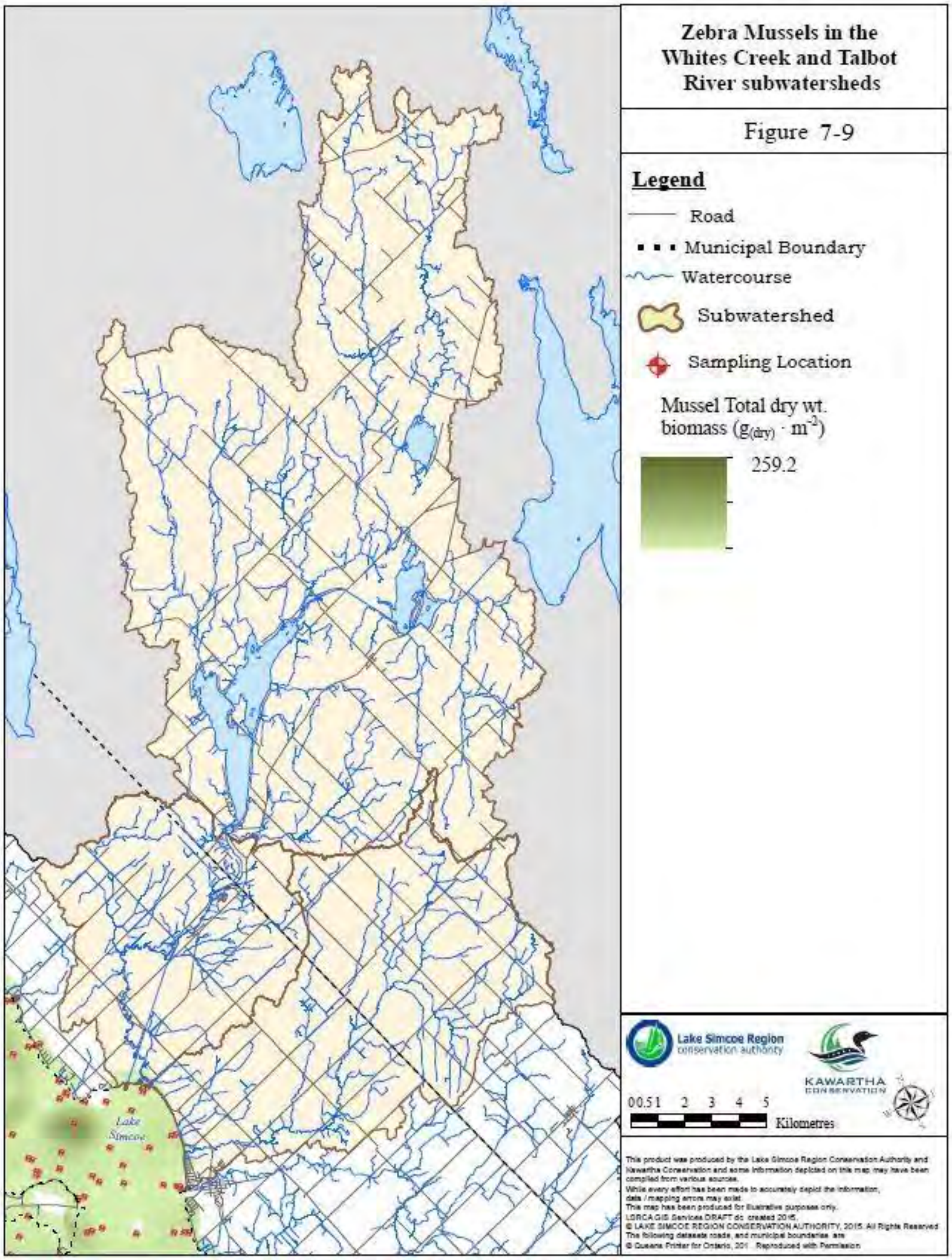
Figure 7-8: Angler activity assessed through aerial counts during Ontario's Broad Scale Fish Community Monitoring Program (Ontario Ministry of Natural Resources and Forestry, Science and Research Branch) for Canal Lake as compared to FMZ 17.

Note: Counts are estimates per Km2 and were assessed in the summer of 2009 (summer vessel count) and winter of 2010 (winter-hut counts and winter-open ice counts).

7.2.1.4 Benthic invertebrate community health

The LSRCA Lake Science Research and Monitoring Program also monitors invasive species with the goals of assessing the impact on native biological communities, tracking changes through time, and identifying new risks (a complete list of invasive species within the tributaries and within Lake Simcoe can be found in the Stressors section of this chapter). While some exotic species are studied under other projects (e.g. Eurasian milfoil and curly-leaf pondweed with aquatic plant monitoring, spiny waterflea with our zooplankton projects), a targeted survey was carried out in 2009-10 to supplement the annual benthic invertebrate monitoring and determine the extent of dreissenid mussel (zebra mussel, *Dreissena polymorpha*; quagga mussel, *Dreissena rostriformis bugensis*) impact on Lake Simcoe. Since their initial invasions in 1995 (zebra mussel) and 2004 (quagga mussel), these two species have colonized a large portion of the lake area and have caused significant ecological changes, in particular to native food webs, shifted energy flow from shallow to deep water, and increased the penetration of sunlight into the water column. The changes have resulted in a hardening of the substrate in shallow water due to mussel shells, a decline in native bivalve species (16 species were recorded in 1926-9, four species are recorded at present – the two invasive mussels and extremely low numbers of two native species which are on the threshold of extirpation in Lake Simcoe), an increase in plant biomass due to deeper light penetration into the water column and a larger area now available for plant colonization. In general, these mussels are limited to sandy or hard substrates in Lake Simcoe, and limited to depths shallower than 20 m (Figure 7-9).

Benthic invertebrate community surveys have not yet been undertaken in Canal or Mitchell Lakes.



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
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Figure 7-9: Zebra mussels in the Whites Creek and Talbot River subwatersheds

7.2.1.5 Rare and endangered species

American eel (*Anguilla rostrata*; Endangered) has been documented by the MNRF in Lake Simcoe. This catadromous species spawns in the Atlantic Ocean, and spends the rest of its life cycle in fresh water. While not documented in Canal or Mitchell Lakes, it is thought to have accessed Lake Simcoe via the Trent Severn Waterway.

7.2.2 Water and sediment quality

7.2.2.1 Water quality

Kawartha Conservation has been taking water quality samples in both lakes as well as in the tributaries flowing into and out of Canal and Mitchell Lakes since 2013. As in much of the rest of the Lake Simcoe watershed, nutrients are the main parameters of concern, particularly phosphorus.

The tributaries of the lakes are relatively healthy, with few exceedances of water quality guidelines. The average total phosphorous concentrations are below the Provincial Water Quality Objective (PWQO) for streams (0.030 mg/L), although there are a few samples where concentrations are above the PWQO. The tributaries were sampled a combined 304 times over the three year period and demonstrated exceedances in only 14 of those samples. These results are discussed in more detail in Chapter 4 – Water Quality.

The Grass Creek tributary of Mitchell Lake does not show any exceedances of the PWQO for streams, which is 0.03 mg/L, during the sampling period. The average concentration was just over 0.01 mg/L. The Talbot River flowing into Canal Lake at McGuire Beach Road (referred to as the Upper Talbot River site) showed a number of exceedances of the PWQO, particularly during the spring, although the average concentration was approximately half the PWQO, at 0.016 mg/L. The maximum concentration at this site was 0.04 mg/L, more than 30% greater than the PWQO. The northern tributary draining into Canal Lake at Centennial Park Road had somewhat better concentrations of phosphorus, with only two samples exceeding the PWQO and an average concentration of 0.014 mg/L. In this sample there were, however, several samples that exceeded the phosphorus PWQO for lakes of 0.02 mg/L, which could affect the health of the lake ecosystem. The Lower Talbot River, at the Canal Lake outlet also displayed exceedances of both the river and lake PWQOs, and had an average concentration of 0.013 mg/L over the sampling period. Average concentrations in the tributaries for each sampling year are shown in Figure 7-10).

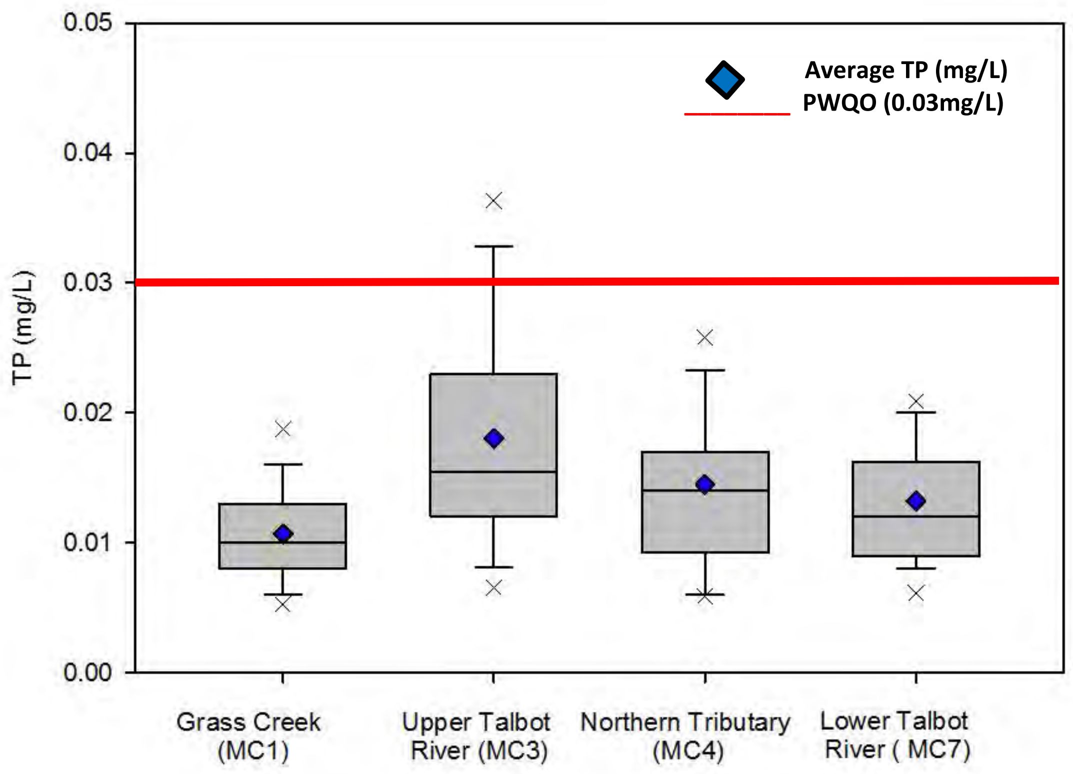


Figure 7-10: Average total phosphorus concentrations in Canal and Mitchell Lake tributaries (2013-2015)

In the lakes themselves, the average for total phosphorus falls below the Provincial Water Quality Objective of 20 µg/L at all stations (denoted by the blue diamonds in Figure 7-11). The 75th percentile of the data does exceed the PWQO at the Mitchell Lake outlet, the 95th percentile exceeds at all samples except for the Canal Lake outlet. This indicates that while, overall, concentrations meet the objectives, there are a number of instances throughout these lakes where concentrations exceed recommended concentrations; this is likely contributing to some of the issues that have been identified in the lakes, such as the excessive growth of aquatic plants.

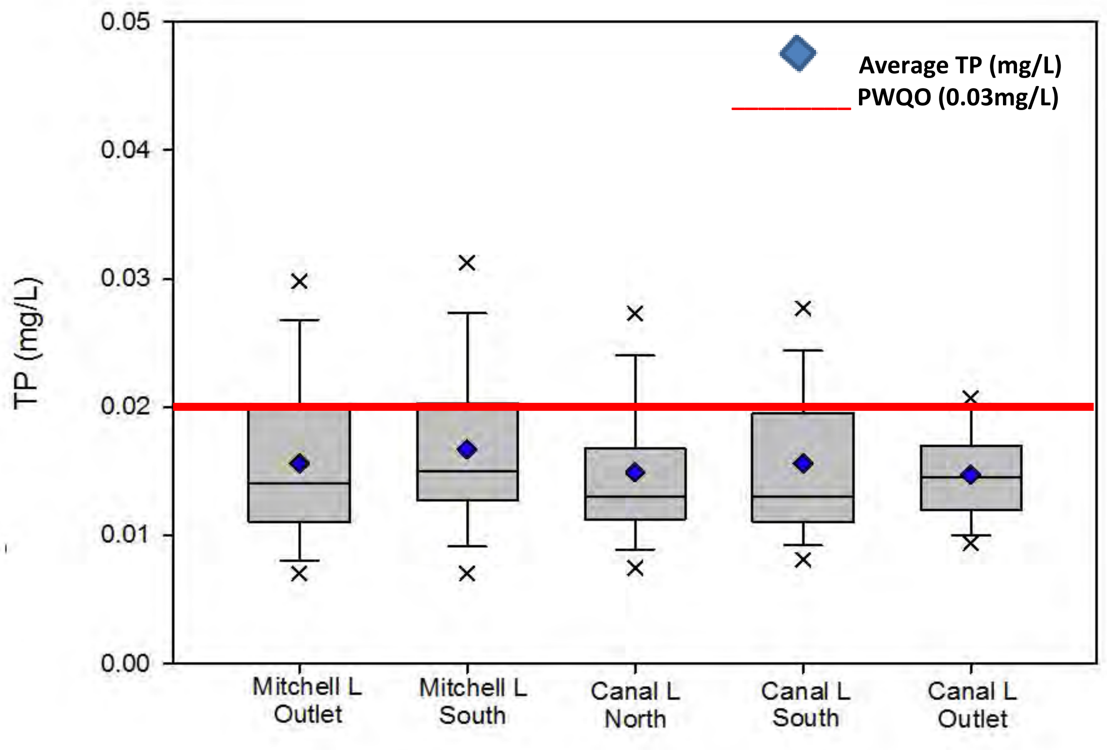


Figure 7-11: Total phosphorus (TP) concentrations in Canal and Mitchell Lakes, 2013-2014

Water quality has been sampled at one site in Lake Simcoe near the outlets of the Whites Creek and Talbot River subwatersheds at station WO-2. The phosphorus concentrations at this site generally fall within provincial guidelines, with only one sample for the period of 2009-2014 reaching the PWQO (0.02 mg/L); the average concentration at this station falls well below the PWQO, at 0.0087 mg/L.

7.2.2.2 Sediment Quality

The chemistry of the sediments of Lake Simcoe is also tested through the Nearshore Monitoring Program. This is, in large part, due to the high amount of phosphorus that may be present in the lake's sediments, and that this phosphorus may be released under certain conditions in the lake.

The area near the outlet of the Talbot River has one of the highest sediment phosphorus concentrations in the entire lake, at 1400 µg/g (Figure 7-12). This high level is likely due to the export of nutrient-rich waters and the deposition of plant materials from further upstream in the Trent Severn Waterway, as they senesce, break loose, and flow downstream in the fall.

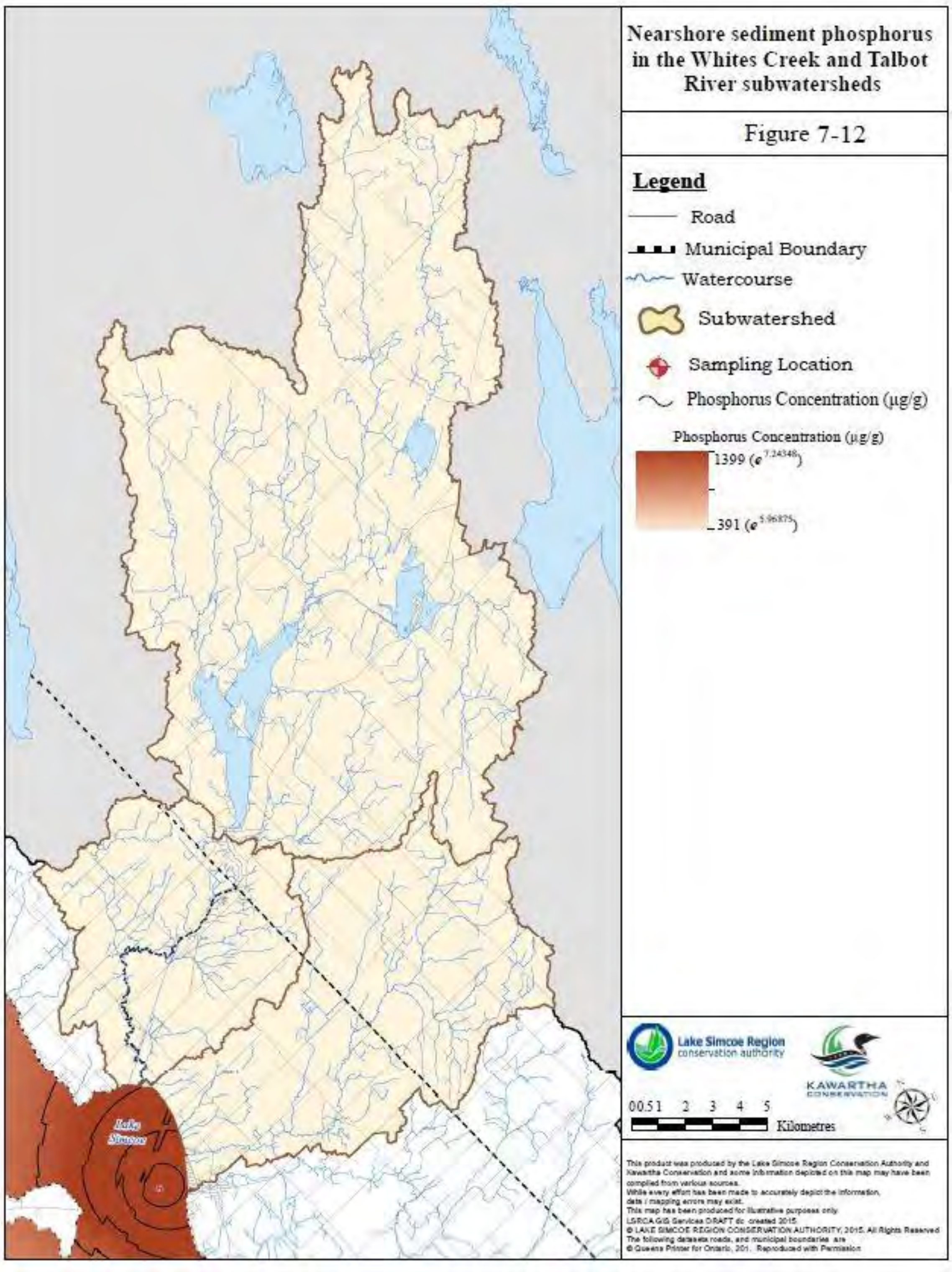


Figure 7-12: Nearshore sediment phosphorus concentrations in the Whites Creek and Talbot River subwatersheds

7.2.2.3 Beach water quality

There are two public beaches located in the study area’s lakes; Mitchell Lake Beach on Mitchell Lake, and Centennial Park, on Canal Lake. The Haliburton, Kawartha, Pine Ridge (HKPR) District Health Unit monitors bacteriological contamination at Centennial Park beach west, located on Centennial Park Rd., on the North shore of Canal Lake. The Mitchell Lake beach is not monitored by the HKPR. In order to ensure that the lake beaches are safe for swimming, Health Unit inspectors collect water samples for *Escherichia coli* analysis every week from the beginning of June until the end of August.

Escherichia coli (E.coli) is a bacterium found in the intestines of birds and mammals and is excreted in their feces. The *E.coli* presence in water indicates fecal contamination and presence of pathogens that can be harmful to humans. Sources include faulty septic systems, agricultural and urban stormwater runoff, dog and wildlife waste, waterfowl. The PWQO for *E. coli* is 100 cfu/100 mL, which is geometric mean of a minimum 5 samples.

The HKPR *E. coli* data from 2011-2015 indicates that Centennial Park beach west has good bacteriological water quality, having been posted for exceedences over the PWQO of 100 cfu/100ml only four times in the past five years, which represents 8% of the samples taken over that period (Table 7-3; Figure 7-13).

Table 7-3: Haliburton, Kawartha, Pine Ridge District Health Unit beach monitoring data for Centennial Park Beach (2011-2015)

Beach	**Lake or River**	**2011**		**2012**		**2013**		**2014**		**2015**	
		Geomean, cfu/100mL	Exceedances, %	Geomean, cfu/100mL	Exceedances, %	Geomean, cfu/100mL	Exceedances, %	Geomean, cfu/100mL	Exceedances, %	Geomean, cfu/100mL	Exceedances, %
Centennial Park beach west	Canal Lake	20	8	26	8	19	0	19.5	8	30	18

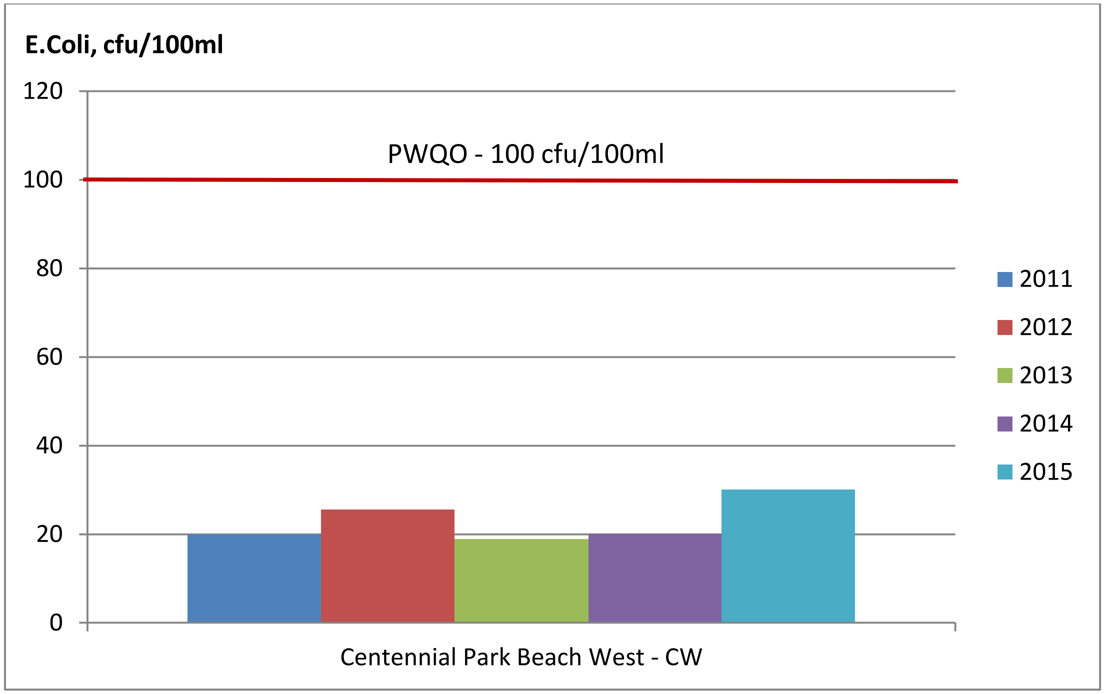


Figure 7-13: Annual Geometric Mean *E.coli* Concentrations at Centennial Park Beach West

7.2.3 Hydrology

Mitchell Lake and Canal Lake form part of Trent-Severn Waterway (TSW) system. The TSW provides a navigable route that connects Lake Huron and Lake Ontario, crossing natural watersheds boundaries on its way. The summit in Kirkfield is a dividing point between water flowing west to Georgian Bay and east toward Lake Ontario. In late 1990s Mitchell Lake, which is part of the Lake Huron watershed (Upper Talbot River subwatershed) was connected to Balsam Lake, the uppermost lake of the Kawartha Lakes system that forms Lake Ontario watershed (Trent River subwatershed) by means of the man-made Trent Canal. A series of dams, locks, and canal cuts were built in this section of the Waterway in order overcome the difference in elevation and create a navigable route (Parks Canada, 2013). The Kirkfield hydraulic lock, the second tallest lock of this kind in the world, is situated on the Trent Canal.

According to the TSW water level management strategy, the water levels in Balsam and Mitchell Lakes are kept at the same level during the summer and fall, therefore minimal outflow occurs from the Kawartha Lakes watershed to the Lake Simcoe watershed. In the fall and winter seasons, a guard gate (type of temporary dam) is installed in the canal, which gives the opportunity to keep the lakes at different levels, as required by the overall TSW water management strategy. Some flow, in the range of 0-5 m^3/sec is released, depending on the difference in water levels. These flows are maintained through the vaults at the guard gate in order to sustain a sufficient amount of oxygen in Mitchell Lake to support the aquatic community (Dave Ness, pers. comm.). Figures 7-14 and 7-15 show the seasonal variation in water levels for Canal and Mitchell Lakes.

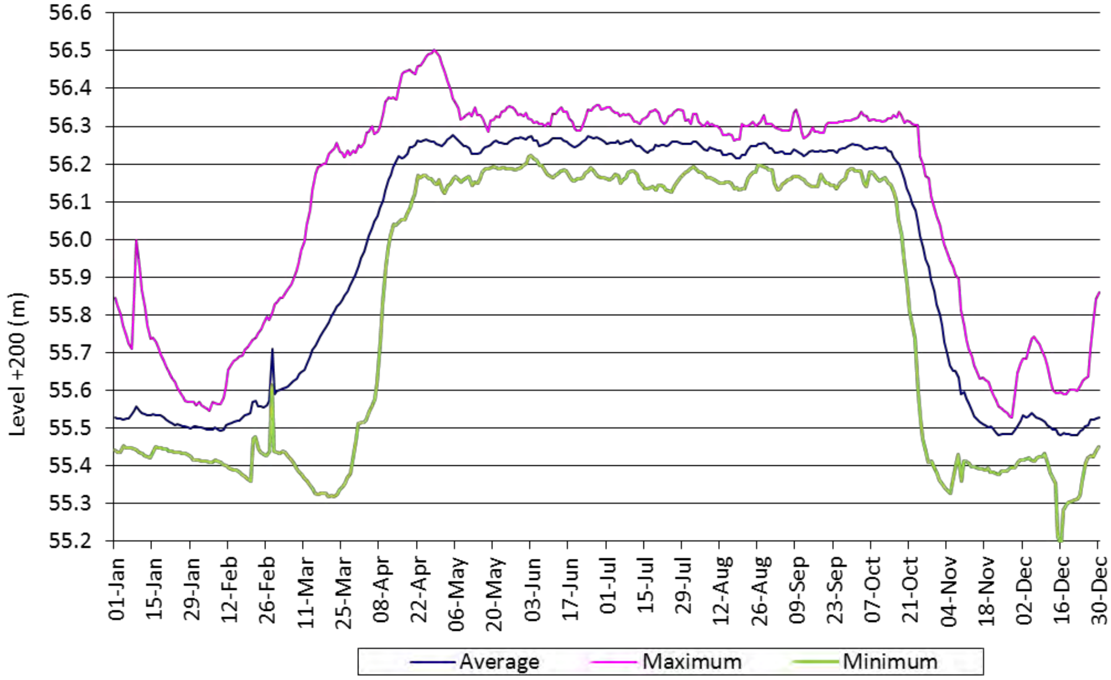


Figure 7-14: Average water levels in Mitchell Lake (2004 – 2015)

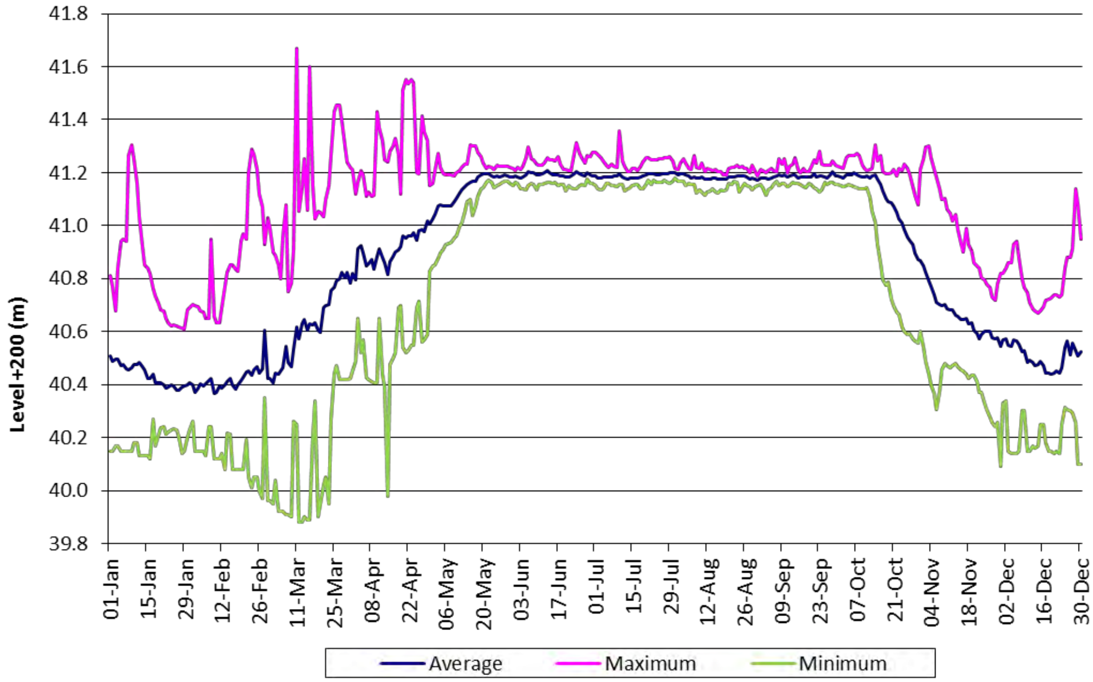


Figure 7-15: Average water levels in Canal Lake (1973 – 2015)

Key Points - Current Lake Health Status:

- Canal Lake and Mitchell Lakes drain west into the Talbot River, and were created through flooding at the beginning of the 20th century to navigate the Balsam Lake to Lake Simcoe section of the Trent-Severn Waterway. Both lakes are relatively shallow and productive, with Canal Lake having a mean depth of 3 metres (maximum depth of 4 metres), and Mitchell Lake having a mean depth of 1.4 metres (maximum depth of 1.8 metres).
- The watershed area of both lakes is 29,455 ha, and is mostly comprised of natural heritage features (85%). Agriculture accounts for 12% of the land use, and remaining lands consist of a mixture of urban areas, roads, aggregate operations, and golf courses.
- The shoreline of Canal Lake is approximately 40 kilometres in length, and Mitchell Lake is approximately 23 km. Most of the shorelines of both lakes remains in a natural state. In Canal Lake, 24% of the shoreline is considered in a developed state, and 16% is developed along Mitchell Lake shoreline. Cottage properties dominate, but there has been a recent trend towards year-round conversion. Dominant artificial features include docks, flagstone, concrete, riprap, steel, gabion baskets, and manicured lawns up to the water's edge.
- Sediment cores were used to reconstruct the environmental history of both Canal and Mitchell lakes from the time of flooding when the Trent-Severn Waterway was constructed to present day conditions. This also shows the effects of zebra mussel colonization in the early 1990s, with a nutrient-rich system dominated by macrophytes rather than algae.
- Current fish community data is only available for Canal Lake. This data indicates a diverse warm/cool water fish community containing several important game fishes. According to the most recent netting data, yellow perch along with golden shiner, bluegill, pumpkinseed, and brown bullhead contribute to over 85% of the relative abundance of all fish caught. The remaining fishes captured comprising 15% of the relative abundance include: largemouth bass, northern pike, black crappie, rock bass, Lepomis sp., white sucker, walleye, bowfin, and smallmouth bass.
- Water quality within both lakes, as indicated by nutrient concentrations, is relatively good. Average phosphorus concentrations meet the Provincial Water Quality Objective of 0.02 mg/L at all stations, and Mitchell Lake has higher phosphorus concentrations than Canal Lake. Water quality at Centennial Park Beach on Canal Lake is quite good, as the beach has only been posted as "unsafe for swimming" four times within the past 5 years due to high *E.coli* concentrations.
- In Lake Simcoe, the area near the outlet of the Talbot River has one of the highest sediment phosphorus concentrations in the entire lake, at 1400 µg/g.

7.3 Factors impacting status – stressors

Stressors to the health of the Canal Lake, Mitchell Lake, and Lake Simcoe ecosystems include:

- Nutrient inputs
- Shoreline alterations and development
- Land use change
- Tourism and recreation
- Invasive species
- Climate change

7.3.1 Nutrient inputs

Inputs of nutrients, such as phosphorus and nitrogen are common stressors on lakes in Southern Ontario. Phosphorus is of particular concern in the study area lakes, where high concentrations, combined with the increased water clarity caused by zebra and quagga mussels, have contributed to the excessive growth of plants, and the expansion of the area that these plants are able to grow. This growth has impacts on the aquatic ecosystem, particularly in Lake Simcoe, where the decomposition of this plant material depletes the dissolved oxygen concentrations in the deeper areas of the lake, and has significant effects on the cold water fish population. Lake residents and visitors are also affected, as they can be unable to undertake activities such as swimming, boating, and fishing due to the plant growth. Navigation through the Trent Severn Waterway, including through Canal and Mitchell Lakes, has become more difficult due to the plants, an issue that has been exacerbated since the introduction of zebra mussels into the system in the mid-1990s.

As is discussed in **Chapter 3 - Water Quality**, there are a number of sources of phosphorus in the study area. These can include sources near the lake, such as poorly functioning septic systems in cottages and residences near the shoreline, inputs from agricultural areas, and runoff from urban areas. For example, through shoreline surveys undertaken for the development of this plan, staff noted areas of agriculture on Canal Lake where livestock had direct access to the lake, which could be a significant source of nutrients. In addition, because the study area falls within the Trent Severn Waterway, it can be influenced by land uses well upstream of the study area. Balsam Lake is found upstream of the study area, and flow is occasionally discharged into Mitchell Lake, when water levels are high. Balsam Lake and surrounding areas are well populated, both by cottage residents and by nearby urban areas, such as the community of Lindsay. In addition to the large number of septic systems that are found in this area, there would be runoff of stormwater from the urban areas, and there is also a municipal water treatment plant discharging into the system at Lindsay. While some of the nutrients from these sources would be deposited as the water moves downstream, not all would, and the study area lakes are subject to the cumulative impacts of these upstream areas due to the connected nature of the system.

7.3.2 Shoreline alterations and development

Because of the proximity of the study area lakes to large urban centres in southern Ontario, they have been subject to a significant amount of cottage development along their shores. Cottage development is often associated with changes to the shoreline, and these changes can often be associated with impacts to aquatic habitat. Changes include the removal of shoreline vegetation, often to improve views; shoreline hardening to prevent erosion; the installation of docks, boathouses and trails; the deposition of sand and other 'non-native' materials to create beaches; the use of fertilizers, which can contribute nutrients to the lake; and the planting of non-native species. Other changes include agricultural activities along the shore, including pasture lands in which the cattle have access to the lake. The impacts of these shoreline alterations can include the removal of and impacts to fish habitat; inputs of sediment, nutrients, and bacteria; the removal of aquatic vegetation; shoreline erosion, which can often be displaced and/or exacerbated by the use of hardening techniques; and a decrease in the amount of native materials input into the lake that would typically provide habitat for aquatic organisms.

Approximately 24% of the shoreline in Canal Lake, and 16% of the shoreline in Mitchell Lake has been altered in some way. To inventory the shoreline issues found on both these lakes, a shoreline survey was undertaken in 2014. This Best Management Practices (BMP) Opportunities survey found close to 2500 opportunities along the shoreline of Canal Lake where BMPs could be undertaken to improve conditions, and close to 900 in Mitchell Lake. In Canal Lake, areas with insufficient riparian cover were the most prevalent opportunity, with 19% of the total opportunities. Runoff from manicured lawns and impervious surfaces (18% and 2%), shoreline hardening (18%, or 15% 'good' shoreline hardening and 3% 'failed' shoreline hardening), docks (16%), and boathouses/boatlifts (8%) constituting the majority of the remaining opportunities. There were also three sites on Canal Lake where cattle have unrestricted access to the lake, presenting a potential source of nutrients and bacteria, and potentially contributing to the erosion of the shoreline. The prevalent opportunities were fairly similar along the shoreline of Mitchell Lake, with 20% of the opportunities being related to insufficient riparian cover, and runoff from lawns and impervious surfaces (19% and 4%), docks (18%), shoreline hardening (14% 'good' and 3% 'failed'), and boathouses and boat lifts (9%) being the predominant opportunities.

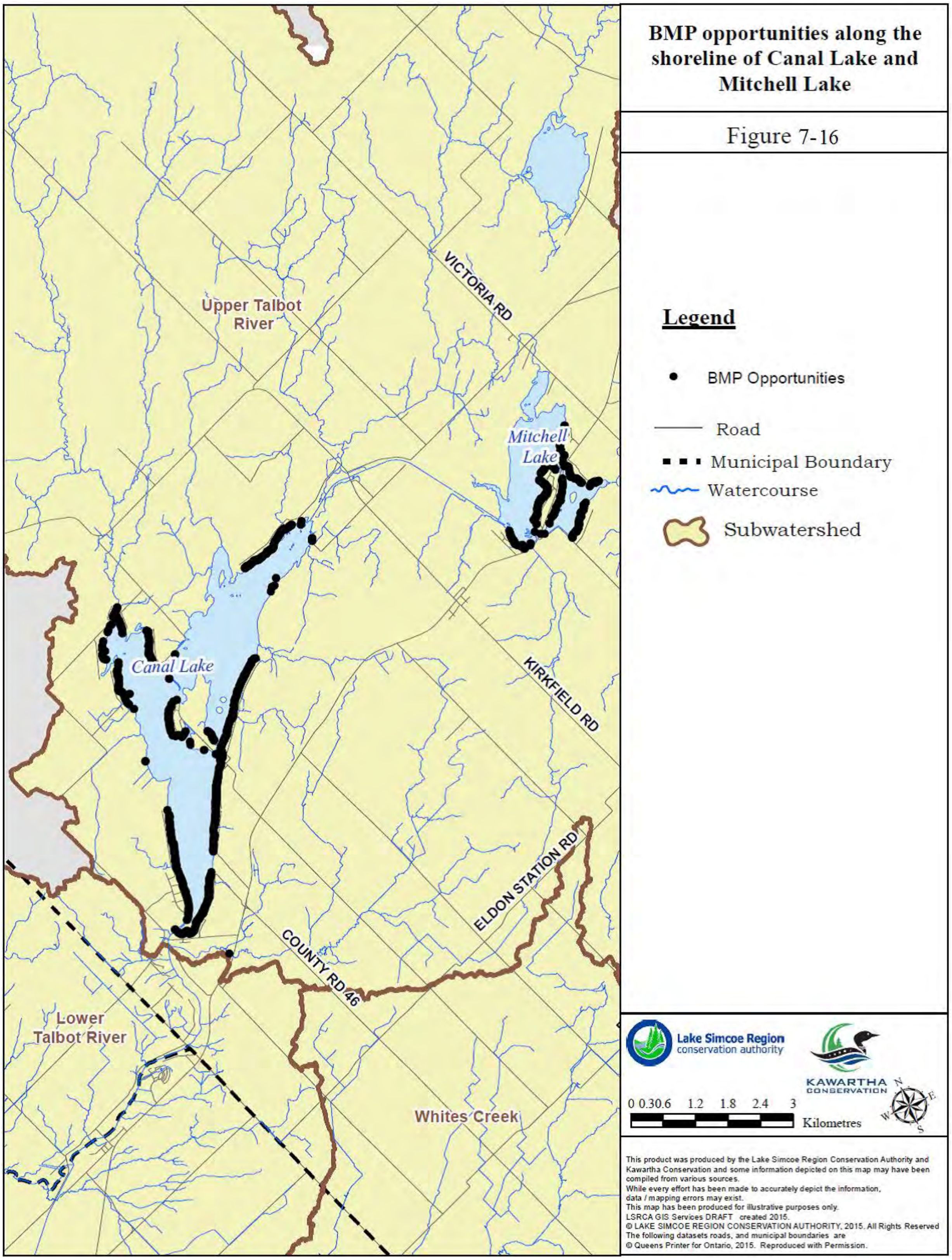


Figure 7-16: Best Management Practices (BMP) opportunities identified through shoreline surveys on Canal Lake and Mitchell Lake.

7.3.3 Land use change

As noted in the above sections, land use changes can significantly affect lake environments. While the impacts of upstream lakes and changes in shoreline areas have been discussed, land use changes throughout a subwatershed can be source of stress in these systems. The land drains to tributary streams, which eventually reach the main Talbot River, which flows through and/or discharges into these lakes. Much of the upper portion of the Talbot River subwatershed, in which Canal and Mitchell Lakes can be found, remains in natural cover (85%); however, approximately 13% of the area has been converted to agricultural land uses, and just over 1% is in urban land use, particularly in the vicinity of the lakes and the Talbot River. The closer these land uses are to the lakes, the greater impact they will have. In this study area, the greatest change has been the creation of the Trent Severn Waterway, and the associated flooding that created Canal and Mitchell Lakes from the wetlands that they once were.

7.3.4 Invasive species

The changes to ecosystems caused by invasive species is a significant concern in the Lake Simcoe watershed and beyond. Because of the access to numerous upstream and downstream lakes via the Trent Severn Waterway, which stretches from Lake Ontario to Lake Huron, the study area’s lakes are particularly vulnerable to invasions of non-native species, which can be transported in a number of ways. A boat travelling from a lake outside of the system could easily transport seeds, plant materials, and small or juvenile forms of aquatic animals to the system, and once they are introduced, they can spread quickly throughout the system. The use of bait from outside of a watershed by anglers, while illegal, does occur, and is another potential vector for the spread of invasive species. As mentioned above, invasions can also occur through the use of non-native plants in horticulture – this is applicable to both terrestrial and aquatic species.

Once introduced, these species can have a number of impacts on the native ecosystem, and are very difficult to control or eradicate. They can out-compete native species for food, habitat, and other resources. Species considered invasive are often prolific, and can reproduce quickly or by multiple methods, giving them a competitive edge over native species by crowding them out of an area or overwhelming their populations. Species such as zebra and quagga mussels or carp can physically alter the habitat, making it less suitable for the native species. Many of these species are known to feed on the eggs and young of native species, which also places downward pressure on these populations. These species can also introduce diseases to the native species. In addition to these more direct impacts, they can also have indirect impacts. For example, the filtering activities of zebra mussels have been theorized to actually shift the nutrient dynamics in Lake Simcoe and other lakes, by keeping more of it in the nearshore areas, and limiting what it deposited in deeper areas.

There have also been a number of invasive species identified that can impact the nearshore environments and the tributaries in the study area. These include*:

- Eurasian watermilfoil (*Myriophyllum spicatum*),
- Curly-leaf pondweed (*Potomogeton crispus*),

- Common carp (*Cyprinus carpio*),
- Rainbow smelt (*Osmerus mordax*),
- Round goby (*Neogobius melanostomus*),
- Spiny waterflea (*Bythotrephes longimanus*),
- Rusty crayfish (*Orconectes rusticus*),
- Zebra mussel (*Dreissena polymorpha*),
- Quagga mussel (*Dreissena rostriformis bugensis*),
- Banded mysterysnail (*Viviparus georgianus*)
- European common reed (*Phragmites australis* subs. a*ustralis*)
- European frog-bit (*Hydrocharis morsus-ranae*)

(*source: EDDMAPS, queried May 8, 2015)

7.3.5 Tourism and recreation

In addition to the potential to introduce and/or spread invasive species noted above, there are other issues associated with various types of recreation activities that can affect the health of the lake ecosystems in the study area.

The effects of boating, which is among the most popular activities on these lakes, include shoreline erosion due to the wakes of boats travelling at excessive speeds near the shore, fouling of the water due to grey water discharge or improper fuel handling, increased turbidity and decreased water clarity in shallow areas, and the potential to spread aquatic plants – some are able to grow via cuttings, which can occur as a boat's propeller moves through them and breaks off pieces or uproots them. Fish populations can also be affected directly, as the noise of the boats can scare them off of their nests, leaving their eggs vulnerable to predation, or can cause them to move into less ideal habitat.

7.3.6 Climate change

There are a number of potential impacts to the study area's lakes due to climate change. Changes in the hydrologic regime, including increasing surface runoff and groundwater recharge in the winter months, and decreasing availability in the summer may result in an increased frequency of low water levels and drought events during the summer, and an increased risk of flooding during the winter (MacRitchie and Stainsby, 2011). The changing hydrologic regime and increasing temperatures may cause an increase in phosphorus loading and have a negative effect on ecological health and trophic status (Crossman *et al.*, 2013). The Lake Simcoe Climate Change Adaptation Strategy (2013), prepared by the MOECC, lists a number of possible impacts in the watershed that may affect lake health. These include a variation in streamflow regimes and lake levels that may affect fish and wildlife habitats and sediment transport processes, and changes to ice cover that could affect evaporation, infiltration, shoreline erosion, precipitation, seasonality, and lake effect snow.

Utilizing the above information and a number of climate change models, Earthfx Inc. undertook water budget and climate change modelling work in support of this subwatershed plan. This work found that, compared with baseline conditions, possible impacts include an increased proportion of rain as precipitation in the winter months, which will shift the spring freshet to earlier in the season and produce a broader crest in spring groundwater levels, by approximately a month. This may affect the discharge to the lakes in the summer months, which could have an effect on lake levels and nearshore habitat. Potential issues may include an increase in plant growth due to warmer conditions and less movement of water, increased algal growth, changes in the fish community, and changes in water levels.

Key Points – Factors Impacting Lake Health – stressors:

- Excessive nutrient inputs can lead to accelerated aging of the lake, including proliferation of aquatic plants. Major nutrient sources are associated with shoreline areas, such as poorly functioning septic systems in cottages and residences, and tributaries from inputs from agricultural areas and runoff from urban areas.
- Both lakes have dense shoreline development. The impacts of shoreline alterations can include the removal of fish habitat, inputs of sediment, nutrients, and bacteria, the removal of aquatic vegetation, and shoreline erosion. Shoreline surveys found close to 2500 opportunities for improvement along Canal Lake, and 900 in Mitchell Lake, including: insufficient natural riparian areas, runoff from manicured lawns and impervious surfaces, locations where livestock were accessing the lake, shoreline hardening, docks, and boathouses.
- Invasive species have invaded both lakes (e.g., Eurasian watermilfoil, rusty crayfish, zebra mussels, etc.). Once introduced, these species can have a number of impacts on the native ecosystem, and are very difficult to control or eradicate. They can out-compete native species for food, habitat, and other resources. The interconnectedness of the Trent-Severn Waterway system facilitates the spread of exotic species between the Kawartha Lakes and Lake Simcoe basins.
- Recreational activities on the lakes, particularly motor boating, can have impacts to the lake ecosystems including: shoreline erosion due to the wakes of boats travelling at excessive speeds near the shore, fouling of the water due to grey water discharge or improper fuel handling, increased turbidity and decreased water clarity in shallow areas, the potential to spread aquatic plants, and interfering with fish spawning.
- Changes to the lakes associated with climate change are expected, including a number of possible impacts in the watershed that may affect lake health. These include a variation in streamflow regimes and lake levels that may affect fish and wildlife habitats and sediment transport processes, changes to ice cover that could affect evaporation, infiltration, shoreline erosion, precipitation, seasonality, and lake effect snow, and increases in water temperature that could increase the growth of aquatic plants.

7.4 Current Management Framework

Various programs exist to protect and restore aquatic natural heritage values in the lakes found in the Lake Simcoe watershed, as well as in Lake Simcoe itself, ranging from regulatory mechanisms, to funding and technical support provided to private landowners, to ongoing research and monitoring.

Many of these programs already address some of the stresses facing Canal Lake, Mitchell, Lake, and Lake Simcoe, as outlined below.

7.4.1 Protection and policy

There are numerous acts, regulations, policies, and plans aimed at maintaining or improving health in the study area's lakes. These include the *Fisheries Act*, *Endangered Species Act*, the Lake Simcoe Protection Plan, and municipal official plans. This management framework addresses many of the stresses identified in this subwatershed. In Table 7-4 we categorize nine such stressors, recognizing that many of these overlap and that the list is by no means complete. The legal effects of the various Acts, policies, and plans on the stressors is categorized as 'existing policies in place' (shown in green), or 'no applicable policies' (shown in red). The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 7-4: Summary of the current management framework as it relates to the protection and restoration of lake health

Stressor affecting aquatic habitat	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2014)	Endangered Species Act (2008)	Ontario Water Resources Act (1990)	Fisheries Act (1985)	Ontario Fisheries Regulations (1989)	Lakes and Rivers Improvement Act (1990)	LSRCA Watershed Development Policies (2015)	City of Kawartha Lakes Official Plan (2012)	Township of Brock Official Plan (2014)	Township of Ramara Official Plan (2003)	Parks Canada Policies For Inwater and Shoreline Works (2007)
Loss of riparian areas/shoreline vegetation	🟩 [1]	🟥	🟩	🟩 [4]	🟥	🟩	🟥	🟩 [5]	🟩	🟩	🟩	🟩 [10]	🟩
Docks and boathouses	🟩	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟩	🟩	🟥	🟩 [11]	🟩
Shoreline hardening	🟩	🟥	🟩	🟥	🟥	🟩	🟥	🟩 [6]	🟩	🟩	🟥	🟥	🟩
Impervious surfaces	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩 [12]	🟩
Uncontrolled stormwater	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩 [8]	🟩	🟥
Interference with groundwater recharge / discharge	🟩	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟩 [8]	🟩	🟩	🟥
Degradation of water quality (including thermal impacts)	🟩 [2]	🟩	🟩	🟥	🟩	🟩	🟥	🟩 [7]	🟩	🟩	🟩	🟩 [13]	🟥
Introduction of invasive species	🟩 [3]	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟥
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟩 [9]	🟥	🟥

🟩 Existing policies in place

🟥 No applicable policies

[1] Regulations only apply to those areas outside designated Settlement Areas

[2] Only contains specific policies and targets about phosphorus reduction, none about other contaminants

[3] Discusses developing proposed regulations, conducting studies/risk assessments, developing response plans, education programs, but nothing banning use/etc

[4] Related to those features that are part of SARO listed species' habitat

[5] Not directly stated, but applicants who are applying for approval under the *Lakes and Rivers Improvement Act* need to be aware of the rights of riparian owners, and take into account the effect that the proposed work will have on the rights of riparian owners.

[6] Refers to channelization, including revetments, embankments, and retaining walls in rivers

[7] Not directly stated, but most of the policies would indirectly cover this

[8] Consistent with LSPP

9 Consistent with LSPP, specific to consideration of stormwater management effectiveness

[10] Township adopt guidelines for stormwater measures including maximum impervious area on individual lots – only applies in Shoreline Residential Areas

[11] Requires appropriate permits to be obtained for their construction

[12] Township adopt guidelines for stormwater measures including maximum impervious area on individual lots – only applies in Shoreline Residential Areas

[13] There are policies related to water quality, although none specifically mention thermal impacts

Legislation and policy restrictions are the primary source of protection for aquatic natural heritage features in the Lake Simcoe watershed, including lake features. However, some stresses are better suited to policy and regulation than others. For example, stressors such as climate change and invasive species are hard to regulate; however, activities related to the loss of habitat, or capture and killing of fish are much easier to define and enforce.

The new Federal *Fisheries Act* manages threats to fish that are part of or support commercial, recreational or Aboriginal fisheries with the goal of ensuring their productivity and ongoing sustainability. Under the Act, the Fisheries Protection Policy Statement applies to proponents of existing or proposed works, undertakings or activities that are likely to result in impacts to fish or fish habitat that are part of or support commercial, recreational or Aboriginal fisheries, including projects that have the potential to affect the passage of fish or modify the flow of watercourses.

The *Fisheries Act* is complemented by the Lake Simcoe Protection Plan, which (outside of designated settlement areas) establishes restrictions to development or site alteration within 100 m of the Lake Simcoe shoreline (30 m in already built-up areas, subject to a natural heritage evaluation) (policies 6.1 and 6.2), or within 30 m of Key Hydrologic Features (which includes Canal and Mitchell Lakes), with natural heritage evaluations necessary for development proposed within 120 m of the feature (policies 6.22 – 6.25). Exemptions to these policies are provided for existing uses, municipal infrastructure, and aggregate operations, and other low impact activities. These activities will be required to demonstrate that they maintain or improve fish habitat in the lake, watercourse, wetland, or riparian area. Other policies related to Lake Simcoe and other lakes within the watershed include restrictions on boathouses if they impede the natural flow of water along the shoreline, are intended for use as a dwelling, or if the construction would harmfully alter fish habitat. Some shoreline works are permitted, if they are for the purpose of altering drainage works, infrastructure stabilization, erosion control, or protection purposes, and these are only permitted if it is demonstrated that natural shoreline treatments that maintain the natural contour of the shoreline are used (where practical), and that a vegetated riparian area will be established to the extent feasible.

Aquatic habitat is also offered some protection by municipal official plans. In the Official Plan for the City of Kawartha Lakes, Policy 3.5.9 requires a review of available information from the local conservation authority, MNRF, the Trent Severn Waterway, and the Department of Fisheries and Oceans for proposals for lands within 120 metres of the water’s edge to determine if the water in the area is fish habitat. If it is found to be fish habitat, an environmental impact statement is required, and the appropriate agency will determine if the project can proceed and which approvals are required. The City’s OP is also consistent with the Lake Simcoe Protection Plan, so those lands within 30 metres of the shorelines of the lakes should be protected, as they are considered to be Key Hydrologic Features. In the Township of Ramara, Policy 5.2.3.7 of the OP’s Natural Area Framework outlines a limited number of uses permitted on lands of provincial, regional and local significance identified as fish habitat. Some of these uses include passive recreation, permitted agricultural activities, facilities for preservation and conservation of natural areas, and water supply, wastewater treatment, storm water management, and road, railway and utility infrastructure approved under applicable provisions. The Township of Brock’s shoreline is limited to Lake Simcoe, and their Official Plan contains policies consistent with those of the Lake Simcoe Protection Plan with regard to the protection of, and potential development within, shoreline areas.

Drainage works, such as those permitted under the Provincial *Drainage Act,* are exempt from many of the policy provisions provided under the Lake Simcoe Protection Plan and municipal official plans, but are not exempt from the requirements of the Federal *Fisheries Act* or the Provincial Regulation on development and interference with wetlands (O. Reg. 179/06).

7.4.2 Restoration and remediation

Staff from Kawartha Conservation, with support from the City of Kawartha Lakes, the Municipality of Trent Lakes, the OMAFRA Economic Development Program, and the RBC Blue Water Project, have been out on a number of the Kawartha Lakes (including Canal and Mitchell Lakes) in support of their Blue Canoe program, speaking with shoreline landowners about how they can affect the health of the lake. Through this program, conservation authority staff canoe around the shorelines of the lakes, according to a pre-set schedule, so that property owners can anticipate their visit. They offer information and advice to educate and encourage landowners to undertake the necessary steps to improve and maintain a healthy shoreline property. When multiple landowners take these steps, the result is a healthier lake which, in a system as connected as this one, improves the health of the overall watershed, as well as improving the enjoyment of those living on and visiting the lake. This also provides benefits to the local economy. More information on this program can be found at http://www.kawarthaconservation.com/bluecanoe.

7.4.3 Science and research

An ongoing commitment to applied science and research is necessary to improve our understanding of the extent, character, and function of the fish and other aquatic natural heritage values within the Lake Simcoe watershed. Ongoing monitoring programs led by the MNRF, Kawartha Conservation, LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

The Ministry of Natural Resources and Forestry has been studying the structure and function of Lake Simcoe's ecosystem, including internal energy dynamics, food web interactions, and the impacts of invasive species and climate change since 1951 when the Lake Simcoe Fisheries Assessment Unit was created. This unit uses a series of research and monitoring programs, including creel surveys, index netting, angler diaries, spawning studies, and water level and temperature monitoring, among others, to meet the needs of fisheries resource managers (as outlined in Philpot *et al*, 2010).

The Lake Simcoe Region Conservation Authority monitors fish communities, benthic invertebrates, and temperature at a network of sites throughout the watershed. Some of these sites are visited only once, to describe the aquatic system, and some are visited annually to document changes in the health of the tributaries.

More recently, the LSRCA began a nearshore monitoring program in the Lake, to better understand the connection between watershed land use and the health of the Lake Simcoe ecosystem. This monitoring program includes a study of the aquatic plants, benthic invertebrates, and sediment chemistry in this nearshore zone.

In addition to these ongoing monitoring programs, numerous scientific and technical reports have been published based on research conducted in the Lake Simcoe watershed. As a result of this combined focus, Lake Simcoe is one of the most intensively studied bodies of water in Ontario. The results of this research have been summarized, in part, in LSEMS (2008) and Philpot *et al.* (2010), and have informed the development of this subwatershed plan.

The Lake Simcoe Protection Plan commits the MNRF, MOECC, LSRCA, and others to continue to invest in research and monitoring related to aquatic communities of Lake Simcoe and its tributaries. Ongoing research is proposed to examine the biological components of the ecosystem, their processes and linkages; to build on existing knowledge; or address knowledge gaps (policy 3.5). The proposed monitoring program is intended to build on the existing monitoring described above, to describe the fish communities, benthic communities, macrophytes, and/or fishing pressure in the lake, its tributaries, and other inland lakes within the watershed (policy 3.6).

7.5 Management Gaps and Recommendations

(Note: It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.)

7.5.1 Stewardship

Given the high level of shoreline development around the study area's lakes, and the numerous issues that have been noted within them, the implementation of stewardship projects in partnership with study area landowners will be important in improving the water quality and aquatic health of these lakes. In addition to the focus on prioritized activities noted in Recommendation 6-10 in the Aquatic Habitat chapter, there are a number of lake-focused recommendations that should be undertaken.

Recommendation 7-1 - That LSRCA, Kawartha Conservation, and the subwatershed municipalities work to implement lot-level measures such as reducing fertilizer use, increasing infiltration, capturing stormwater runoff, and other practices that conserve water and reduce pollution in targeted urban areas and waterfront communities. An example of this is the Township of Ramara's bylaw restricting the use of fertilizers containing phosphorus on non-agricultural lands, and associated rebate program.

Recommendation 7-2 - That the LSRCA, Kawartha Conservation, and the subwatershed municipalities work with property owners to implement a natural landscaping approach along shoreline properties, with particular focus on decommissioning hardened shorelines and addressing severely eroded/ice-damaged sections.

Recommendation 7-3 - That the subwatershed municipalities, community groups, and other beach stewards enhance community enjoyment of public beaches and parks by deterring geese, conducting regular maintenance, and increasing public access to shorelines. The results of the Rewilding project being undertaken at Centennial Beach on Canal Lake should be evaluated, and the feasibility of downscaling project features such that individual shoreline landowners can undertake them should be explored.

Recommendation 7-4 - That the City of Kawartha Lakes manage ditch run-off from the municipal roads that end at the shorelines of Canal and Mitchell Lakes with rock check dams, and/or the use of vegetation, bioretention areas, or other methods, to reduce the export of phosphorus, sediment, and other contaminants to the lakes.

Recommendation 7-5 – That the LSRCA and Kawartha Conservation, in partnership with the Trent Severn Waterway and Trent Matters, develop and profile communication materials that describe the natural processes of aquatic plants in Canal Lake and Mitchell Lake, for shoreline residents and lake users.

Recommendation 7-6 – That Trent Matters and the Trent Severn Waterway work to ensure that more information is made available and accessible to shoreline residents and lake users regarding aquatic plant control options that are permissible within the lakes, and that current aquatic plant management policies be reviewed.

Recommendation 7-7 – That shoreline residents, with support from Parks Canada and other regulatory agencies, consider various direct in-lake approaches that would provide immediate control of aquatic plants in areas where lake use has been significantly impacted by prolific aquatic plants.

7.5.2 Protection of Water Quality

The protection of the quality of the water within the study area's lakes, as well as the tributaries draining into them, will help to mitigate some of the issues being noted in the lake. Although many of the water quality samples meet provincial guidelines, the concentration of nutrients in bottom sediments may be higher; and contribute to the nuisance growth of aquatic plants. Preventing sediment and nutrients, as well as bacteria and other parameters of concern, from reaching the lake will be important in improving conditions for lake residents and users.

Recommendation 7-8 - That the subwatershed municipalities, OMAFRA, conservation authorities, and the construction industry work to implement effective sediment and erosion control measures and other practices to prevent contaminants from reaching local watercourses during road work, agricultural drainage, and other construction projects.

7.5.3 Invasive species

As noted in **Chapter 6 – Tributary Health,** invasive species can have numerous impacts on an aquatic ecosystem. As part of the Trent-Severn Waterway, Lake Simcoe, Canal Lake, and Mitchell Lake are particularly vulnerable to the introduction and spread of aquatic invasive species. The implementation of measures to limit the spread of these species will be important for maintaining the health of the aquatic ecosystem throughout this area. Recommendation 6-13 is applicable in the study area's lakes as well as its tributaries.

7.5.4 Monitoring and assessment

Regular monitoring of the conditions within the study area's lakes is important to identify any changes that are occurring, and to assess the effectiveness of management actions that are undertaken to improve conditions in the lake. It also provides an opportunity to assess the effectiveness of new and innovative practices that can be undertaken to address the issues identified in the lake, and to determine if the continued and/or expanded use of those practices is recommended.

Recommendation 7-9 - That local communities, with support from agencies and/or academic institutions, undertake small-scale pilot projects to test the effectiveness of practical, affordable, and/or innovative approaches to aquatic plant control through scientific studies and quantitative reporting.

Recommendation 7-10 – That the LSRCA, Kawartha Conservation, MOECC, and MNRF implement a coordinated lake monitoring program that regularly tracks key indicators of lake watershed health including nutrients, aquatic plant cover, fish communities, and oxygen levels.

There could also be a substantial role for citizen scientists in conducting this monitoring; the partners should explore this option through the development of the program.

Recommendation 7-11 – That LSRCA incorporate data on the health of Canal and Mitchell Lakes into their forthcoming Key Performance Indicators reporting.

Recommendation 7-12 – That the LSRCA, Kawartha Conservation, MOECC, and LSRCA conduct research to identify how the lake ecosystem responds to stressors such as cumulative development, climate change, and invasive species.

Recommendation 7-13 – That the LSRCA and Kawartha Conservation expand their monitoring network to include Raven and Talbot Lakes.

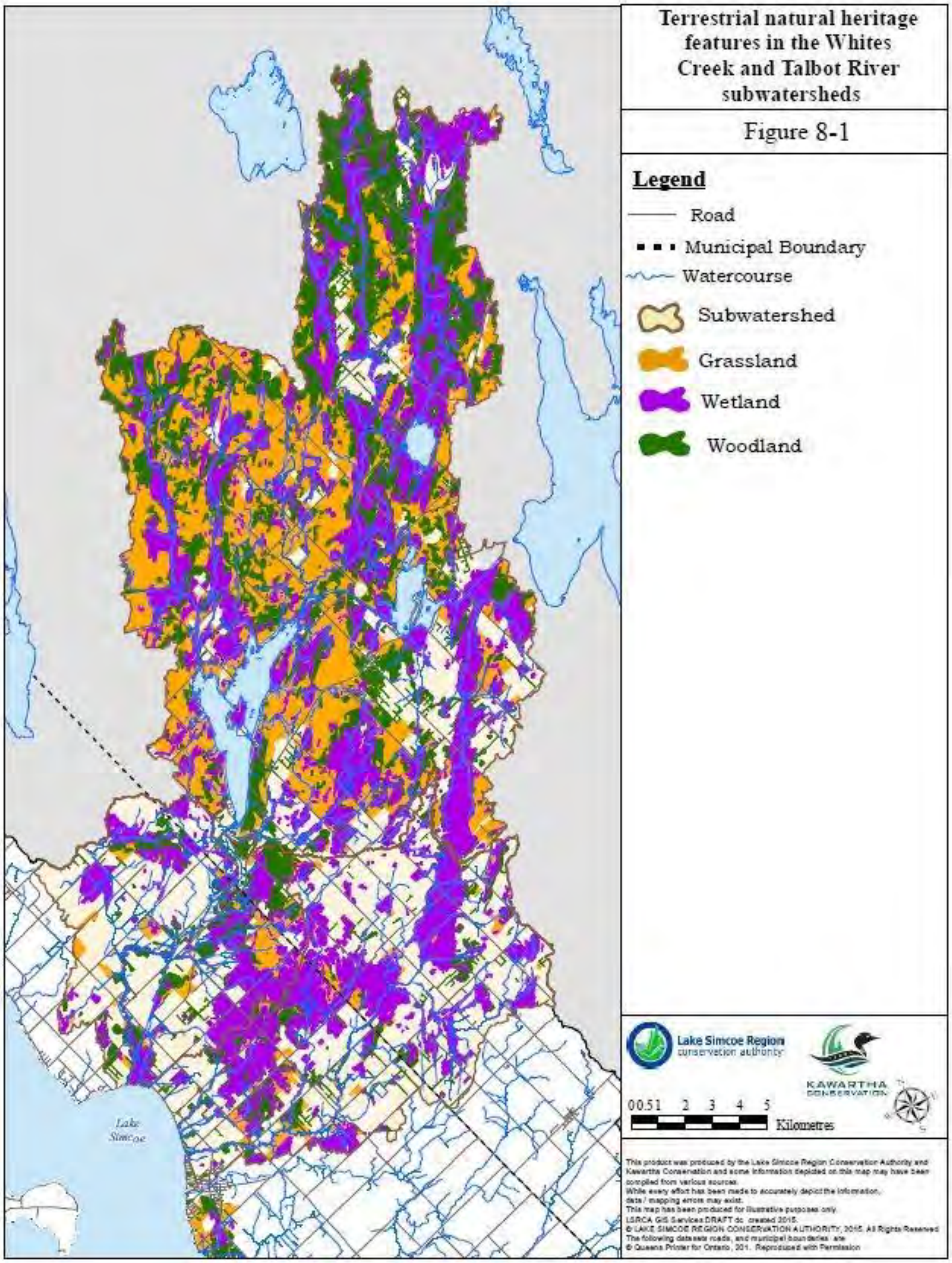
8 Terrestrial Natural Heritage

8.1 Introduction

Terrestrial natural heritage features are extremely important components of subwatershed health, as they not only provide habitat for many of the species residing in the subwatershed, but also influence subwatershed hydrology and water quality. They are among the most important parts of the ecosystem, and are the most likely to be directly impacted by human activities.

A terrestrial natural heritage system is composed of natural cover (features), natural processes (functions), and the linkages between them. The matrix of agricultural, rural, urban, and natural areas within the Ramara Creeks subwatershed's terrestrial system interacts with other hydrological and human systems, and serves as habitat for flora and fauna throughout the subwatershed. The system includes not only large tracts of natural features, but also the small features that can be found within urban and agricultural areas. Measuring the quantity, quality, and distribution of natural heritage features within the subwatershed can tell us a great deal about its health. Figure 8-1 details the distribution of natural features in the subwatershed.

Currently, natural heritage features account for 76% of the Talbot River subwatershed (including 26% wetland, 19% upland forest, and 28% grassland). The Whites Creek subwatershed has just over 38% natural heritage cover, with 24% wetland (this includes wooded wetlands), 7% upland forest, and 6% grassland.



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT dc created 2015.

Figure 8-1: Terrestrial natural heritage features in the Talbot River and Whites Creek subwatersheds

8.2 Current Status

Terrestrial natural heritage features, as described by the Provincial Policy Statement, include woodlands, wetlands, valleylands, Areas of Natural and Scientific Interest, habitat for endangered species, and wildlife habitat. The Provincial Policy Statement provides direction for the protection of *significant* natural heritage features throughout the Province.

The Lake Simcoe Protection Plan (LSPP) provides further targets for the Lake Simcoe watershed, to:

- Ensure no further loss of natural shorelines on Lake Simcoe;
- Achieve a greater proportion of natural vegetative cover in large high quality patches;
- Achieve a minimum 40 percent high quality natural vegetative cover in the watershed;
- Achieve protection of wetlands;
- Achieve naturalized riparian areas on Lake Simcoe and along streams;
- Restore natural areas or features, and;
- Achieve increased ecological health based on the status of indicator species and maintenance of natural biodiversity

The current state of natural heritage features in the Whites Creek and Talbot River subwatersheds can be described, relative to these targets, where data permits.

The Talbot River subwatershed has a relatively high proportion of natural heritage cover, with 44% of the land use comprised of wetland, woodland and native grassland habitat, which exceeds the LSPP target of 40% high quality cover; though it is has not yet been determined what proportion of this cover would be considered 'high quality.' Additionally, 32% of the land use is characterized by early successional or cultural features. Agriculture comprises much of the remaining land in the watershed, occupying approximately 20% of the land area. The Whites Creek subwatershed falls close to the middle of Lake Simcoe subwatersheds with respect to natural cover, at 31% forest, wetland and native grassland, and another 7.4% cultural or early successional features. Whites Creek has a high level of agriculture, with close to 60% percent of the subwatershed area being occupied by this land use. Other, less prevalent land uses in both subwatersheds include rural development, aggregate extraction operations, and urban, industrial, and institutional land uses (Figure 2-2).

8.2.1 Woodlands

The *Natural Heritage Reference Manual* (OMNR, 2010) lists a variety of important functions associated with woodlands and Larson *et al*. (1999) summarize the importance of woodlots. These important functions can generally be described as follows:

- **Economic Services and Values:** oxygen production, carbon sequestration, climate moderation, water quality and quantity improvements, woodland products, economic activity associated with cultural values

- **Cultural/Social Values:** education, recreation, tourism, research, spiritual and aesthetic worth
- **Ecological Values:** diversity of species, structural heterogeneity, nutrient and energy cycling.
- **Hydrological Values:** interception of precipitation, reduction of intensity of rainfall runoff, slower release of melt water from snowpack, shade to water courses

Woodlands include all treed communities, whether upland or wetland. The Ecological Land Classification (ELC) communities that were considered to represent woodlands are forest, swamp, plantation, and cultural woodland (the breakdown of these woodland types is displayed in Table 8-1 and Figure 8-2). Some woodlands in this section are also counted as wetlands later in the chapter (e.g. wooded swamp), as the two terms are not mutually exclusive.

The ecological function of woodlands tends to be influenced by factors relating to fragmentation (the splitting of larger woodlands into ever smaller pieces), patch size (the requirement of woodland pieces to be of a certain area for the maintenance of some functions), woodland quality (such as shape, interior habitat, age, composition, structure and the presence of invasive species), and total woodland cover (i.e., the woodland area within a jurisdiction or watershed).

Of these factors there is increasing scientific evidence to show that the total woodland cover of a landscape may exert the most important influence on biodiversity. Obviously, the loss of woodland cover results in a direct loss of habitat of that type. This reduction in habitat can result in proportionally smaller population sizes, and animals in habitat remnants may experience altered dispersal rates, decreased rates of survival, decreased productivity, altered foraging behaviours, and decreased mating opportunities (Fahrig, 2003). Research that has examined the independent effects of habitat loss and habitat fragmentation suggests that habitat loss has a greater effect than habitat fragmentation on the distribution and abundance of birds (Fahrig, 2002) and there is now substantive evidence that total woodland cover is a critical metric (e.g., Austen *et al.* 2001; Golet 2001; Fahrig 2002; Lindenmayer *et al.* 2002; Trzcinski *et al.* 1999; Friesen *et al.* 1998, 1999; Rosenburg *et al.* 1999; Radford *et al*. 2005).

The Lake Simcoe Protection Plan sets a target of the retention of a minimum of 40% high quality natural vegetative cover in the entire Lake Simcoe watershed, which would include forest, native grassland, and non-forest wetland ecosystems. Clearly, this amount of natural cover cannot be achieved uniformly throughout the watershed, as development pressures are distributed unevenly throughout the watershed. At 76% natural cover, the Talbot River subwatershed significantly exceeds this target and, due to the large area, actually helps to increase the natural heritage percentage for the entire Lake Simcoe watershed. The Whites Creek subwatershed fall just below this target, with 38% natural heritage cover. LSRCA's Integrated Watershed Management Plan allows for uneven distribution of woodland cover, while still setting a target of a minimum of 25% forest cover within each of Lake Simcoe's subwatersheds. At 35% and 22% for the Talbot River and Whites Creeks subwatersheds, these subwatersheds demonstrate how cover can vary across the watershed. The Talbot River subwatershed is well in exceedance of the target, while Whites Creek falls just slightly below.

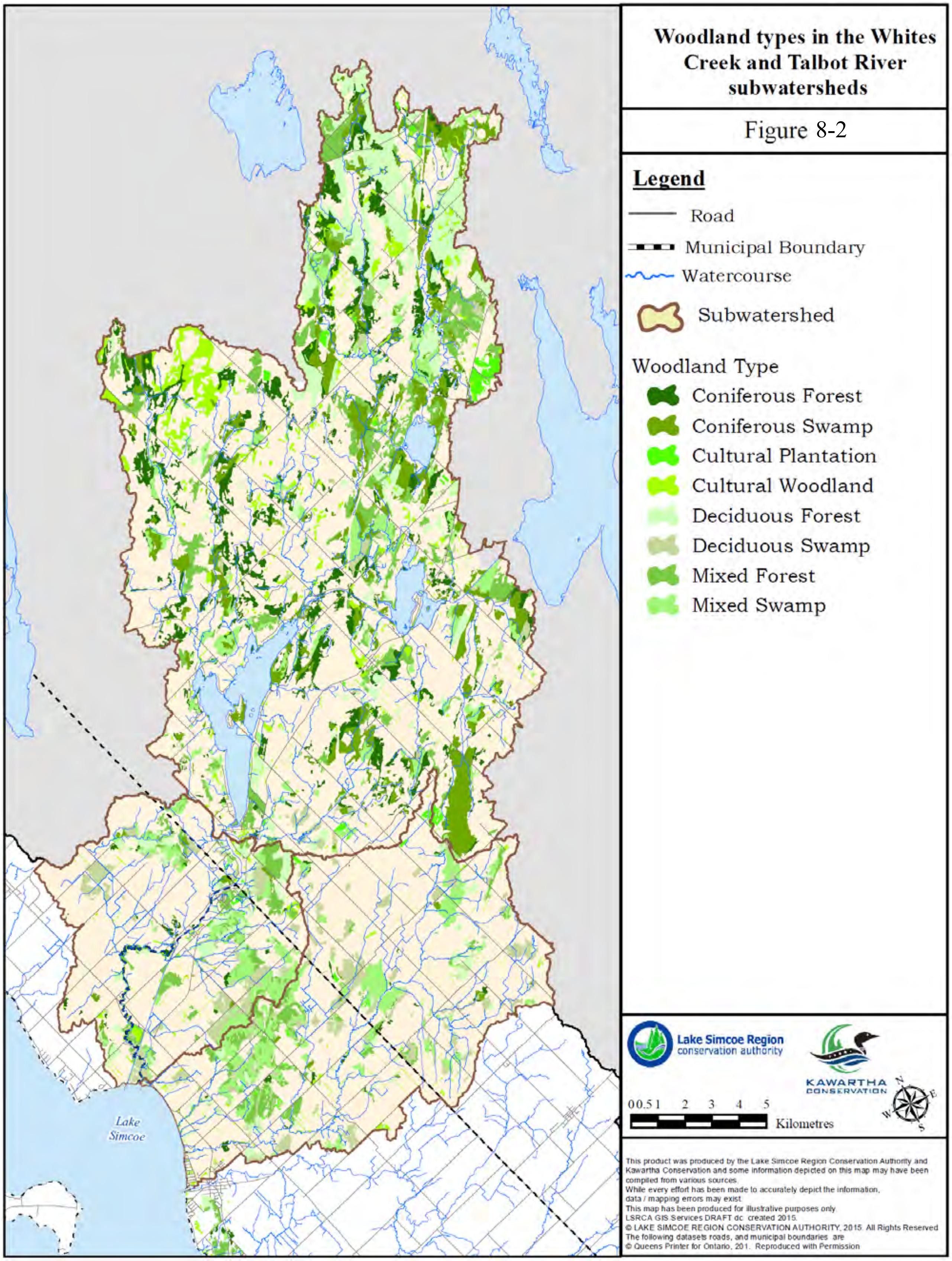


Figure 8-2: Woodland types in the Talbot River and Whites Creek subwatersheds

Table 8-1: Woodland cover types in the Talbot River and Whites Creek subwatersheds

Woodland Type		**Woodland Cover – Talbot River**		**Woodland Cover – Whites Creek**	
		Area (ha)	**Area (%)**	**Area (ha)**	**Area (%)**
Upland forest	Cultural Plantation (CUP)	182.0	0.5	44.1	0.4
	Cultural Woodland (CUW)	1092.8	3.0	84.2	0.8
	Conifer Forest (FOC)	2236.7	6.1	46.8	0.4
	Deciduous Forest (FOD)	2416.1	6.6	227.7	2.2
	Mixed Forest (FOM)	2067.4	5.7	434.5	4.1
Swamp forest	Conifer Swamp (SWC)	2444.8	6.7	29.7	0.3
	Deciduous Swamp (SWD)	818.4	2.2	713.8	6.8
	Mixed Swamp (SWM)	1454.6	4.0	775.6	7.4
Total upland forest		**6902.1**	**18.9**	**753.1**	**7.1**
Total forest		**12712.8**	**34.9**	**2356.4**	**22.4**
Target (LSPP)[1]		**5085.1**	**40**	**942.6**	**40**
Target (LSRCA IWMP)[2]		**3178.2**	**25**	**589.1**	**25**

The most common forest types in the Talbot River subwatershed are conifer swamp (a wetland community where tree cover is over 25%, and the coniferous coverage is over 75%), deciduous forest (an upland forest community with over 60% canopy cover and more than 75% deciduous species), and conifer forest (another upland forest type with over 60% forest cover, and greater than 75% coniferous species). Coniferous forests and swamps are relatively rare, and provide habitat for unique wildlife communities, particularly those which prefer coniferous woodlands, such as pine warbler (*Dendroica pinus*), Cooper's hawk (*Accipiter cooperii*), and blue jay (*Cyanocitta cristata*) (Bird Studies Canada *et al.,* 2008). In the Whites Creek subwatershed, the lowland forest communities of mixed and deciduous swamps are the most prevalent forest types. Both are wetland communities where tree cover is greater than 25%, with the mixed swamp having both deciduous and coniferous species making up over 25% of the community (Table 8-1).

Relatively uncommon in the Talbot River subwatershed are cultural plantations and cultural woodlands, as well as deciduous swamps. Upland forest communities, such as cultural woodland, conifer forest, and deciduous forest are relatively rare in the Whites Creek subwatershed, and account for just over 7% of the subwatershed area. This could be a function of the relatively flat and poorly drained nature of much the subwatershed, as well as the

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[1] The Lake Simcoe Protection Plan sets a target of 40% high quality natural vegetative cover (which includes, but is not restricted to, woodlands) for the entire Lake Simcoe watershed

[2] LSRCA's Integrated Watershed Management Plan recommends a target of 25% woodland cover per subwatershed

removal of the upland forests to accommodate the high level of agriculture found in the subwatershed.

Structural diversity of habitat is a key driver of biodiversity. In woodlands, habitat niches can range from microhabitats such as the surfaces of fissured trunks, leaves, and rotting logs to macrohabitat features such as the horizontal layers within the woodland (e.g., supercanopy, canopy, subcanopy). In addition, woodlands are present in a wide variety of topographic settings and soil and moisture regimes. For all of these reasons it is not surprising that many woodland species are obligates (i.e., they are only found in woodlands), or that woodlands provide habitat for a wide range of flora and fauna. They form important building blocks of the natural heritage system.

The summary statistics reflecting the percentage of the watershed under forested cover cannot address these more detailed issues related to the diversity and ecological integrity of individual forest patches. These issues typically relate to factors such as forest size, forest age, proximity to other natural areas, topographic heterogeneity, and structural diversity within the forest. Policy 6.48 of the LSPP requires the MNRF (in collaboration with the LSRCA, First Nations, and Métis communities) to map and identify `high quality` natural areas in the Lake Simcoe watershed. When this policy has been developed and mapping complete, more could be said about the distribution of these site-specific quality measures in this study area.

Although the total extent of forest cover in a subwatershed is the primary driver for many forest-dependent ecological processes, some species are also sensitive to the size of remnant forest patches (Robbins *et al.,* 1989; Lee *et al.,* 2002), the amount of ‘interior’ forest habitat (Burke and Nol, 1998a; Burke and Nol, 2000), and the proximity or connectivity between remnant forest patches (Nupp and Swihart, 2000).

Contiguous woodland areas have been calculated and the distributions of woodland patch sizes are displayed in the graph below (Figure 8-3). While the total area of woodland represents the amount of forest completely within the subwatershed, the number of patches also includes any patches touching the subwatershed boundary. This methodology was used to avoid underestimating the number of large patches. If only patches within the subwatershed boundaries were considered, the number of large patches would be underestimated.

The study area contains a wide range of forest patch sizes, ranging from less than 0.5 hectares to over 900 hectares. Over 30% of the study area’s forest patches are less than 0.5 hectares in size, although these patches account for less than 1% of the forest area. There are far fewer large forest patches, yet these account for a large proportion of the area’s forest area; for example, over 25% of the forest area in the study area is found in the eight largest forest patches. Over half of the study area’s forested area is found in patches 100 ha or larger (Figure 8-3).

Beyond issues of habitat size however, is the issue of amount of interior habitat available. Many species and ecological functions have been shown to be influenced by forest edges, a symptom known as ‘edge effect’. These effects can extend up to 20 m into the woodland for climatic factors such as light, temperature, moisture levels and wind speed (Burke and Nol, 1998b), up to 40 m for the prevalence of non-forest plant species (Matlack, 1994), and 100 m or greater for the rate of predation on nesting birds (Burke and Nol, 2000). Although this research has typically been interpreted such that 100 m becomes the rule of thumb for differentiating between 'edge' and 'interior' forest habitats, more recent research (Falk *et al.,* 2010) suggests that the impacts of edge effect on predation rates and nest survival in forest-dwelling songbirds may extend over 300 m into woodlots.

As can be seen in Figure 8-3, there are a number of interior forest patches in the Talbot River and Whites Creeks subwatersheds. Over 40% of these are less than 0.5 ha in size, but there are also a number of larger patches, with 28 patches over 50 ha in size; 11 of these falling in the 100-200 ha range. The largest patches account for approximately 36% of the interior forest in the study area, and likely support a diverse array of sensitive forest species. In addition, "deep forest core" areas, which are those areas lying deeper than 200 metres from the forest edge, were analyzed for the study area subwatersheds. There were 119 such areas identified; close to one third of these are less than 0.5 ha in size. About one third of the deep forest core area is found within the eight largest patches, ranging in size from 50 to 108 ha. These patches could potentially support some of the most sensitive forest dwelling species, with few edge effects being felt.

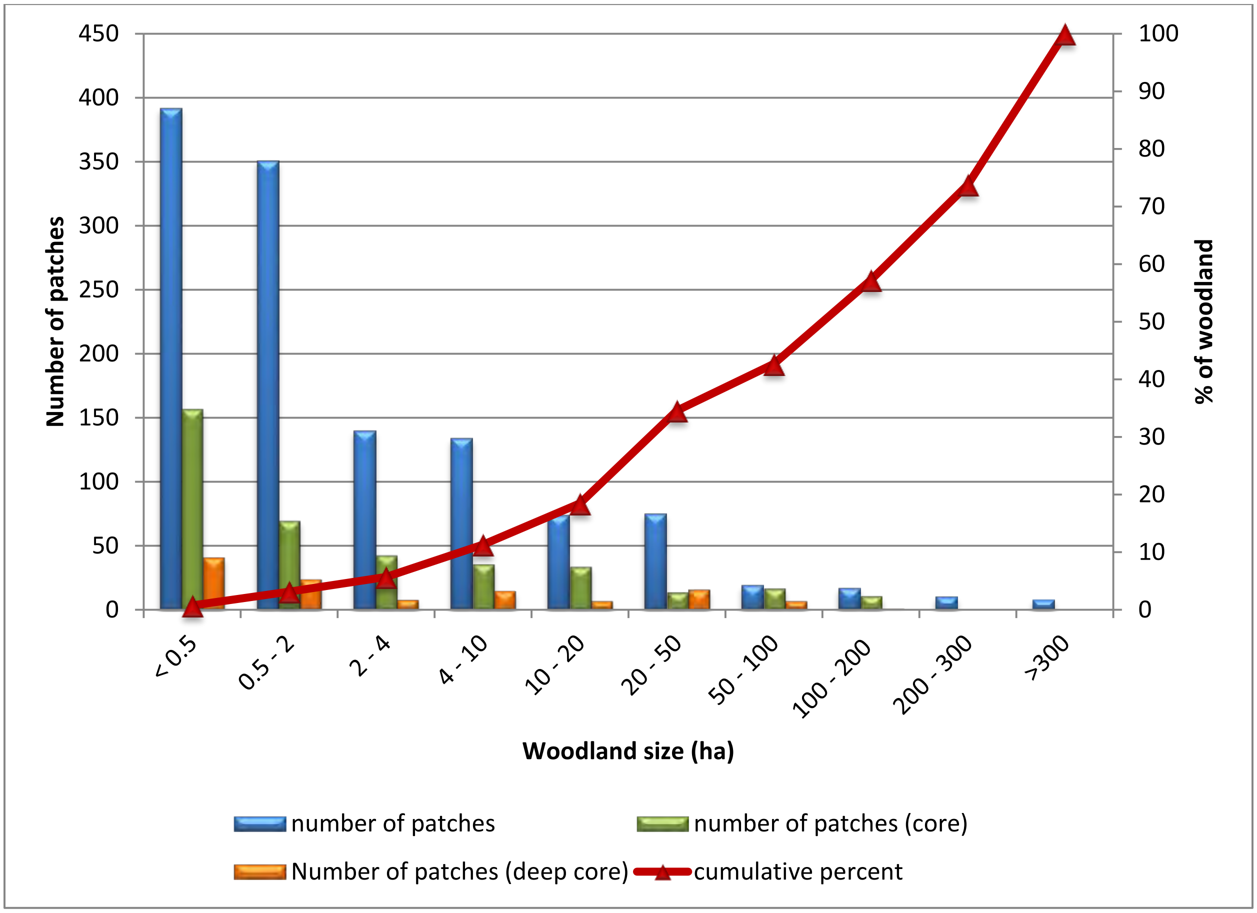

Figure 8-3: Woodland patch size distribution in the Whites Creek and Talbot River subwatersheds

Despite the recent evidence of the importance of total forest area for the preservation of wildlife, the importance of maintaining physical connectivity between woodlands should not be overlooked. Some forest-dwelling species, particularly small mammals, amphibians, and plants, require contiguous forested habitat to allow them to move from one habitat patch to another. Species which are unable to disperse in this way are somewhat vulnerable to local extinction, caused by factors such as inbreeding depression, disease epidemic, or mere chance.

8.2.2 Wetlands

The Provincial Policy Statement defines wetlands as lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs, and fens. The study area contains all of these wetland types.

Wetlands provide numerous functions for an ecosystem. These include (OMNR, 2010):

- **Natural water filtration:** by removing contaminants, suspended particles, and excessive nutrients, wetlands improve water quality and renew water supplies
- **Habitat:** wetlands provide nesting, feeding and staging ground for several species of waterfowl and other wildlife including reptiles and amphibians, as well as spawning habitat for fish
- **Natural shoreline protection:** these vegetated areas protect shorelines from erosion
- **Natural flood control:** by providing a reservoir, wetlands help to control and reduce flooding through water storage and retention
- **Contribution to natural cycles:** wetlands provide a source of oxygen and water vapour, thus playing a role in the natural atmospheric and climatic cycles
- **Opportunities for recreation:** these include hiking, birdwatching, fishing, and hunting

In its ‘How Much Habitat Is Enough?’ guidelines, Environment Canada (2013) recommends that, at a minimum, the greater of 10% of a watershed, or 40% of the historic wetland coverage, should be protected and restored. Subwatersheds that meet these characteristics experience greatly reduced flood frequencies, and more stable base flow. The additional benefits of wetland cover, listed above, are also maintained. In addition, improvements to water quality have been found when wetlands occupy more than 18% of a given watershed, and amphibian and fish communities are more persistent when wetlands occupy more than 30% and 50% of the total watershed area respectively (Detenbeck *et al.,* 1993; Gibbs, 1998; Brazner *et al.,* 2004). Although the Lake Simcoe Protection Plan does not set a quantitative target for wetland cover within the watershed, it identifies the “protection of wetlands” as a target, implying no further loss of wetland beyond that in existence when the LSPP came into force.

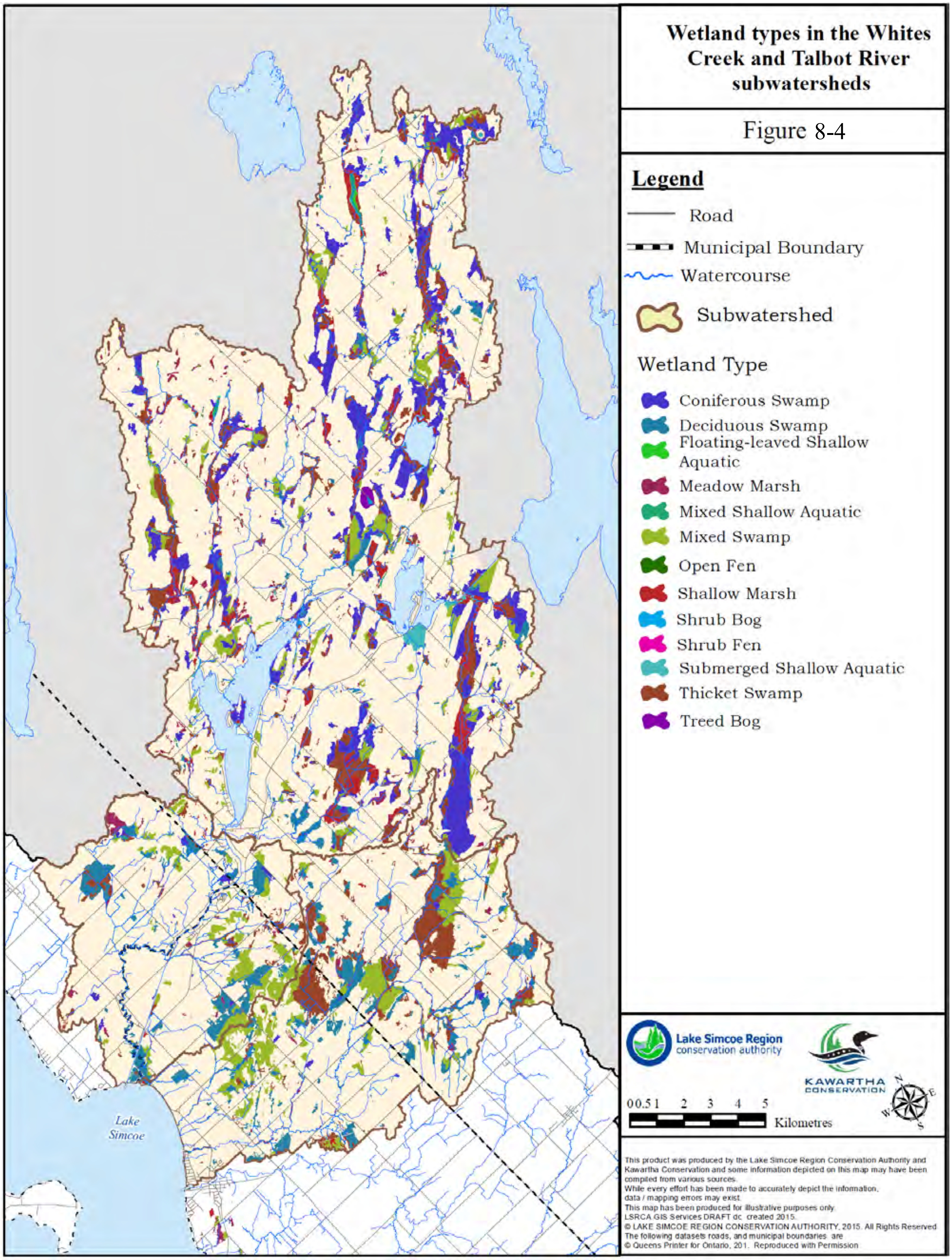

Figure 8-4: Wetland types in the Talbot River and Whites Creek subwatersheds

In a study undertaken by Ducks Unlimited Canada in 2010, it was estimated that, prior to European settlement, 20.1% of Victoria County (the area now known as the City of Kawartha Lakes, a portion of which is found in both study area subwatershed) was wetland (DUC, 2010). Wetlands were lost as settlement occurred, reducing the relative cover in Victoria County to 11.8% by 1967. Wetland levels have been fairly steady since 1967; a slight decrease was seen in the 1982 data, but this may have been due to improved mapping and analysis; and in the 2002 numbers, Victoria County has 11.3% wetland cover; fairly consistent with the 1967 level (DUC, 2010). In the Township of Ramara, a portion of which is found within the Talbot River subwatershed, pre-settlement wetland cover was estimated to be 34.9%. By 1967, this had dropped to 22.3%; and has remained relatively stable with the 2002 cover estimated at 22.6%. In the Township of Brock, a portion of which is found in both study area subwatersheds, pre-settlement wetland cover was 20.7%, dropping to 14.1% by 1967. A slight increase was seen in the estimate for 1982, and the 2002 cover was estimated to be 12.9%. It should be noted that the Ducks Unlimited study derives its estimates of wetland distribution from soil maps, and likely underestimates the current extent of wetlands in this subwatershed. Thus, they may also underestimate the amount of wetland lost since the time of settlement (pre-settlement maps may provide a better estimate).

Currently, there are approximately 8130 ha of wetland in the Talbot River subwatershed, which is 22% of the land area. There are 2500 ha of wetland in the Whites Creek subwatershed , accounting for 24% of the land area (Figure 8-4, Table 8-2).

Table 8-2: Distribution of wetland types in the Talbot River and Whites Creek subwatersheds

Wetland type	Wetland Cover – Talbot River		Wetland Cover – Whites Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Meadow marsh (MAM)	401.9	1.1	85.0	0.8
Shallow marsh (MAS)	920.3	2.5	25.5	0.2
Floating leaved shallow aquatic (SAF)	20.9	0.06	0	0
Mixed shallow aquatic (SAM)	80.7	0.2	<1	<1
Submerged shallow aquatic (SAS)	307.0	0.8	4.1	<1
Coniferous swamp (SWC)	2444.8	6.7	29.7	0.3
Deciduous swamp (SWD)	818.4	2.2	713.8	6.8
Mixed swamp (SWM)	1454.6	4.0	775.6	7.4

Wetland type	**Wetland Cover – Talbot River**		**Wetland Cover – Whites Creek**	
	Area (ha)	**Area (%)**	**Area (ha)**	**Area (%)**
Thicket swamp (SWT)	1649.4	4.5	893.2	8.5
Treed bog (BOT)	27.8	0.1	0	0
Shrub fen (FES)	3.4	<1	0	0
Treed fen (FET)	1.3	<1	0	0
Total marsh	**1730.8**	**4.7**	**114.6**	**1.1**
Total swamp	**6367.2**	**17.5**	**2412.3**	**22.9**
Total bog	**27.8**	**<1**	**0**	**0**
Total fen	**4.7**	**<1**	**0**	**0**
TOTAL	**8130.5**	**22.3**	**2526.9**	**24.0**

As can be seen from Table 8-2, both of the subwatersheds in the study area contain a number of wetland types. In the Talbot River subwatershed, the dominant wetland type is swamp, which is a wetland that is dominated by woody plants, with coniferous swamp having the largest area, followed closely by mixed swamp and thicket swamp. Swamps are also the most prevalent wetland type in the Whites Creek subwatershed, occupying 95% of the wetland area. Thicket swamp, mixed swamp, and deciduous swamp are the most common types found in the subwatershed. Of particular note is that the Talbot River subwatershed contains small areas of both fen and bog habitat. While these wetland types are common in northern Ontario, they are considered to be relatively rare in southern Ontario. Both habitat types are peatlands, with bogs being fed by rainwater and fens being fed by groundwater; and can be home to unique species including pitcher plants and sundews.

Like forests, wetland size and proximity to other natural areas has a significant influence on some wildlife species and ecological functions (e.g. Detenbeck *et al.,* 1993; Gibbs 1998; Guadagnin & Maltchik, 2006). Contiguous wetland areas have been calculated and the distribution of wetland patch sizes is displayed in the graph

What is a Provincially Significant Wetland?

The Ontario Wetland Evaluation System was developed by the Ontario Ministry of Natural Resources (1993). It was implemented in a response to an increasing concern for the need to conserve wetland habitats in Ontario. The wetland evaluation system aims to evaluate the value or importance of a wetland based on a scoring system where four principal components each worth 250 points make a total of 1000 possible points.

The four principal components that are considered in a wetland evaluation are the biological, social, hydrological, and special features. Wetlands which score 600 or more total points (or 200 points in the biological or special feature components) are classified as being Provincially Significant. The Province of Ontario, under the Provincial Policy Statement (PPS) protects wetlands that rank as Provincially Significant. The PPS states that *"Development and site alteration shall not be permitted in significant wetlands."*

below. While the total area of wetland represents the amount of wetland completely within the subwatershed, the number of patches also includes any patches touching the subwatershed boundary. This methodology was used to avoid underestimating the number of large patches.

There are approximately 8130 ha of wetland in the Talbot River subwatershed, which is approximately 22% of the landscape (Table 8-2). In the Whites Creek subwatershed, the 2527 ha of wetland occupy approximately 24% of the subwatershed area. There are wetlands spread throughout the Talbot River subwatershed, but the largest wetland areas can be found in the Raven Lake Provincially Significant Wetland (PSW) in the northeast, the Talbot River PSW in the middle of the upper portion of the subwatershed, the Sedge Wren Marsh PSW in the northern portion, the Butternut Creek PSW near the border with the Whites Creek subwatershed, and the Talbot Rivermouth PSW at the outlet into Lake Simcoe. The Grass Creek PSW is a long, narrow stretch of wetland that is straddles the boundaries of the Talbot River and Whites Creek subwatersheds; this is the only PSW found within the Whites Creek subwatershed. Other wetlands within the watershed include the Argyle Northwest Locally Significant Wetland, which is found in the centre of the subwatershed, and the locally significant Eldon West Wetland Complex, which is found along the border with the lower Talbot River subwatershed. There are also patches of swamp straddling the boundary between the Whites Creek and the lower Talbot River subwatershed. These swamps, and the remainder of the wetlands in the study area, have been identified by LSRCA in their natural heritage system mapping, but have not been evaluated under the provincial system (Figure 8-4).

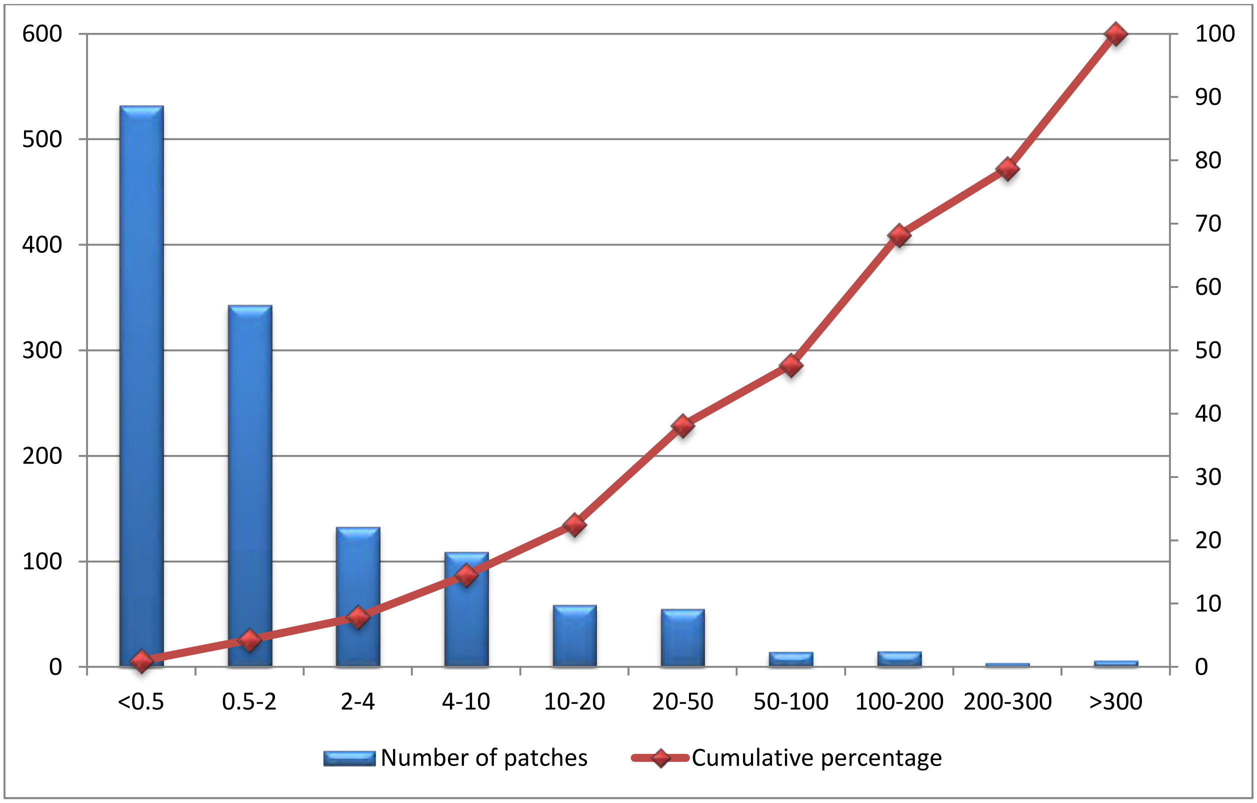

Figure 8-5: Wetland patch size distribution in the Whites Creek and Talbot River subwatersheds

Again, like woodlands, the physical connections between individual wetland patches are extremely important for some species. In the case of wetlands specifically, many species of turtles, frogs, and salamanders require both upland and wetland habitat to meet the needs of their breeding cycle. Preserving these species in a rural-urban landscape like that found in the lower sections of the study area requires that both habitat types, as well as physical connectivity between them, be protected.

8.2.3 Valleylands

A valleyland is a natural depression in the landscape that is often, but not always, associated with a river or stream. Valleylands are an important part of the framework of a watershed as the landscape is generally a mosaic of valleylands and tablelands.

Valleylands provide numerous functions for an ecosystem. These include (OMNR, 2010):

- **Ecological Values:** dispersal and migration of wildlife, microclimate for plant communities
- **Hydrological Values:** movement of surface water, groundwater discharge areas, transport of sediment and nutrients, often associated with floodplains
- **Cultural values:** location of aboriginal travel routes, influence current development patterns

In the Talbot River subwatershed, approximately 2850 ha (or 7.8%) of the land area has been identified as valleyland. Much of this is located in the upper portion of the subwatershed, particularly along watercourses in the northeast section, with smaller sections spread throughout. There is a small section in the mid-reaches of the lower Talbot River subwatershed. Very little area, only 18 ha (or 0.2 % of the subwatershed), has been identified as valleyland in the Whites Creek subwatershed. These small patches can be found in the upper, eastern part of the subwatershed (Figure 8-6).

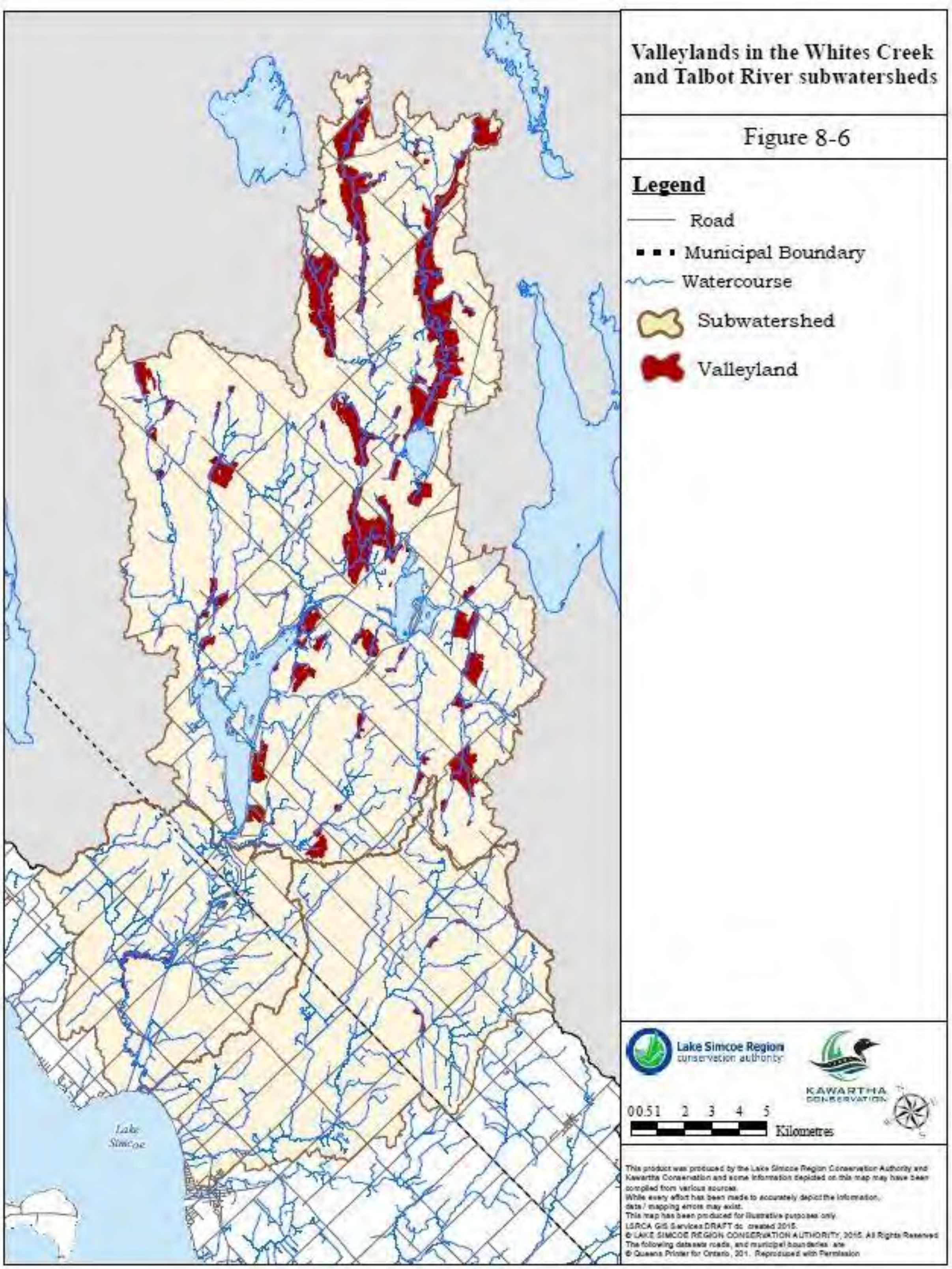

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Figure 8-6: Valleylands in the Talbot River and Whites Creek subwatershed

8.2.4 Riparian and shoreline habitat

The term riparian refers to the area of land adjacent to a stream, river, or lake. These areas provide important fish and wildlife habitats, such as natural linkages among different habitat features that create critically important wildlife migration corridors (Environment Canada, 2004).

Riparian vegetation contributes to ecological function within a watershed in a number of ways:

- The flow of stormwater is slowed, causing sediment to be deposited on land rather than in the river or stream
- The slower moving stormwater has increased opportunity for infiltration into the groundwater, replenishing aquifers and helping to maintain baseflow
- The roots of the plants absorb some of the contaminants contained in stormwater, preventing them from reaching the waterway
- Erosion of the streambank is prevented, as the roots help to keep the soil in place
- Vegetation provides shade, helping to maintain cool stream temperatures
- Falling debris (branches, leaves) from the riparian vegetation provide food and shelter for benthic invertebrates and fish
- The linear nature of these features are extremely important to migrating birds and other terrestrial wildlife travelling throughout the watershed
- The seasonal flooding of most riparian areas provides habitat to specialized plant communities that may not be found elsewhere in the watershed

Although neither the Lake Simcoe Protection Plan nor the Lake Simcoe Integrated Watershed Management Plan identify a quantitative target for natural cover along the Lake Simcoe shoreline, the LSPP identifies “no further loss of natural shorelines” as a management target.

The shorelines throughout much of the study area have experienced a great deal of development pressures and shoreline manipulation. Along the Lake Simcoe shoreline, only 13% of the area within a 30 metre buffer remains in natural vegetation, with the remaining area being comprised of urban (71%) and rural/agricultural (6.6%) land uses. As the distance from the shoreline increases, the proportion of natural heritage cover also increases somewhat, with 23% natural cover at 120 m and 27% at 200 m, while the percentage of urban land uses decrease with increasing distance and the amount of rural/agricultural land use increases. These numbers are reflective of the high demand for properties directly on or adjacent to the shoreline.

Levels of natural heritage cover along the shoreline of Canal Lake are relatively higher, with about 58% of the 30 metre buffer in natural heritage cover. Thirty-three percent of this area is urban, which would include recreational properties, and 5% is agricultural. At 120 m from the shoreline, these levels remain relatively consistent, but at 200 m natural cover increases significantly to 76%, while urban drops to 16%. Agriculture drops to just slightly less than 5% at this distance.

In Mitchell Lake, natural heritage cover constitutes 64% of the 30 metre buffer area, with urban at 25%, and rural/agriculture at 9%. As with Canal Lake, these numbers remain fairly consistent at the 100 metre distance, but at 200 metres natural heritage cover increases to 76%, urban cover drops to 8%, and rural/agriculture exhibits a slight increase to 14%.

The Lake Simcoe Integrated Watershed Management Plan (LSRCA, 2008) aspires to have all streams within the watershed naturally vegetated, with a 30 metre buffer containing natural vegetation on either side of the watercourse. Although the Lake Simcoe Protection Plan does not specify a quantitative target, it sets a target of “naturalized riparian areas on Lake Simcoe and along streams,” referring to a minimum to a 30 m width along watercourses and the Lake Simcoe shoreline. In its ‘*How Much Habitat is Enough’* (2013) document, Environment sets a guideline of 75% natural vegetation within a 30 metre buffer on either side of a watercourse.

With its extensive natural heritage features, the Talbot River subwatershed has 81% of the riparian buffers along its watercourses are in natural heritage cover; exceeding the Environment Canada target. This number drops somewhat when looking at wider buffer widths, with the 120 metre and 200 metre widths having 75% and 72% natural cover, respectively. There are significant differences between the riparian cover in the lower portion of the Talbot River, where a higher proportion of the land has been converted from natural cover, in comparison with the upper portion of the Talbot River, which has remained largely natural. The natural cover within the 30 metre buffer in the lower section is 51.5%, dropping to 41% at 120 metres, whereas these same buffer widths have 91% and 86% natural cover in the upper Talbot River (Figure 8-7).

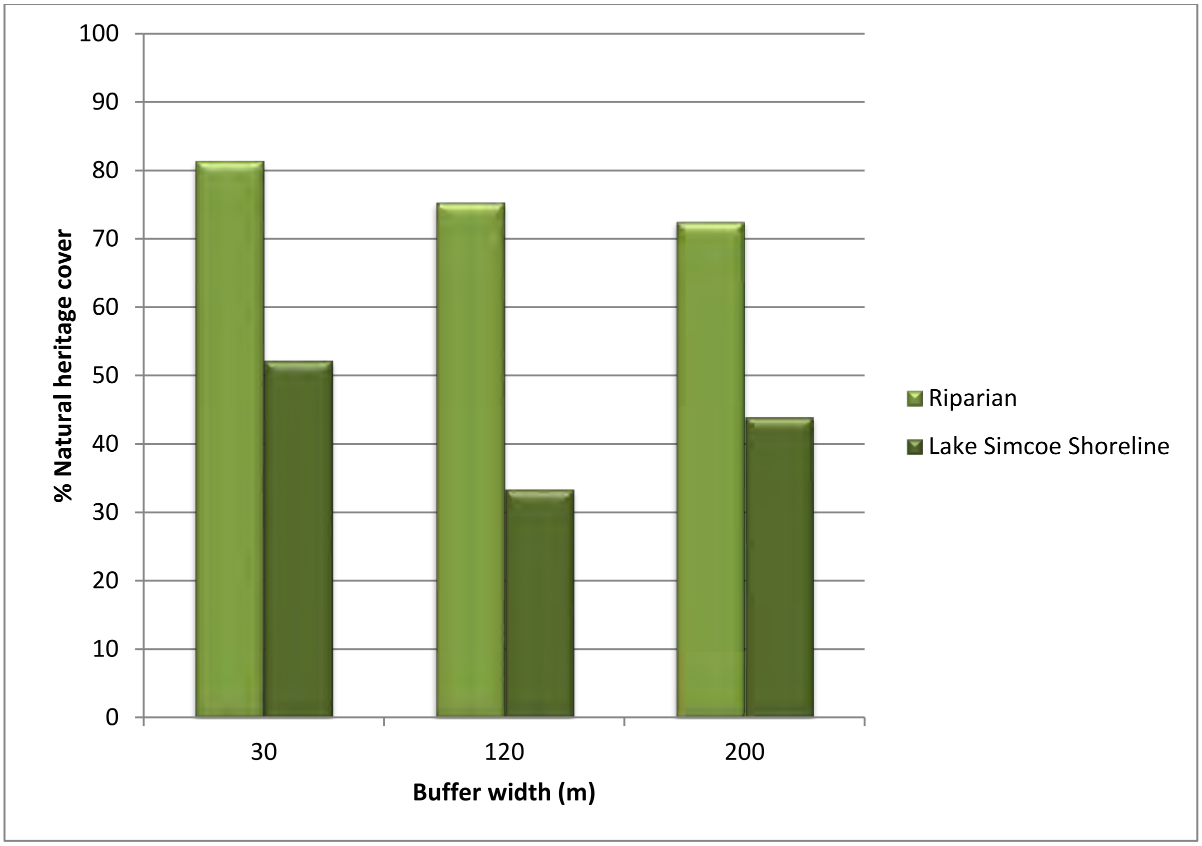

Figure 8-7: Analysis of natural heritage cover within 30 metre, 120 metre, and 200 metre buffer widths for streamside riparian and shoreline areas for the Talbot River subwatershed.

The Whites Creek subwatershed has a comparatively lower level of natural cover within the 30 metre riparian buffer along its watercourses, with 52.9% of this area occupied by natural heritage features. At 120 metres, this number drops to 38.5%, and is 34.6% at 200 m (Figure 8-8).

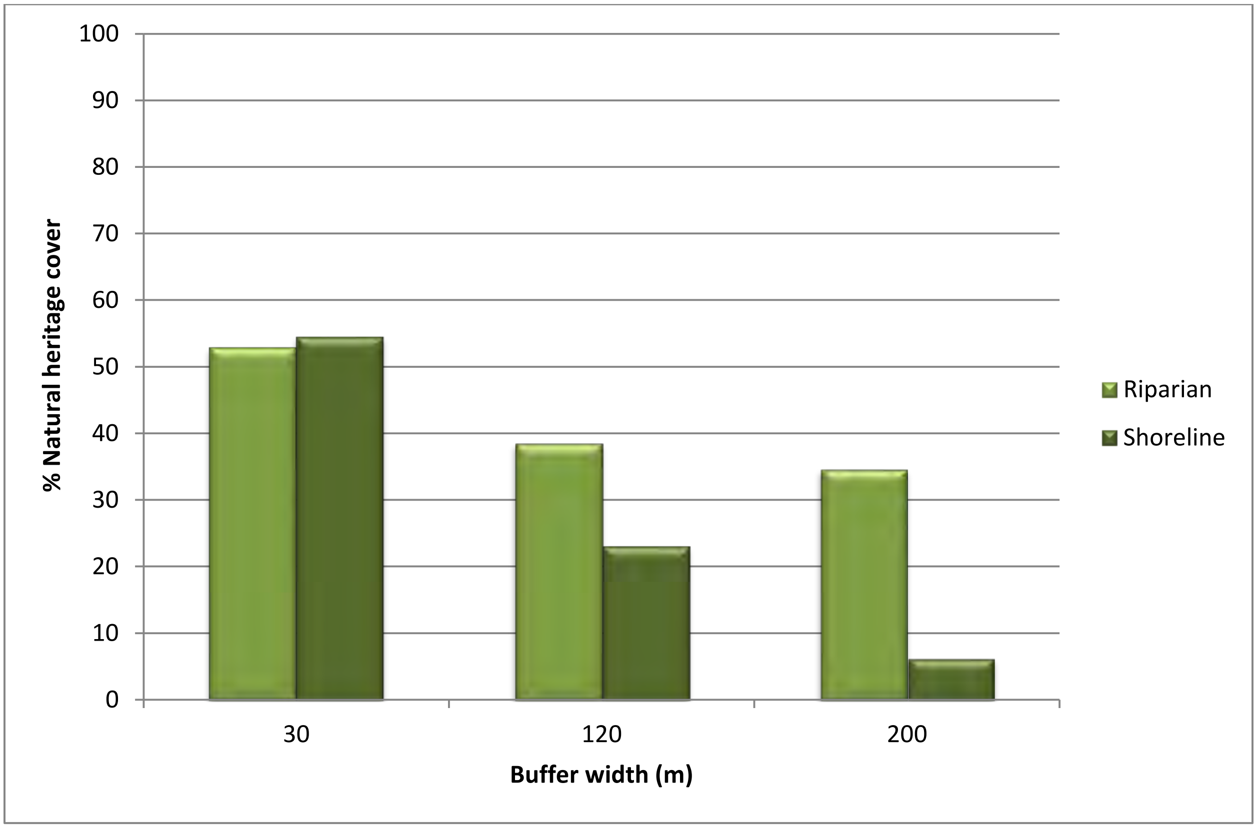

Figure 8-8: Analysis of natural heritage cover within 30 metre, 120 metre, and 200 metre buffer widths for streamside riparian and shoreline areas for the Whites Creek subwatershed.

It may be difficult to achieve a 30 metre vegetated buffer in some parts of these subwatersheds, particularly in the agricultural areas. For some, it can mean taking large swaths of land out of production; causing a significant impact on the livelihood of the farmers managing the land. Maintaining a buffer of this size can also make it difficult to maneuver machinery around smaller pieces of property. It is important in these circumstances to recognize the importance of maintaining as wide a vegetated buffer as possible, on one or both sides of the watercourse, both for the health of the stream and to prevent the loss of farm land and soils through erosion. A balance between these competing demands should be sought wherever possible.

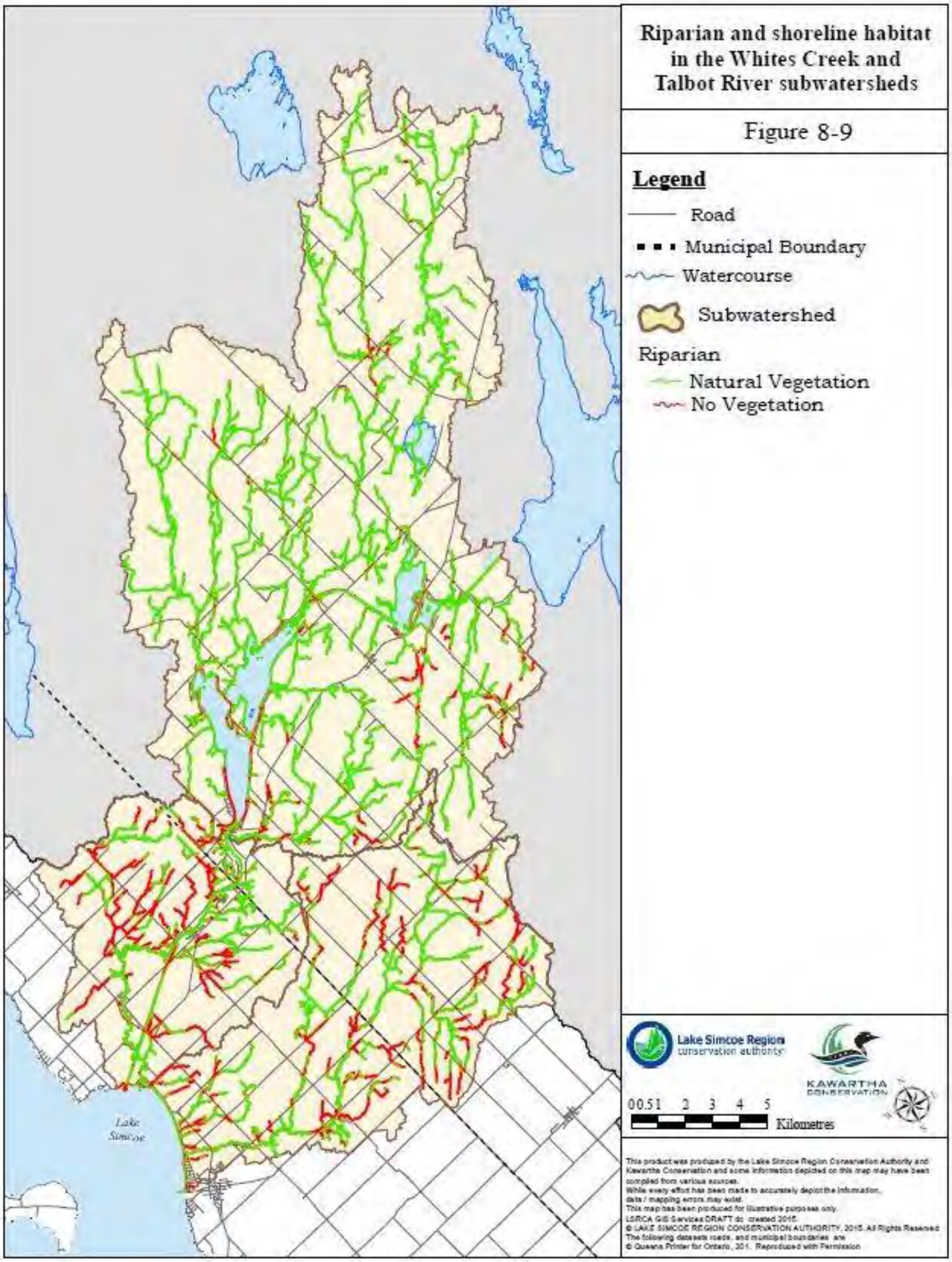

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Figure 8-9: Riparian and shoreline habitat in the Whites Creek and Talbot River subwatersheds

8.2.5 Areas of Natural and Scientific Interest

To encourage the protection of unique natural heritage features and landscapes in southern Ontario, the Ontario Ministry of Natural Resources and Forestry developed the provincial Areas of Natural and Scientific Interest (ANSI) program.

There are two types of ANSIs, life science and earth science. Life science ANSIs are based on biological and ecological characteristics. Earth science ANSIs are based on geological landform characteristics.

The selection criteria used by the MNRF to define ANSIs are:

1. Representation;
2. Diversity;
3. Condition;
4. Ecological function; and
5. Special features.

Candidate sites of each of a list of landform types within each ecodistrict are evaluated and ranked using the criteria above. Those scoring the highest are deemed to be the ‘best’ example of that landform type in that ecodistrict, and are classified as a Provincially Significant ANSI, and are protected under the Provincial Policy Statement. Candidates with the second highest score are identified as a Regionally Significant ANSI, and are afforded protection in some parts of the province.

There are eight ANSIs falling within the boundaries of the Talbot River subwatershed, including the Kirkfield Beach, Quarry and Liftlock, and the Gamebridge Quarry, all of which are provincially significant. The Victoria Road Bog (regionally significant) is also found in this subwatershed. There are three ANSIs, one confirmed and two candidate, that fall across the boundaries of both study area subwatersheds, including the Eldon Site (confirmed, regionally significant), the Beaverton Alvar and Wetlands (candidate, provincially significant), and the Bolsover raised beach (candidate, regionally significant) (Table 8-3). The Beaverton Alvar and Wetlands are identified as part the Kawartha Lakes Wetlands target area for the LSRCA’s land acquisition program (further detail on this program is provided in section 8.4.1.2)

Table 8-3: ANSIs found in the Talbot River and Whites Creeks subwatersheds

Subwatershed	ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)
Talbot River	Kirkfield Beach	Provincial	Confirmed	Earth Science	905.2
Talbot River	Kirkfield Quarry	Provincial	Confirmed	Earth Science	21.2

Subwatershed	ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)
Talbot River	Kirkfield Liftlock	Provincial	Confirmed	Earth Science	18.8
Talbot River	Gamebridge Quarry	Provincial	Confirmed	Earth Science	10.2
Talbot River	Victoria Road Bog	Regional	Confirmed	Life Science	241.6
Talbot River	Verulam Formation (contact)	Regional	Confirmed	Earth Science	<1
Talbot River	Lake Simcoe Moraine (Logan’s Hill)	Regional	Confirmed	Earth Science	<1
Talbot River	Johston Lake Bog	Regional	Candidate	Life Science	22.8
Both	Eldon Site (Verulam Formation)	Regional	Confirmed	Earth Science	8.1
Both	Beaverton Alvar and Wetlands	Provincial	Candidate	Life Science	10,029.5
Both	Bolsover (raised beach)	Regional	Candidate	Earth Science	3,595.4

8.2.6 Species of conservation concern

The frequency of occurrence of all native species of plants, mammals, birds, amphibians, reptiles, and fish in Ontario have been documented by the Ministry of Natural Resources using a series of S-ranks (or Sub-national ranks). Those designated as being provincially rare (i.e. ranked S1-S3) are those which are typically considered as being of ‘conservation concern.’ Other species may be further protected by designation as being Endangered, Threatened, or of Special Concern under the Federal *Species at Risk Act* or Provincial *Endangered Species Act*.

Species of conservation concern thought to be found in the Talbot River and Whites Creek subwatershed include:

- Eastern loggerhead shrike (*Lanius ludovicianus migrans*; S3B; Endangered); a robin-sized bird that typically prefers pastures and other grasslands with few small trees and shrubs. In Ontario, these birds are found only in a few areas, one of which is the Carden alvar, where it thrives on the short grass and exposed bedrock, which makes it easier for them to spot prey.
- Blanding's Turtle (*Emydoidea blandingii*; S3; Threatened), which live in shallow water, usually in large wetlands;
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern), which inhabit large wetlands;
- Black tern (*Chlidonias niger*; S3B, Special Concern), which build floating nests in loose colonies in shallow marshes;
- Bobolink (*Dolichonyx oryzivorus*, Threatened), which nest in hayfields and other grasslands;
- Golden-winged warbler (*Vermivora chrysoptera;* S4; Special Concern), which nest in areas with young shrubs surrounded by mature forest, or recently disturbed areas;
- Whip-poor-will (*Caprimulgus vociferus*; S4B; Threatened), usually found in areas with a mix of open and forested areas.
- Canada warbler (*Wilsonia canadensis*; Special Concern. Possible sighting noted in 2nd Breeding Bird Atlas). This species resides in moist thickets, nesting in riparian thickets or brushy ravines.
- Least bittern (*Ixobrychus exilis;* Threatened). There are records of this small secretive bird nesting in marshes along the margin of Canal Lake
- Milksnake (*Lampropeltis triangulum*; Special Concern). This non-venomous snake lives in alvar areas, along forest edges, and in farm fields.
- Eastern ribbonsnake (*Thamnophis sauritus*; Special Concern). This small relative of the garter snake lives near marshes and other wet areas.
- Butternut (*Juglans cinerea*; Endangered). Butternut can be found in a wide range of habitats, and although it is still somewhat frequently encountered in the Lake Simcoe watershed, its numbers are declining across its range due to butternut canker (*Ophiognomonia clavigignenti-juglandacearum*), a non-native fungus that infects and kills otherwise healthy trees.

8.2.7 Alvars

Alvars are open habitats with a limestone base, which has a very thin layer of soil, if there is soil present. Their unique geologic and physical characteristics, provides habitat for species that can only be found in this type of habitat. They are extremely rare habitats, only being found in a few locations globally, including northeastern North America, islands off the coast of Sweden, the Baltic Region of eastern Europe, and the United Kingdom and Ireland (Nature Conservancy Canada, 2015). Approximately three quarters of the alvars in North America are found in Ontario, with the Carden Alvar, a portion of which falls within the Talbot River subwatershed, being one of these important areas.

The Carden Alvar contains alvar grasslands, shrublands, forests, and wetlands, and has been found to be critical to the survival of globally rare communities and nationally threatened species such as the nationally endangered eastern loggerhead shrike. It is known to support 450 species of plants, 142 butterfly and dragonfly species, and 238 bird species (Nature Conservancy, 2016). The Carden Plain has been identified as an Important Bird Area (IBA). These are areas that are:

- Places of international significance for the conservation of birds and biodiversity;
- Recognized worldwide as practical tools for conservation;
- Distinct areas amenable to practical conservation action; and
- Identified using standard criteria.

The IBA program notes that, in Canada, these areas have been used to design conservation reserve networks, and to prioritize lands for acquisition. They have also been used by governments in assessing impacts and establishing guidelines for proposed development projects (Important Bird Areas Canada, 2016).

This area has been identified as an IBA because it supports nesting Eastern Loggerhead Shrikes, one of the few areas in the country that remain, as well as a number of other nationally threatened species, including red-shouldered hawk, short-eared owl, least bittern, red-headed woodpecker, and yellow rail. The Carden Plain is also noted for its significant concentrations of grassland birds; it provides ideal habitat for these species (Important Bird Areas Canada, 2016).

The IBA program identifies the threats to the area as being loss of habitat due to land use changes, natural succession, and the expansion of quarry operations. Other factors include road mortality, the use of pesticides at neighbouring agricultural areas, and the use of dust suppressant on roads (Important Bird Areas Canada, 2016).

A National Recovery Plan has been prepared for loggerhead shrikes, and identifies the Carden Plain as one of the sites that should be monitored for loggerhead shrikes. A captive breeding program has been undertaken through Wildlife Preservation Canada in order to increase the population numbers, and regular monitoring of the population is undertaken. In addition, the Couchiching Conservancy has been actively involved in acquiring and maintaining properties within the Carden Plain to preserve and enhance habitat for this important species.

The City of Kawartha Lakes official plan provides some protection for alvars and their adjacent areas, stating that development and site alteration is not permitted unless it can be demonstrated though the completion of an environmental impact study that the alvar is not significant wildlife habitat, or that there will not be negative impacts on the features or functions of the significant wildlife habitat if it is determined to be significant wildlife habitat.

8.2.8 Grasslands

Even grasslands dominated by non-native plants (i.e. hayfields or old-field ecosystems) can be home to a number of at-risk species including monarch butterflies, bobolinks, and eastern meadowlark (*Sturnella magna*; recommended by COSEWIC, not yet listed). In fact, grassland-dependent wildlife are experiencing significant population declines in Ontario (McCracken, 2008). There are scattered grasslands throughout the study area, primarily on the margins of woodlands, swamps, and agricultural areas; these areas comprise just over 28%* of the Talbot River subwatershed area, and 6% of Whites Creek (Figure 8-1, Table 8-4).

Table 8-4: Distribution of grassland types in the Whites Creek and Talbot River subwatersheds

Grassland type	Grassland Cover – Talbot River*		Grassland Cover – Whites Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Cultural meadow (CUM)	4057.0	11.1	333.7	3.2
Cultural thicket (CUT)	6226.4	17.1	317.3	3.0
Total	**10,283.4**	**28.2**	**651.0**	**6.2**

* Land cover mapping is being updated to more accurately reflect the distinction between grassland and alvar habitat. These numbers will be updated when this update is complete.

Key Points - Current Terrestrial Natural Heritage Status:

- The Talbot River subwatershed contains 76% natural heritage cover, with 26% wetland (this includes wooded wetlands), 19% upland forest, and 28% grassland/alvar. The Whites Creek subwatershed has 38% natural heritage cover, consisting of 24% wetland, 7% upland forest, and 6% grassland.
- The Talbot River has very healthy levels of natural riparian cover, with 82% of the area within a 30m buffer along its watercourses consisting of natural heritage cover. The Whites Creek subwatershed had a relatively lower level, at 53%. Environment Canada recommends that 75% of this area be in natural cover (EC, 2013).
- There is a wide range of forest patch sizes in the study area, from <0.5 ha to over 900 ha, with a number of patches containing forest interior habitat, which supports a number of sensitive bird species. More than 25% of the forest area can be found in the eight largest patches, and more than 50% of the forest area is in patches larger than 100 ha. In addition, there are also several large patches of deep forest interior, which is the core forest found more than 200 m from the forest edge.
- There is also a wide range of wetland patch sizes. The majority of the patches are smaller than 50 ha in size; however over 50% of the wetland area is contained within 25 wetland patches that are over 100 ha in size.
- There are a number of Species of Conservation Concern found in these subwatersheds, including the endangered Eastern loggerhead shrike, the bobolink, and whip-poor-wil. The Carden Alvar, in the Talbot River subwatershed provides habitat to a high concentration of species of concern.
- The natural heritage component of the assessments of the Talbot River and Whites Creek subwatersheds is relatively data-poor, particularly as it relates to the distribution of flora and fauna throughout the subwatershed. The exception to this is in the Carden Plain area, where the flora and fauna have been extensively studied.
- The Lake Simcoe Protection Plan allows for uneven distribution of natural heritage features (associated with the uneven distribution of people) throughout the Lake Simcoe watershed, by setting natural heritage targets for the Lake Simcoe watershed as a whole.

8.3 Factors impacting natural heritage status – Stressors

There are numerous factors that can affect terrestrial natural heritage features. They range from natural factors such as floods, fires, and droughts; to human influences, such as land use conversion, water use, the introduction of invasive species, and climate change. Natural factors are generally localized and short in duration, and a natural system is generally able to recover within a relatively short period. Some degree of natural disturbance is often a part of the life cycle of natural systems. Conversely, human influences are generally much more permanent – a forest cannot regenerate after it has been urbanized, natural communities have a great deal of difficulty recovering from the introduction of an invasive species, and wetlands may be unable to survive when their water source has been drawn down.

8.3.1 Land use change

Prior to European settlement, it is likely that the study area was almost entirely covered by upland and wetland forest. This would be consistent with what was found in neighbouring Simcoe County (Larson *et al.,* 1999; DUC, 2010). The loss of natural habitat and its conversion to agriculture and urban land use began almost immediately upon European settlement, and has been ongoing. This habitat conversion represents the most significant threat to terrestrial natural heritage features in this subwatershed.

The creation of the Trent-Severn waterway has likely also impacted the natural features within the study area. The construction of the waterway, with its locks and canals, caused flooding in some areas, creating lakes and wetlands where none existed, changing what was likely forested land. Because of its connection to Lakes Ontario and Huron, the waterway can also act as a vector for invasive species. This is more of a concern for aquatic species, but the potential also exists for the introduction of terrestrial invasive species.

While the loss of natural areas has not been as extensive in the study area as in other areas of the Lake Simcoe watershed, there has been a significant loss of natural features. While the Talbot River has an exceptionally high level of natural cover with 76%, further examination shows that the upper portion of the subwatershed accounts for a high proportion of this natural cover. When broken down into its upper and lower reaches, the portions of the Talbot River contain 84.5% and 40.8% natural cover, respectively. The majority of the loss of natural features was through their conversion to agricultural land uses. Areas of aggregate extraction and small pockets of urban area located throughout the subwatershed account for much of the remaining areas where natural features have been lost. Similar to the lower Talbot River, the Whites Creek subwatershed has retained less than half of its natural heritage cover (38% remains), with the majority of the land use change being undertaken to accommodate agriculture. There are few small pockets of urban development; the largest of these is in the area of Beaverton, along the shores of Lake Simcoe (Figure 2-2).

Natural heritage features within settlement areas are those most susceptible to land use change, as these areas are experiencing the greatest relative growth pressure, and as these areas aren’t subject to the higher level of protection provided by policies under the Lake

Simcoe Protection Plan. Ecosystem types that are under this type of pressure include deciduous and mixed forests.

Notwithstanding the above, the greatest change expected in some parts of the study area into the future will be a shift from existing agricultural land uses to more intensive land uses including residential, commercial, industrial. Thus, the greatest impacts to natural heritage features may be indirect in nature, through changes to the landscape matrix within which extant natural heritage features are situated.

Forests in urban settings are subject to stresses that forests in more rural or agricultural settings aren't, including an increase in predator pressure from house cats and racoons, increased noise levels, increased levels of ground level ozone, and an increased density of invasive non-native species. As a result, forest-dwelling songbirds and amphibians living in primarily urban landscapes tend to be much less common, and restricted from smaller forests, than those living in primarily rural landscapes (Austen *et al*., 2001; Homan *et al.,* 2004).

Similarly, wetland-dependent wildlife face additional challenges in primarily urban landscapes. As natural areas are converted to farmland, amphibians make increasing use of irrigation ponds as replacement breeding habitat for lost wetlands, making these critical wildlife habitats in some regions (Hecnar and M'Closkey, 1998). As landscapes convert to urban land uses, amphibians make similar shifts to stormwater ponds. However, stormwater ponds in many cases can be detrimental to amphibian populations, particularly if they are hypoxic, are surrounded by unsuitable upland habitat, are located near roads, or have high concentrations of petrochemicals or other contaminants. In those cases, stormwater ponds can act to decrease amphibian populations beyond the suppression caused by wetland habitat loss alone (Hamer and McDonnell, 2008).

Under the Provincial Growth Plan for the Greater Golden Horseshoe (Ontario Ministry of Infrastructure, 2012), the City of Kawartha Lake and the Township of Ramara are both slated to have some additional growth, although they are not designated as 'growth centres' under the plan. The City of Kawartha Lakes has been designated to receive an increase in population of over 30,000 people (an increase of 36%) by 2041, while the Township of Ramara is scheduled to increase by 3,725 people (an increase of 35%) within this same time frame. An analysis of current and future land uses was undertaken in 2010 by the Louis Berger Group; which looked at the future land use scenario to a horizon of 2031. This study found that the estimated growth area for high intensity development is approximately 199 ha in the lower Talbot River subwatershed (the upper Talbot was not included in this analysis), which would result in an increase of the urban area to close to 5.5% of the subwatershed area. In the Whites Creek subwatershed, the estimated urban growth area is 1798 ha, which would result in an increase in this land use to 11.6% of the subwatershed area (Louis Berger Group, 2010). As this development proceeds, there will likely be stresses associated with the loss and fragmentation of natural habitat.

The expansion and/or creation of new aggregate extraction operations in the study area is also expected to occur, and will likely have some impacts, at least to the localized areas where it occurs. This is of particular concern in the Carden Plain area, where the limestone is found close to the ground surface and is therefore ideal for easier extraction.

8.3.2 Habitat fragmentation

The conversion of natural vegetation to other land uses is perhaps the most obvious stress related to land use change, but the perforation or fragmentation of extant natural vegetation can be a significant stress as well. One issue of particular concern in urban or suburban areas is the encroachment of estate residential development into forests, and the related decline in forest interior conditions. In some parts of North America, exurban development (also known as estate residential development, or non-farm rural land use) is becoming a significant proportion of all development. Many people prefer to locate their houses in or near natural heritage features for the aesthetic appeal, the privacy, and the access to outdoor recreational opportunities. As demonstrated in Figure 8-10, this type of development not only reduces the amount of habitat on the landscape, but can have disproportionate effects on interior forest habitat (i.e. that area more than 100 m from a forest edge).

Based upon studies of birds and mammals, it has been found that this type of development increases habitat that supports human-adapted species at the expense of more sensitive species (Odell and Knight, 2001). Findings by Friesen *et al*. (1998) found that that the number of houses surrounding a forest undermined its suitability for Neotropical migrants. These species consistently decreased in diversity and abundance as the level of adjacent development increased. Similarly, non-native vegetation is much more common in woodlots near exurban development than in woodlots in more rural or forested landscapes (Hansen *et al.,* 2005).

Figure 8-10: Example of loss of forest interior resulting from estate residential development

In the Lake Simcoe watershed as a whole, this type of development has a significant impact on interior forest habitat, with an estimated loss of about 8% of this highly productive wildlife habitat to estate residential development (LSRCA, 2008).

The Official Plan of the City of Kawartha Lakes contains policies encouraging that development is located such that it has minimal impact on woodlands. In the Township of Ramara's Official Plan, one of the objectives is to preserve woodlands for their natural area functions including interior bird habitats and wildlife corridors, and the plan identifies woodland cores and corridors as part of the Core Areas and Corridors as part of its natural area framework, with the policies setting limits on what can be undertaken in these areas.

8.3.3 Shoreline development

The Lake Simcoe, Canal Lake, and Mitchell Lakes shorelines have long been a draw for cottage and housing development, but this type of development has impacts on native species and habitats as well. The impacts of shoreline development on fish and aquatic habitats (as described in **Chapter 5 – Aquatic Natural Heritage**) is perhaps best documented, but the clearing of vegetation along shorelines has also been associated with a decline in native songbirds (Clark *et al.,* 1984; Henning and Remsburg 2009), amphibians (Henning and Remsburg 2009), and small mammals (Racey and Euler, 1982), and an increase in non-native species.

The lakeshore has been subject to significant urban development. Currently, only 13% of the Lake Simcoe shoreline along the study area remains under natural cover. Natural cover along the shoreline is higher in Canal and Mitchell Lakes, with 58% and 69%, respectively. Much of the shoreline area that has been changed from natural cover is defined as urban, with much of this, particularly along Lake Simcoe, being found in a narrow band along much of the shoreline. There are also some areas of agriculture, rural development, and manicured parklands.

8.3.4 Road development

In addition to the loss and fragmentation of habitat associated with land use change, the development and use of roads can have impacts on natural heritage values as well. Roads can have significant impacts on wildlife communities and the ability of wildlife to move throughout their home ranges. Direct mortality of animals related to roads can be particularly significant for species such as frogs, turtles, and salamanders, which are relatively slow moving but need to travel from wetland to upland areas to fulfil the requirements of their breeding cycle (Fahrig and Rytwinski, 2009). Even more mobile animals such as mammals (Findlay and Houlahan, 1997) and birds (Kociolek *et al.,* 2011) can be subject to increased mortality along roads. In addition to the direct impacts associated with mortality, roads can decrease the value of adjacent natural areas as breeding habitat, by increasing noise levels and increasing illumination at night (Kociolek *et al.,* 2011), and by acting as a source of chloride or petrochemicals to amphibian breeding ponds (Fahrig and Rytwinski, 2009). Conversely of course, some scavenger species such as American crows and red-tailed hawks respond positively to the presence of roads, as roads provide a consistent food source for them.

Wildlife collision 'hotspots' that have been noted in the study area, based on data provided by Ontario Nature and the Toronto Zoo, include:

City of Kawartha Lakes

- In the vicinity of the Provincially Significant Sedge Wren Marsh; on Wylie Road between Alvar Road and McNamee Road (casualties include several garter snakes, as well as Dekay's brown snake, green frog, midland painted turtle, northern water snake, smooth green snake, American toad); Kirkfield Road between Centennial Park Road and Fitzgerald Road (Northern water snakes and Eastern garter snakes)
- Doyle Road between North Mountain Road and Victoria Road (casualties include easter garter snake, northern water snake, red-bellied snake, Dekay's brown snake, American bullfrog)
- Victoria Road between Doyle Road and Talbot Road (Eastern garter snake, northern water snake, red bellied snake)

Township of Brock

- A number of collisions within the Provincially Significant Beaverton River wetland complex (Northern leopard frog, Midland Painted Turtle, other turtles – species not indicated)

Research in the United States and Europe suggests that this 'road effect zone' can extend for hundreds of metres from roads (Forman and Deblinger, 2000), suggesting that many of the natural heritage features in the study area may be exhibiting these types of impacts, although there are many large tracts of natural features that will not likely be showing impacts yet. If these effects are not considered, development in the subwatershed will increase the number of natural areas vulnerable to these effects.

8.3.5 Changes to the hydrologic regime

Although the current status of, and stressors on, surface water hydrology are dealt with more fully in **Chapter 5 – Water Quantity**, changes to the hydrological regime in the subwatershed can have impacts on the extent and quality of natural heritage features as well, particularly wetland and riparian ecosystems. These ecosystems and their associated vegetation are dependent upon natural variations in hydrologic conditions such as baseflow rates, seasonal flooding, and drainage. Any alteration to the hydrologic regime can lead to loss or changes in the condition of these ecosystem types. Factors leading to changes in hydrologic regime include loss of upland and wetland natural heritage features, and their conversion to impervious cover. This relationship is discussed more fully in Chapter 5.

Perhaps less obvious, but also important from a natural heritage standpoint, is the introduction of agricultural drains, particularly in remnant natural heritage features. When agricultural drains are introduced to swamps or mesic forests, it results in a lowering of the water table. This lowering of the water table changes the infiltration rate of surface water; in some cases, enough to change the hydroperiod of vernal pools. These small shallow and temporary water bodies are critical breeding habitat for a range of frog and salamander species, as well as stopover habitat for migratory waterfowl. In some areas, the lowering of the water table caused by agricultural drains causes the vernal pools to dry up more quickly, exposing the eggs and tadpoles.

As soil moisture is a major determining factor for the presence or absence of many plant species, lowering the water table can also have significant impacts on plant communities in remnant natural areas. Further, in areas of residential development, many of the plants which colonize rapidly changing areas such as this are non-natives.

While there are a handful of municipal drains in lower portions of the study area, generally this is not a significant issue. Some of these drains do flow through areas classified as swamps, and may be having some impact; however most are quite short, and their impacts are likely not widespread.

8.3.6 Invasive species

Non-native species can be a significant threat to biodiversity as well. Some species, when in the absence of predators or disease to check the growth of their populations, can become extremely abundant. This is particularly the case with species which aren't native to North America. Many of these species, when introduced as a garden plant or house pets, or inadvertently through international shipping, can become extremely aggressive invasives. The most aggressive of these can reduce biodiversity by outcompeting native species for resources such as food (e.g. red-eared slider), breeding habitat (e.g. house sparrow), sunlight (e.g. dog-strangling vine), or through direct consumption (e.g. emerald ash borer).

Little is known about which terrestrial invasive species are present in the Talbot River and Whites Creek subwatersheds; however this is no doubt reflective more of a lack of documentation, than a lack of invasive species. The Carden Alvar area has been more well studied than much of the rest of the study area, and the highly invasive dog-strangling vine (*Vincetoxicum rossicum,* Figure 8-11) has been noted in the area. The Couchiching Conservancy has undertaken efforts to control this species in order to protect this unique and important habitat.

Figure 8-11: Dog strangling vine along a trail (photo: Greg Bales, OMNR)

The Lake Simcoe Protection Plan recommends the development and implementation of a monitoring program which will document the presence and extent of terrestrial invasive species in the Lake Simcoe watershed. This monitoring program has the potential to make significant contributions to filling this data gap.

The Lake Simcoe Protection Plan has also developed a 'watch list' of invasive species which are not yet in the Lake Simcoe watershed, but which, if they do appear here, are expected to have significant negative impacts on natural areas. Terrestrial species on that list are: kudzu (*Pueraria lobata*), emerald ash borer (*Agrilus planipennis*), Asian long-horned beetle (*Anoplophora glabripennis*), chronic wasting disease (which affects deer), oak wilt, and white nose syndrome (which affects bat populations).

Within five years of the release of the LSPP (i.e. 2014), the MNRF was to develop response plans to address invasive species in the watershed, and those on the watch list (Figure 8-12).

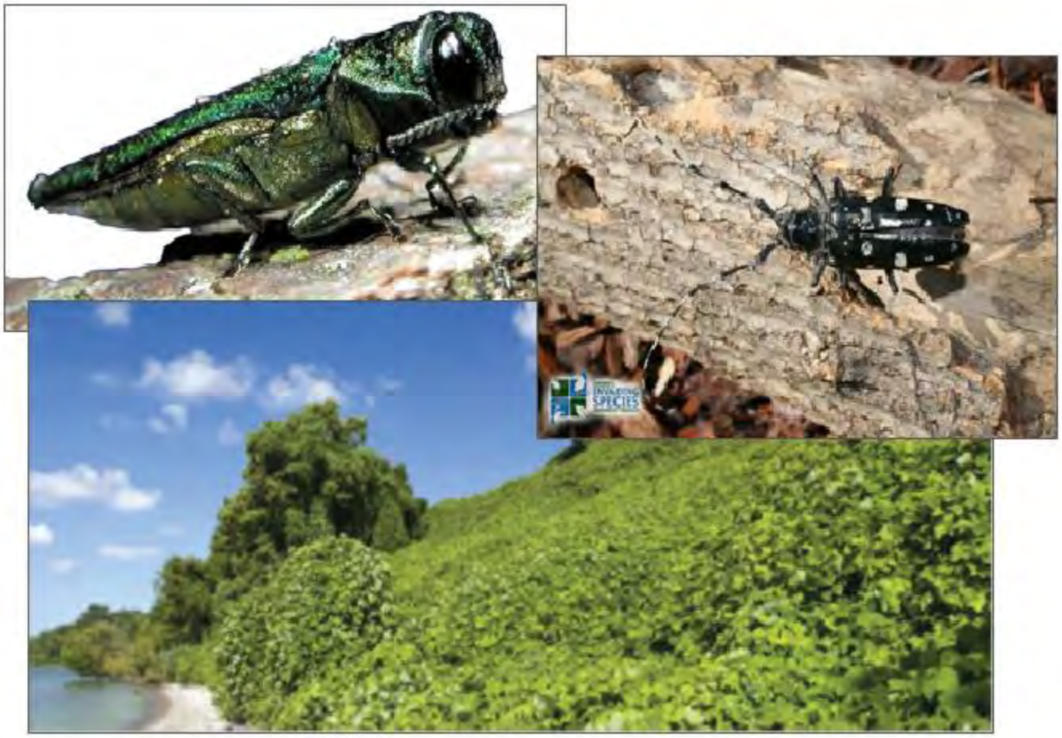


Figure 8-12: Invasive species on Lake Simcoe Protection Plan 'watch list' – emerald ash borer (top left, photo: CFIA website, David Cappaert, Michigan State University); Asian long-horned beetle (centre-right, photo: David Copplefield, Ontario's Invading Species Awareness Program); Kudzu (bottom, photo: Sam Brinker, MNRF)

8.3.7 Trophic cascades

Land use changes can not only affect wildlife populations directly through the loss or disturbance of habitat, they can also be affected indirectly as significant decreases or increases in populations of one species affect species elsewhere in the food web, through processes known as "trophic cascades."

An example of such a trophic cascade is the decrease in songbirds that has been observed as top carnivore populations decrease (Crooks and Soulé, 1999). This trophic cascade occurred because the loss of top predators (in that case coyotes), allowed populations of mid-level predators such as housecats, skunks, and racoons to increase. Although these species aren't at the top of the food chain, they are extremely effective predators, so an increase in their populations led to a significant decline in the populations of their prey (in that case, songbirds). Similar trophic cascades have been observed in wildflowers, nesting songbirds, butterflies, and other invertebrates, by high levels of selective grazing of woodland vegetation as populations of white-tailed deer increase (Cote *et al.,* 2004).

A similar trophic cascade that has recently come to light in Ontario is the decline of songbirds that feed on flying insects. This group, which includes species as diverse as swifts, swallows, nighthawks and flycatchers, has seen population declines of up to 70% in the past two decades. Although there are a lot of stresses facing these species, the only attribute they share that best explains their concurrent decline is their reliance on flying insects such as bees, wasps, butterflies, and moths as a food source. There are a number of factors contributing to the decline of these insects, including light pollution, loss of wetlands and other natural vegetation, declines in water quality, climate change, and increased use of insecticides in urban and rural settings (McCracken, 2008).

8.3.8 Recreation

Despite the social values related to outdoor recreation, if not properly managed, recreation itself can become a stressor on natural heritage features. Impacts from recreational activities can include increased soil erosion (e.g. Marion and Cole, 1996), destruction of vegetation (Cole, 1995), introduction of invasive species (Potito and Beatty, 2005), and disturbance to resident wildlife (Miller *et al.,* 1998). These impacts can be largely mitigated with the appropriate design and location of trails and other recreational features, and the management of recreational users, to ensure that motorized vehicles and off-leash dogs are prohibited from sensitive sites.

These types of issues are of particular concern in the Carden Alvar, which, due to its incredibly unique assemblage of birds, plants, and other wildlife, is a popular attraction for birders and other naturalists. Visitors to the area are encouraged to stay within designated areas and on trails in order to minimize impacts to the fragile ecosystem.

Shoreline development along Lake Simcoe, Canal Lake, and Mitchell Lake is extensive and ongoing, and can have impacts on the form and function of natural features in the area. Whenever possible, landowners in these areas should be mindful of the potential impacts of the activities and works being undertaken, and should take steps to minimize these impacts.

This could include steps such as maintaining natural vegetation along shorelines, ensuring that the plants being used in gardens are native or at least non-invasive species, and minimizing the fragmentation of habitat.

While development in the study area will be limited compared to other areas of the Lake Simcoe watershed, these types of impacts will no doubt increase, as the combination of larger populations in this and the surrounding areas and small lot sizes will tend to increase the numbers of people looking for opportunities for outdoor recreation. Further, as development proceeds, accessible upland natural areas may become even rarer, concentrating this pressure into increasingly rare remnant habitats. As a result, as development proceeds, the need to manage the impacts associated with outdoor recreation will only intensify.

8.3.9 Climate change

Projections suggest that climate change will have significant impacts on terrestrial natural heritage features in the Lake Simcoe watershed. Recent modeling work was completed for the Lake Simcoe watershed, examining the response of tree species to climate change, as influenced through factors such as the current range of the species, its current local abundance, phenology, and seed production (Puric-Mladenovic *et al.,* 2011). As climates change, the model predicts that balsam fir (*Abies balsamea*), yellow birch (*Betula alleghaniensis*), paper birch (*Betula papyrifera*), American beech (*Fagus grandifolia*), Jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*), and white pine (*Pinus strobus*) will all decreases in their occurrence in the forests of the Talbot River and Whites Creek subwatershed. In fact, the projected shifts in climate may cause some species which are currently relatively widely distributed to become more narrowly restricted to remaining habitat, including red maple becoming restricted to wetlands, as they shift to areas with moister soil, and yellow birch becoming restricted to ravines, as they shift to areas with cooler and moister microclimate. Other species, notably red oak (*Quercus rubra*) and sugar maple (*Acer saccharum*), are anticipated to become more common as a result of the warming climate.

Modeling results suggest that forests in cooler microclimates in ravines and north facing slopes, which tend to have a relatively high dominance of eastern hemlock, yellow birch, and American beech, may be among the most sensitive ecosystem to the changing climate. Sadly though, the species which the model suggests are the most vulnerable to climate change are those which we think of as being prototypically Canadian. White pine (*Pinus strobus*) (Ontario's provincial tree) is predicted to experience severe declines in the Talbot River and Whites Creek subwatersheds (Puric-Mladenovic *et al.,* 2011).

A separate set of models, developed to assess the vulnerability of wetland ecosystems, suggest that a 'worst case' climate change scenario would have catastrophic impacts on wetlands in the Lake Simcoe watershed. The increases in average annual temperature and decreases in average annual precipitation projected to occur by the year 2100 is estimated to make 90% of the swamps and 84% of the marshes in the Lake Simcoe watershed vulnerable to drying. As drying occurs, it is expected that marshes would shift in composition to become swamp (or thicket swamp) type communities, and treed swamps would shift to become mesic forests.

These same models suggest that the wetlands in the study area are quite vulnerable to these changes, due to the changes in groundwater discharge combined with changes in air temperature and precipitation (Chu, 2011).

In sum, these models suggest that there will be a shift in community composition in the natural areas in the Talbot River and Whites Creek subwatershed, and a net loss of tree species diversity; although the relatively high levels of natural cover in this subwatershed may to provide refugia for some species. Unfortunately, natural areas lacking in biodiversity tend to be more vulnerable to other threats such as insects, disease, and invasive species, suggesting that the impacts seen to terrestrial natural heritage features may become cumulative in nature.

This loss in native tree species diversity may be mitigated somewhat by the ability of species not currently found here to thrive in the expected new climate. Species found in southern Ontario (such as Eastern cottonwood [*Populus deltoides]*) or the southeastern US (such as black hickory [*Carya texana*]) may become relatively common in forests in these subwatersheds, further influencing the shift in plant community composition. However, the fragmented nature of the landscape that these species would need to cross will no doubt limit their ability to colonize forest remnants in some parts of the study area, without assisted migration (i.e. planting) (Puric-Mladenovic *et al.,* 2011).

Other, less desirable, species may also be able to respond positively to changing climates as well. Some invasive species are projected to experience a northward range expansion (e.g. Kudzu [*Pueraria lobata*], an extremely invasive vine), or experience increased growth rates and biomass (e.g. Eurasian water milfoil [*Myriophyllum spicatum*], a widespread invasive aquatic plant) (Sager and Hicks, 2011).

The predicted impacts of climate change on wildlife are less clear. Some authors (e.g. Walpole and Bowman, 2011) suggest that as average annual temperature increases, more species of both birds and mammals will be able to inhabit the Lake Simcoe watershed. Others caution that, for some species, the disadvantages of climate change may outweigh the advantages. For example, wetland-dependent species may suffer significant population declines as wetlands dry up (Chu, 2011). Similarly, although some migratory birds have been able to take advantage of warmer springs and are migrating earlier, other species appear less able to adapt their behaviour to changing temperature and are vulnerable to not being able to find sufficient food resources or suitable nesting sites later in the season (Burke *et al.,* 2011). These relationships may be even more complicated in this subwatershed however, as the interacting effects of climate change, landscape fragmentation, and intensive land uses may constrain the ability of wildlife to colonize habitat areas, and to persist within them.

Key Points – Factors Impacting Terrestrial Natural Heritage - stressors

- There are multiple stressors to natural heritage systems in the Talbot River and Whites Creek subwatershed, many of which interact.
- Over the short term, the greatest impact to natural heritage features is expected to be due to changes in land use. These impacts can only be expected to increase as the population in this subwatershed increases.
- In addition to the direct loss of natural areas, development is typically associated with an increase in roads and traffic along existing roads (which can cause mortality in wildlife and disturbance to remaining nearby natural areas), an increase in impervious surfaces (which can affect the hydrology of remnant natural areas), and the loss of natural habitat along shoreline and other riparian areas (which tend to be disproportionately important to wildlife).
- Remnant natural areas in settled landscapes typically face more intense stresses as well, including an increase in the number and diversity of invasive species, increased pressure from recreational users, and trophic cascades caused by changes in food webs and other inter-species relationships.
- The emerging threat of climate change will interact with all of these threats, creating additive long-term stresses on natural areas and wildlife populations. Although research in this area is still emerging, initial predictions suggest a loss of wetlands and wetland-dependent species, and a loss of some of our most-loved species of native trees.

8.4 Current Management Framework

Various programs exist to protect and restore terrestrial natural heritage features in the Lake Simcoe watershed, ranging from regulatory mechanisms, to education programs, to funding and technical support provided to private landowners.

Many of these programs already address some of the stresses facing terrestrial natural heritage in the Talbot River and Whites Creek subwatersheds, as outlined below.

8.4.1 Protection and policy

8.4.1.1 <u>Land use planning and policy</u>

Several acts, regulations, policies, and plans have shaped the identification and protection of the terrestrial natural heritage of the Talbot River and Whites Creek subwatersheds. Those having most impact on natural heritage features are summarized in Table 8-5. This management framework relates to many different stressors that can potentially affect natural heritage, ranging from direct impacts associated with habitat loss and urban development, to stresses such as climate change and invasive species which are more global in nature.

Table 8-5 categorizes eight such stressors, recognizing that many of these activities overlap and that the list is by no means inclusive of all activities. The legal effects of the various Acts, policies, and plans on the stressors are categorized as ‘existing policies in place’, or ‘no applicable policies’. The policies included in the table include those which have legal standing and must be conformed to, or policies (such as some of those under the Lake Simcoe Protection Plan) which call for the development of further management tools, research or education programs.

The intent of these regulations, policies and plans are summarized in **Section 1.3 – Current Management Framework**. Readers interested in the details of these regulations, policies and plans are directed to read the original documents.

Table 8-5: Summary of the current management framework as it relates to the protection of terrestrial natural heritage

Stressor affecting the protection and restoration of terrestrial natural heritage	Lake Simcoe Protection Plan (2009)	Growth Plan for the Greater Golden Horseshoe (2006)	Provincial Policy Statement (2005)	Endangered Species Act (2008)	LSRCA Guidelines for the Implementation of O. Reg. 179/06 (2015)	Simcoe County Official Plan (2007)	Township of Ramara Official Plan (2003)	City of Kawartha Lakes Official Plan (2012)	Durham Region Official Plan (2013)	Township of Brock Official Plan (2014)
Site alteration in upland natural heritage features	🟩 1,4	🟥	🟩	🟩 6	🟥	🟩 2,4	🟩 4, 5	🟩 2,4	🟩 2,4	🟩 2,4
Site alteration in wetlands	🟩 1,4	🟥	🟩	🟩 6	🟩 4	🟩 4	🟩 4	🟩 4	🟩 4	🟩
Shoreline development	🟩 4	🟥	🟩	🟩 6	🟩	🟩	🟩 9	🟩 12	🟩	🟩 12
Loss of connectivity between natural heritage features	🟩	🟥	🟩	🟥	🟥	🟩	🟩 10	🟩 12	🟩	🟩
Impervious areas	🟩	🟥	🟩	🟥	🟥	🟥 7	🟩 11	🟥	🟩 14	🟥
Climate change	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟩	🟩 15
Introduction of invasive species	🟩 3	🟥	🟥	🟥	🟥	🟥	🟥	🟩 13	🟩 12	🟥
Protection of species of conservation concern	🟩	🟥	🟩 8	🟩 6	🟥	🟩 6, 8	🟩 6,8	🟩 6,8	🟩 6,8	🟥

🟩 Existing policies in place

🟥 No applicable policies

[1] Regulations specific to those areas outside settlement areas

[2] Development not permitted in wetlands, *significant* forests*, significant* valleylands (e.g. other than wetlands, features not considered significant are not afforded the same protection)

[3] Discusses developing proposed regulations (to be considered by federal government under fisheries act), conducting studies/risk assessments, developing response plans, education programs, but nothing banning use/etc

[4] Includes the feature plus a designated set back (or 'buffer' or 'adjacent lands')

[5] Where feature is included in Natural Area Framework

[6] Specific to Endangered and Threatened species

[7] Targets for impervious cover provided for the Oak Ridges Moraine Conservation Plan area, but not the subject area

[8] In the context of "Significant Wildlife Habitat"

[9] Contains policies related to required setbacks from shorelines, streambanks

[10] Contains policies around Corridors, but does not directly mention maintaining connectivity between natural heritage features

[11] Only policy is related to adopting guidelines for stormwater management that would include setting a maximum impervious area on individual lots, however only applies within Shoreline Residential areas

[12] Consistent with LSPP

[13] Policies around enhancing the ability of native species survive/thrive, requires the use of native species for buffers

[14] In Major Open Space Areas and on the Oak Ridges Moraine

[15] Consideration given in the development of Stormwater Management Master Plan

Legislation and policy restrictions are the primary source of protection for natural heritage features in the Lake Simcoe watershed, guided by the fundamental Provincial planning policies as articulated in the Provincial Policy Statement (PPS). However, some stresses are better suited to policy and regulation than others. For example, natural heritage stressors such as climate change and invasive species are hard to regulate; however, stresses associated with the loss of habitat and conversion to residential or industrial land uses are much easier to control and regulate.

Policy tools to deal with those stresses can be found in Provincial policy (such as the PPS or LSPP), municipal official plans and zoning bylaws, and Conservation Authority Regulations. Together, these documents are intended to provide protection to features that are significant both locally and provincially, while providing clarity to private landowners, and accountability to the electorate.

Further to the guidelines provided by the PPS, the LSPP identifies additional targets for the retention of natural heritage features in the Lake Simcoe watershed. Targets which would constrain development or other land use change include: ensuring no further loss of natural shorelines on Lake Simcoe, achieving protection of wetlands, and achieving naturalized riparian areas on Lake Simcoe and along streams.

Policies established under the Lake Simcoe Protection Plan will assist in achieving these targets by establishing restrictions to development or site alteration within 100 m of the Lake Simcoe shoreline (30m in already built-up areas, subject to a natural heritage evaluation), or within 30m of a key natural heritage feature (i.e. wetlands, significant woodlands, significant valleylands, or natural areas adjacent to Lake Simcoe), with natural heritage evaluations necessary for development proposed within 120 m of the feature.

The City of Kawartha Lakes Official Plan (OP) has been updated to for consistency with the Lake Simcoe Protection Plan, and thus offers protection to natural heritage features, which include wetlands, significant woodlands, significant valleylands, and permanent and intermittent streams and lakes. Development and site alteration are significantly restricted in these areas. The OP also includes policies around growth management that will serve to protect natural heritage features in the area. These include directing growth the built-up areas through intensification (thus minimizing sprawl outside of the boundaries of built-up areas), directing development of settlement areas, particularly those that offer municipal water and wastewater systems; and prohibiting the establishment of new settlement areas. The OP identifies an Environmental Protection Designation, the goal of which is to identify land that is subject to flooding, is identified as Provincially Significant Wetland by the MNRF, or is unsuitable for development due to physical hazards. The objective of this land use designation is to prevent development or site alteration on lands which are hazardous due to flooding. Poor drainage, deep organic soils, erosion, steep slopes, or any other physical condition which could cause loss of life, personal injury, property damage, or degradation of the environment. There is a very limited number of uses permitted within areas designation as Environmental Protection; these mostly related to agriculture, conservation, or natural resources management. The creation of lots within these areas for the purpose of development is not permitted. The OP's Waterfront policies have a number of stipulations for minimizing the impact of this type of development, including that it will generally be low density; that natural form and function will dominate, with naturalized and/or naturally vegetative shorelines being retained and restored wherever possible; stipulating that an environmental impact study is required where there is a wetland between the open water and the shoreline where development is proposed; and limits on their extent of shoreline activity areas, such as docks, boathouses, pump houses, and other structures).

There are a number of directions and policies in the Township of Brock's Official Plan related to the protection and enhancement of natural features. One of the Plans' Strategic Directions is 'Strengthening and Integrating Natural, Cultural and Heritage Resources.' The OP's objectives related to this direction include preserving, protecting, and enhancing the significant features, functions, and attributes of the natural environment so that it will continue to sustain life, maintain health, preserve the visual landscape, and provide a high standard of living; ensuring that the relationship between natural and built environments and the principle of preserving resources and protecting the natural environment for future generations will form a basis for the planning and development of the Township; protecting woodlands and tree coverage, particularly in settlement areas; and recognizing that Lake Simcoe and its associated rivers, streams, and wetlands are essential to the quality of life in the township and its economic prosperity. Another strategic direction is 'Enhancing Public Areas', which includes the enhancement of the Lake Simcoe waterfront to support tourism development and improve recreational and cultural opportunities. Objectives related to this direction include ensuring that shoreline development will protect and restore the shoreline; pursuing a program to enhance public access along the waterfront; developing a trail system within and between the settlement areas and key natural heritage features. The OP includes a section on Healthy Communities, in which it defines Open Space as space which provides enhancement and provision of opportunities for recreation, the creation and reinforcement of physical and social spaces, and the preservation and protection of natural features and functions, hazard lands, and man-made environments. The policies within this section include some guidance around the development of trails, and notes that the development of recreation and open space uses should be designed to enhance the natural environment wherever possible, to maintain the character of the landscape and minimize disruption to the surrounding existing land uses. In a section entitled 'Open Space Areas', the OP includes objectives such as creating a linked open space system that connects parkland and valleylands; providing for continuous trail and integrated park system within the urban areas with an emphasis on Lake Simcoe and its river valleys, and protecting and expanding existing tree coverage within settlement areas. To minimize the impact of light pollution on natural areas and wildlife, the OP also contains policies around Signage and Environmental Lighting, including some stipulations around suitable lighting, and a recommendation for council to enact a light pollution bylaw.

The Township of Ramara Official Plan contains a number of Natural Area Policies, aimed at the preservation of the municipality's natural areas. In the Natural Area framework classifies significant natural features and functions into two levels:

- **Core Areas and Corridors**, which are natural areas of provincial, regional, and local significance, in which development is strongly discouraged aside from a few permitted activities. These areas include provincially significant wetlands, significant habitat of endangered and threatened species, significant woodland cores and corridors, and fish habitat
- **Supportive and Complementary Areas and Corridors**, which are natural areas of regional and local significance and other areas in County Greenlands, and are subject to a less stringent policy regime. These areas include significant valleylands, environmentally sensitive areas, significant wetlands, significant woodlands, significant wildlife habitat, significant Areas of Natural and Scientific Interest, and regionally and locally significant natural areas features and functions (e.g. headwaters, recharge and discharge areas, watercourses)

Few uses are permitted in the Core Areas and Corridors, as well as in their adjacent areas. A number of uses are permitted in the Supportive and Complementary Areas and Corridors, but these are quite limited. Any development and/or site alteration proposed within any of these areas by an amendment to the plan or zoning by-law may be considered with the preparation of an Environmental Impact Statement, if it can be demonstrated that there will be no negative impact on the Natural Areas features and functions. In addition, the Official Plan contains policies to prevent development and/or site alteration in or near dynamic beaches on the lake as well as within floodplain areas, which should prevent the removal of riparian vegetation.

The LSRCA has been assisting watershed municipalities in identifying natural heritage systems for inclusion in Official Plans with their *Natural Heritage System for the Lake Simcoe Watershed* (Beacon and LSRCA, 2007). This planning tool interprets and applies the Provincial Policy Statement (PPS) to the Lake Simcoe watershed, which, when paired with the Natural Heritage Reference Manual (OMNR, 2010), provides comprehensive science-based criteria to identify significant natural heritage features. The *Natural Heritage System* applies these criteria to the Lake Simcoe watershed to provide specific recommendations to LSRCA staff to guide plan review, and recommendations to municipalities to assist with Official Plan development.

A Natural Heritage System (NHS) has also been developed for the ecologically-based area of the Kawartha Lakes Region, which includes the Cities of Kawartha Lakes (including a portion of the study area for this plan) and Peterborough, as well as Peterborough County, through the *Kawarthas, Naturally Connected* project (van Hemessen, 2013). This system used Marxan modelling software to objectively identify efficient arrangements of natural areas within a landscape to form an NHS, and was developed to help municipalities address their responsibilities under the Provincial Policy Statement and Planning Act. The modelling looks at scenarios which were identified by a project working group with ecological targets (e.g. include a certain percentage of wetlands; always include Provincially Significant Wetlands, etc.). Stakeholders are able to see the effect of varying targets and other considerations on the size, shape, and distribution of the features and area suggested to make up the NHS. The resultant map and associated database can be used by municipalities and other organizations to help them take a strategic approach to their conservation activities.

An additional layer of regulatory control is afforded to wetlands under Ontario Regulation 179/06 (Regulation of development, interference with wetlands and alterations to shorelines and watercourses). Watershed development policies established by LSRCA under that Regulation prohibit development in Provincially Significant wetlands, and restrict development in all other wetlands in the Lake Simcoe watershed.

8.4.1.2 Acquisition of natural heritage features by public agencies

Several mechanisms exist for the acquisition of natural heritage features by the Lake Simcoe Region Conservation Authority, the Couchiching Conservancy, the Nature Conservancy of Canada, and municipal governments.

The LSRCA has a land securement program which aims to acquire significant natural heritage features in the Lake Simcoe watershed, on a willing buyer – willing seller basis. LSRCA has developed a Natural Heritage System Land Securement Project, which focuses LSRCA's securement efforts by identifying nine land securement priority areas (LSRCA, 2010) which will be actively pursued. One of these priority areas falls within the study area; this is identified as the Kawartha Lakes Wetlands, and contains areas of up to two significant ecological features including the Grass Creek and Corben Creek Wetlands, the Beaverton Alvar and Wetland ANSI (Life Science - Provincial). This target area is approximately 2,600 hectares in size. The Grass Creek Wetland is 1,304 hectares with approximately 1/3 within the LSRCA watershed. It is composed of swamp and marsh. The Corban Creek Wetland contains an area of 107 ha. In addition to this priority area, the LSRCA may also consider receiving donations of relatively large parcels of land, if they meet the criteria of the Conservation Land Tax Incentive Program.

The City of Kawartha Lakes also has parkland dedication targets in its Official Plan, an area amounting to 5% of a development, or the equivalent in cash. These targets are intended to ensure that as the population grows, opportunities for outdoor recreation grow as well. Although parkland targets are generally primarily geared towards 'traditional' municipal parks (e.g. soccer fields, baseball diamonds, playgrounds, and other manicured greenspace), larger 'regional' parks sometimes include natural heritage features within them. The Township of Brock also references parkland dedication in its Official Plan, though it does not set explicit targets. There are no ANSIs found within the portion of the Township of Ramara that falls within the study area.

Together the Couchiching Conservancy and the Nature Conservancy of Canada have acquired approximately 10,000 ha of land in the Carden Alvar, mainly through donations from their members. This has allowed for the protection and restoration of this rare habitat type which supports diverse plant and wildlife communities, including several species at risk.

8.4.2 Restoration and remediation

There are a range of programs operating in the study area subwatersheds to help private landowners improve the environmental health of their land, and the Ministry of Natural Resources has developed a report to help to prioritize restoration activities.

The Landowner Environmental Assistance Program (LEAP) is a partnership between the Lake Simcoe Region Conservation Authority, its member municipalities, and the York, Durham and Simcoe chapters of the Ontario Federation of Agriculture. This program provides technical and financial support to landowners in the Lake Simcoe watershed wanting to undertake stewardship projects on their land. Project types which have traditionally been funded by the LEAP program include managing manure and other agricultural wastes, decommissioning wells and septic systems, fencing and planting riparian areas, and increasing the amount of wildlife habitat in the watershed, among others. Between 2005 and 2015, 14 projects were completed under the LEAP in the Talbot River subwatershed, and 15 in Whites Creek. The majority of these were focussed on protecting water quality, but they also included five erosion projects and two tree planting projects.

The Kawartha Lakes Farm Stewardship Fund is a new program at Kawartha Conservation, funded by the Ontario Ministry of Agriculture, Farming, and Rural Affairs. Agricultural landowners within the City of Kawartha Lakes may apply for assistance with a number of on-farm stewardship projects addressing nutrient and soil loss, cropland and shoreline erosion, manure storage runoff, livestock access to watercourses, sediments and contaminants entering water, and farm well management. Due to this funding's emphasis on Lake Simcoe, priority may be given to landowners within the Talbot River subwatershed, however projects with significant stewardship potential in other City of Kawartha Lakes locations will be considered. Information sessions are currently being scheduled for this Fund and applications are being accepted as of June 2015.

The Ontario Ministry of Agriculture, Food and Rural Affairs has also partnered with Agriculture and Agri-Food Canada and the Ontario Soil and Crop Improvement Association to provide the Environmental Farm Program to registered farm landowners throughout the province. This farmer-focused program provides funding to landowners who have successfully completed an Environmental Farm Plan for projects including management of riparian areas, wetlands, and woodlands.

In 2008, 2009, and 2014, LSRCA field staff surveyed 67% of the watercourses in the Whites Creek subwatershed and 43%% of the Talbot River subwatershed through the Best Management Practices Inventory Program, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. Among its findings, this survey found over 77 sites in Whites Creek and 838 sites in the Talbot River where additional riparian planting could be introduced.

In addition, the Ministry of Natural Resources has completed a report entitled 'Delineation of Priority Areas for Restoration in the Lake Simcoe Watershed' (MNR, 2011). The MNRF analyzed existing natural land cover as well as potential areas for restoration using a series of mapping resources and analysis techniques. Through this analysis, priority restoration areas were identified, their area measured, and mapped for all Lake Simcoe subwatersheds. The types of restoration opportunities are riparian areas, which looked at opportunities for all stream orders; wetlands; and linkages and corridors. This report will form an important basis for the identification of priority areas for restoration throughout the study area. The number of patches and area identified for the Whites Creek and Talbot River subwatersheds for wetland and linkage/corridor restoration can be found in Table 8-6 below.

Table 8-6: Wetland and linkage/corridor areas identified in MNR's draft 'Delineation of Priority Areas for Restoration in the Lake Simcoe Watershed' (MNR, 2011)

Subwatershed	Wetlands		Linkages/Corridors	
	# of areas	Total area (ha)	# of areas	Total area (ha)
Talbot River	1095	10165.6	2996	1252.1
Whites Creek	303	2646.3	4082	1457.4

8.4.3 Science and research

An ongoing commitment to applied research and science is necessary to improve our understanding of the extent, character, and function of the terrestrial natural heritage features and wildlife within the Lake Simcoe watershed. Applied science and research can include formal scientific studies, citizen scientist-based monitoring programs, and Traditional Ecological Knowledge.

Comparatively less research is being done on terrestrial natural heritage systems, values, and features than is being done on water quality or aquatic habitats, however MNRF research scientists are undertaking studies related to characterizing the natural heritage features and ecological processes in the watershed. As with water quality and aquatic research, the Lake Simcoe Science Committee plays a role in reviewing this research and making recommendations to the Minister.

In addition to these specific research projects, the MNRF, LSRCA, and MOECC are developing a terrestrial natural heritage monitoring program which will track the condition of the Lake Simcoe watershed with respect to the targets and indicators set by the Lake Simcoe Protection Plan (and described in Section 8.2). When this data becomes available, and trends become evident, it will help to revise and refine this subwatershed plan at its five year review period.

Ontario, as a province, is fortunate in that much terrestrial natural heritage monitoring is undertaken by volunteer citizen scientists, which has the potential to complement these other studies. Programs such as the Marsh Monitoring Program, and Breeding Bird Survey coordinated by Bird Studies Canada provide information on long-term trends in wildlife populations throughout Ontario. At this point there are no Marsh Monitoring Program routes in the study area, and there are a number of Breeding Bird Survey routes that cross through the study area.

Key Points – Current Management Framework Protecting Terrestrial Natural Heritage

- The suite of natural heritage protection policies provided under the Lake Simcoe Protection Plan and municipal official plans provide relatively comprehensive protection for natural heritage features in the study area. Exceptions include grasslands and some small isolated forests.
- Wetlands are effectively protected in the Talbot River and Whites Creek subwatersheds, with the exception of development or site alteration associated with municipal infrastructure
- Existing natural vegetative cover along the shoreline and in the riparian zone of the tributaries is protected by policies provided under the Lake Simcoe Protection Plan and some municipal official plans
- There are a number of programs available to assist private landowners in improving natural heritage features on their property. A major focus of these programs is in increasing natural vegetative cover along the shoreline and in the riparian zone of tributaries
- Despite the existence of these stewardship programs, uptake of stewardship assistance to this point has been limited in these subwatersheds.

8.5 Management gaps and recommendations

As can be seen in the previous sections, there are a number of programs in place to protect and enhance the natural heritage features in the Talbot River and Whites Creek subwatersheds. Despite this strong foundation, there are a number of gaps and limitations in the current management framework that could be improved upon in the future of subwatershed management.

Listed below is an initial 'long list' of recommendations for improving the state of natural heritage values in the Talbot River and Whites Creeks subwatershed, for discussion.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed in the implementation phase.

8.5.1 Official Plan conformity

Under Policy 8.4 of the Lake Simcoe Protection Plan, municipalities must amend their official plans to ensure that they are consistent with the recommendations of this subwatershed plan, upon their five-year official plan review.

> **Recommendation 8-1** - That the LSRCA, Kawartha Conservation, and relevant provincial agencies assist the City of Kawartha Lakes and Townships of Brock and Ramara in ensuring their official plans are consistent with the recommendations presented in the Canal and Mitchell Lakes, Talbot River, and Whites Creek Subwatershed Plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with the City of Kawartha Lakes, Townships of Brock and Ramara, the subwatershed plan working group, and the general public, as outlined in the *Guidelines for developing subwatershed plans for the Lake Simcoe watershed (May, 2011).*

8.5.2 Revisions in Key Natural Heritage Protection Policies

Policy 6.50 of the LSPP requires the MNRF, MOECC, and LSRCA to establish a monitoring program in relation to the targets and indicators established by that plan for natural heritage and hydrologic features, which includes an indicator related to 'habitat quality'. Although there is currently no site level definition for "high quality" natural vegetation, when this definition becomes available, it has the potential to complement existing natural heritage protection policies in provincial plans and municipal official plans to ensure that the most high quality natural areas in the Lake Simcoe watershed are protected from incompatible development and site alteration

> **Recommendation 8-2** – That the MNRF, MOECC, and LSRCA review the terrestrial natural heritage data provided by the comprehensive monitoring program, when it becomes available, to define site level characteristics or indicators of 'high quality' natural heritage features, and provide policy recommendations to subwatershed

municipalities (as necessary) to ensure high quality natural heritage features are adequately protected from development and site alteration.

Given that the Provincial Policy Statement and the Planning Act recognize the importance of Natural Heritage Systems Planning, and that municipalities have responsibilities to be consistent with these documents, tools such as the *Lake Simcoe Natural Heritage System* and *Kawarthas, Naturally Connected Natural Heritage Systems Strategy* have been developed to assist municipalities in this endeavour.

Recommendation 8-3 - That Kawartha Conservation develop policies around the *Kawarthas, Naturally Connected Natural Heritage Systems Strategy* in order to achieve its implementation. Wherever possible, these policies should be consistent with those of the *Lake Simcoe Natural Heritage System* to ensure ease of implementation for municipalities.

Recommendation 8-4 – That the City of Kawartha Lakes, Region of Durham, and Townships of Brock and Ramara incorporate the protection and restoration of areas of critical ecological significance identified through the *Lake Simcoe Natural Heritage System* and/or the *Kawarthas, Naturally Connected Natural Heritage Systems Strategy* into their official plans. Further, that the LSRCA and Kawartha Conservation partner to facilitate this implementation by determining how to mesh the features protected under the two systems, for municipalities that fall within multiple conservation authority jurisdictions.

Recommendation 8-5 - That the City of Kawartha Lakes develop a tree cutting bylaw, in order to address the removal of important features such as hedgerows and trees used as windbreaks.

The existing suite of natural heritage protection policies provided by the LSPP, municipal Official Plans, and Provincial Regulations provide some level of protection from development for much of the natural vegetative cover in the study area. The incomplete coverage of this protection suggests that some marginal loss in natural heritage cover should be anticipated as development proceeds in this area. The LSPP however establishes a target of 40% native vegetation across the Lake Simcoe watershed, which represents an increase of approximately 5% from current conditions. The possibility of meeting this target would be greatly increased with the adoption of a policy of no net loss of natural heritage features.

Recommendation 8-6 - That LSRCA and Kawartha Conservation, in partnership with subwatershed municipalities and other interested stakeholders, develop policies for municipal official plans that would provide mitigation and restoration for development and site alteration within natural heritage features that are not defined as "key" by the Lake Simcoe Protection Plan or as "significant" under municipal official plans, to ensure no net loss in overall natural vegetative cover as a result of development.

Recommendation 8-7 - That the LSRCA, Kawartha Conservation, and subwatershed municipalities promote the use of programs such as the Managed Forest Tax Incentive

Program to provide landowners with financial incentives to preserve the natural features on their properties.

8.5.3 Grassland protection

Grassland habitats are an often overlooked natural heritage feature, and unprotected by natural heritage protection policies. For example, neither the LSPP nor the Provincial Policy Statement accounts for "grasslands" as a type of natural heritage feature. However, as outlined in section 6.2.6, they are disproportionately important for species of conservation concern. Native grasslands are recognized by the Natural Heritage Reference manual, and recommended for inclusion in natural heritage systems designated under municipal official plans as 'rare vegetation communities'.

However, on their own, native grasslands will likely be insufficient to protect grassland dwelling wildlife. There are only five identified native grasslands (i.e. tallgrass prairies or alvars), in the Lake Simcoe watershed. Smaller grassland features will be insufficient for the long-term persistence of grassland birds and insects. The protection of non-native grasslands is difficult however, as many of these are abandoned lots or vacant or non-intensive agricultural land, and as such they are often temporary in nature.

The concern in this subwatershed related to the preservation of habitat for grassland-dependent wildlife is one that is widespread throughout the Province. In 2010, the bobolink was listed under the Provincial *Endangered Species Act* as being a Threatened species, triggering a protection to its habitat. Because of the conflict that creates with farm operations however, in 2011 the Provincial government instituted a three-year exemption for farmers while they study other options for protecting both grassland-dependent birds, and farm businesses

> **Recommendation 8-8 –** That, after the development of the Provincial Grassland Stewardship Initiative, that LSRCA and Kawartha Conservation review their stewardship programming, in consultation with the agricultural roundtable or other representatives of the agricultural industry, to assess if there are additional ways that the Conservation Authorities can support interested landowners in maintaining endangered species on their properties.
>
> **Recommendation 8-9** – That the MNRF, MOECC, and LSRCA, consider including only woodland and wetland habitats, which would be commonly found throughout the Lake Simcoe watershed, within the LSPP target of 40% high quality natural heritage cover, and set additional for some of the other unique habitat types found in the watershed, such as native grasslands and alvars. The historical representation, as well as current cover levels of these features, should be considered to determine the appropriate targets.

8.5.4 Infrastructure as a Key Natural Heritage Feature gap

Infrastructure projects, including roads, sewers, and municipal drains, aren't subject to the Planning Act, and as such are exempt from natural heritage protection policies developed under municipal Official Plans, and are also exempt from natural heritage protection policies under the Lake Simcoe Protection Plan. Protection for natural heritage features with respect to infrastructure projects is provided through the Environmental Assessment process.

Recommendation 8-10 – That the proponents and reviewers of all Environmental Assessments recognize the intent and targets of the Lake Simcoe Protection Plan when developing and assessing alternatives to the proposed undertaking.

Recommendation 8-11 – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, MTO, LSRCA, Kawartha Conservation, and MOECC (when reviewing such documents), give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of appropriate wildlife crossing structures, and/or the use of traffic calming measures (such as signage, including the use of electronic signs at peak migration times; road re-design; and speed bumps) in critical locations.

Recommendation 8-12 - Where roads have already been constructed and wildlife crossing structures are not viable options, seasonal road closures should be considered where possible to minimize wildlife mortality, particularly during peak breeding seasons.

8.5.5 Land securement by public agencies

The protection of a system of natural heritage features by public bodies plays an important role in ensuring the protection of significant and highly vulnerable sites, and in providing natural areas for public use and enjoyment. This includes the Kawartha Lakes Wetlands, which have been identified by the LSRCA as a priority area for securement.

Recommendation 8-13 – That the LSRCA and subwatershed municipalities should continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easements, and should support the work of Land Trusts doing similar work. Priority areas identified by LSRCA's Land Securement Strategy in the Talbot River and Whites Creek subwatersheds include the Grass Creek and Corben Creek Wetlands, and the Beaverton Alvar and Wetland ANSI.

Recommendation 8-14 – That the LSRCA and subwatershed municipalities, with the assistance of the MNRF, continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

Recommendation 8-15 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding, and that the study area municipalities utilize their parkland dedication process, to support securement of notable natural areas.

8.5.6 Stewardship

In addition to protecting existing natural heritage features, programs which support the stewardship, restoration, or enhancement of private lands will be critical to meet the targets and objectives of the Lake Simcoe Protection Plan. To that end, programs are provided through partnerships with the Ministry of Natural Resources and Forestry, Ministry of the Environment and Climate Change, Ministry of Agriculture, Food and Rural Affairs, Ontario Federation of Agriculture, Ontario Soil and Crop Improvement Association, Lake Simcoe Region Conservation Authority, Kawartha Conservation, Couchiching Conservancy and watershed municipalities. Despite this range of players, the uptake of proffered stewardship programs is limited by the number of private landowners who voluntarily participate.

In addition, stewardship programs play an important role in meeting the goals and objectives of the subwatershed plans. However, in order to ensure that they are both effective and efficient, stewardship projects should be selected in the context of the priority needs of the Lake Simcoe watershed, and its subwatersheds. A best management practices prioritization exercise has been undertaken for entire Lake Simcoe watershed, taking into account a number of factors, with the development of associated maps to support this exercise.

> **Recommendation 8-16** – That the MNRF, MOECC, MAFRA, LSRCA, and Kawartha Conservation continue to implement stewardship projects in these subwatersheds, and work collaboratively with other interested organizations, through the Lake Simcoe Stewardship Network, to do the same. Wherever possible, emphasis should be placed on catchments and projects identified as priorities through the aforementioned best management practices prioritization exercise, to ensure the greatest benefit to watershed health.
>
> **Recommendation 8-17** – That governmental and non-governmental organizations continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as a simple web portal, or other, locally appropriate avenues.
>
> **Recommendation 8-18** – That the Federal, Provincial, and Municipal governments be encouraged to provide consistent and sustainable funding to ensure continued delivery of stewardship programs. Furthermore, that partnerships with other organizations (e.g. Ducks Unlimited Canada, TD Friends of the Environment, Royal Bank of Canada, local businesses) be pursued.
>
> **Recommendation 8-19** – That MOECC, MNRF, LSRCA and other members of the Lake Simcoe Stewardship Network, as well as Kawartha Conservation, are encouraged to document completed stewardship projects in a common tracking system to allow efficient tracking, coordinating, and reporting of stewardship work accomplished. This could also involve engaging ‘project champions’ to promote the projects that they have completed and encourage others to do the same.

Recommendation 8-20 – That the MOECC, MNRF, OMAFRA, LSRCA, Kawartha Conservation, and other interested members of the Lake Simcoe Stewardship Network support research to determine public motivations and barriers limiting uptake of stewardship programs in this subwatershed and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 8-21 – The MOECC, MNRF, OMAFRA, LSRCA, and Kawartha Conservation continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. 4H clubs, high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction). Results of these efforts should be shared with the Lake Simcoe Stewardship Network.

Recommendation 8-22 – That the members of the Lake Simcoe Stewardship Network be encouraged to build into their projects relevant provisions for the anticipated impacts of climate change, such as the need to recommend native species which will be tolerant of future climate conditions, and the likelihood of an increase in invasive plants, pests, and diseases which may further limit the success of traditional stewardship approaches.

Recommendation 8-23 - That, given the amount of shoreline area on Lake Simcoe, Canal Lake, and Mitchell Lake, and the level of development adjacent to these shoreline areas, that part of LSRCA and Kawartha Conservation's stewardship efforts be targeted to addressing shoreline stewardship practices, including implementing natural landscaping and decommissioning hardened shorelines.

8.5.7 Dealing with indirect impacts

Despite the gaps in existing natural heritage protection policies as noted above, a large proportion of current natural heritage features in the Talbot River and Whites Creek subwatersheds have some level of protection from development or site alteration. As such, the greatest impacts to natural heritage values in these subwatersheds in coming years may be indirect, rather than direct, in nature. Forests in urban areas are typically under more stress from invasive species, feral cats, unmanaged recreation, and indirect impacts associated with nearby roads.

Recommendation 8-24 – That the MNRF and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 8-25 – That the City of Kawartha Lakes and the Townships of Brock and Ramara, with support from LSRCA and Kawartha Conservation, make information available to residents on the impact of human activities on natural areas. Priority issues include the dangers of invasive species, the importance of keeping pets under control, and the importance of staying on trails while in natural areas.

Recommendation 8-26 – That the study area municipalities give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands.

Recommendation 8-27 – That the Ministry of Transportation, City of Kawartha Lakes, Townships of Brock and Ramara, Region of Durham and the County of Simcoe, in partnership with the Simcoe County Federation of Agriculture, LSRCA, Kawartha Conservation, and MNRF, promote and implement, where appropriate, the use of treed windbreaks and/or 'living snowfences' along roadsides to prevent impacts from wind and blowing snow. The creation of a 'living snowfence' involves selectively harvesting crops in order to leave a specified amount of plant material standing along a roadway to facilitate snow accumulation.

8.5.8 Filling data gaps

Our understanding of the status and pressures related to terrestrial natural heritage features and processes in the Lake Simcoe watershed is relatively limited. Policy 6.50 of the LSPP requires the MNRF, LSRCA, and MOECC to develop a monitoring program for natural heritage features and values in the Lake Simcoe watershed which should contribute significantly to addressing this data gap. This monitoring program could be complemented by the following recommendations to more fully fill data gaps.

Recommendation 8-28 – That the MNRF, with the assistance of LSRCA, Kawartha Conservation and MOECC, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 8-29 – That the MNRF, LSRCA, and OMAFRA update the existing land cover map for the watershed, as defined by the LSPP, and incorporate data available on alvar communities from the MNRF and Nature Conservancy of Canada.

Recommendation 8-30 – That, when completed, the updated land cover map be compared with existing data, to assess the extent and type of land use change within these subwatersheds.

Recommendation 8-31 – That the MNRF and LSRCA take advantage of data that is already available, by developing a biodiversity database that can collate information reported in EIS and EA reports, information reported in natural area inventories, plot-based data collected in the watershed-wide Vegetation Survey Protocol that is underway, plot-based data collected by citizen-scientists for the Breeding Bird Atlas, and other data as may be available.

Recommendation 8-32 – That the MNRF, with the assistance of the LSRCA, take advantage of this soon-to-be compiled data, and develop lists of watershed-rare taxa, and policies to support their protection.

8.5.9 Improving data management

The forthcoming monitoring program identified by the LSPP has the potential to exponentially increase the amount of data on the extent and condition of natural heritage values and features in the Lake Simcoe watershed. However, the number of government agencies contributing to, and utilizing, this database will make data management a significant challenge.

> **Recommendation 8-33** – That the MNRF, LSRCA, and MOECC develop a framework to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program. This framework may include the designation of one agency as the curator of all monitoring data collected in the Lake Simcoe watershed.

9 Integration and Implementation

9.1 Introduction

This subwatershed plan has been developed with technical chapters arranged thematically, to allow us to examine each theme in detail, and to allow this document to address the specific issues identified in the Lake Simcoe Protection Plan. This integration chapter, however, is intended to highlight the interactions between water quantity, water quality, terrestrial ecosystems, and aquatic ecosystems, and to describe some of the natural processes supporting biodiversity and watershed health in the Canal and Mitchell Lakes, Talbot River, and Whites Creek subwatershed. An understanding of how these factors interact is important to gain a full understanding of the watershed ecosystem, and to design conservation programs which are both effective and cost-efficient. To help build this understanding, this chapter examines how some of the key points highlighted in Chapters 4 to 8 interact, through the use of conceptual diagrams. Conceptual diagrams are useful tools for synthesizing complex, detailed information in a form that is attractive and informative. Conceptual diagrams are 'thought drawings' that provide representations of ecosystems or watersheds, and highlight key attributes and interactions, in a form that is readily understandable by a wide range of audiences (Longstaff *et al*., 2010).

9.2 Groundwater interactions - land cover, groundwater, and aquatic habitats

The amount of precipitation that infiltrates through the soil to contribute to groundwater depends on the permeability of the soil. Groundwater recharge is most significant in areas with coarse, highly permeable soils such as sandy or gravelly sites on heights of land, and is often found in the headwaters of watersheds (Figure 9-1) (Earthfx, 2014). In the case of the the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed, the regional groundwater flow contribution from within the subwatershed supports numerous wetland and stream features. Some of the headwater streams are likely reciving groundwater inflow from recharge zones in the Carden Plain alvar and other recharge areas located just outside of the subwatershed boundaries. Where these types of areas are forested, the amount of rainfall that infiltrates into groundwater tends to be greater. Forests promote infiltration by intercepting the rain and reducing the force at which it strikes the soil. They also increase soil porosity through the actions of root growth and decomposition, and the actions of small mammals and other burrowing wildlife.

Groundwater flow in this subwatershed generally follows surface water flow, from the higher topography in the headwaters to the northeast to the lows associated with major stream channels and Lake Simcoe. In their 2014 study of the area, Earthfx found that much of the groundwater flow discharging to some significant features in the study area, including both streams and wetlands, originates from three large groundwater recharge mounds; two are associated with the higher elevations in the Upper Talbot subwatershed, and the third is at the southeast end of the Whites Creek subwatershed.

This groundwater can be released to the surface where it becomes available for use in aquatic or wetland ecosystems, through the process of groundwater discharge (Figure 7-1) (Earthfx, 2013a). This discharge happens in areas with similarly coarse soil, but also in areas where the ground surface lies below the water table, often in depressional areas or in ravines, and can take the form of groundwater seepage or springs. Groundwater flow patterns indicate that the major surface water bodies in the study area, including Balsam Lake, Canal Lake, Mitchell Lake, Head River, and Lake Simcoe, represent areas of groundwater discharge.

Based on modelling results, many of the subwatershed's streams and wetlands are fed by localized recharge, while some features, particularly those streams and wetlands in the headwaters are fed by groundwater originating from outside of the subwatershed, particularly in the areas of the Carden Plain and the area between Lake St. John and Lake Dalrymple mentioned above. Groundwater discharge to the headwater reaches represents a significant portion of the total baseflow. In such cases, the groundwater discharge makes an important contribution to creek ecosystems and to riparian wetlands.

This groundwater recharge – discharge relationship can happen over relatively large distances, and is easily overlooked as it happens below ground. This relationship however is one of the most significant links between upland and aquatic features in watersheds, and preserving this relationship is critical to preserving the functioning of surface water features such as watercourses and wetlands.

For some watercourses, particularly small ones, groundwater discharge can be a significant contributor to flow during times of limited rainfall. Evidence of the importance of this groundwater source is seen in many of the subwatershed's watercourses, particularly through the middle and lower reaches, that are not well connected to the deeper groundwater system, and these systems tend to dry up in the summer months when the shallow sub-surface flow is depleted. In cases where the watercourses supported by groundwater sources, such as in the headwaters, the addition of this water obviously plays a role in protecting fish habitat, but even in larger systems, the typically cold discharged groundwater can decrease the temperature of the creek, helping it to support healthier fish communities. As such, the preservation of groundwater recharge and discharge, even at relatively large distances from creeks, is critical to preserving the fish habitat that is present in this subwatershed.

In areas that have become urbanized, this groundwater relationship can be interrupted (Figure 9-1). Because urban areas constitute such a small portion of the study area, it is not likely that there have been significant impacts to infiltration. It was noted that future recharge inflow conditions within the Talbot River and Whites Creek subwatershed is expected to be reduced by less than one percent of the current conditions (Earthfx, 2014). The Earthfx report (2014) also noted that there are no planned water demand conditions and only assessed current and future water demand conditions within the study area. Under both current and future water demand conditions, the subwatershed was assessed at the low stress level. In addition, a 2-year and 10-year drought analysis was completed, which focused on the predicted response of water levels in the municipal wells, along with the response of groundwater levels, groundwater discharge to streams, and total streamflow within the subwatershed. The results of both analyses found some reduction in groundwater levels, but municipal pumping wells did not go dry. There were some impacts found with regard to streamflow, particularly in the headwater streams, which are dependent on groundwater discharge, with reductions in discharge of up to 61% being seen (Tables 5-24 and 5-25).

One important measure to protect this hydrological-ecological relationship is with the identification and protection of Ecologically Significant Groundwater Recharge Areas (Figure 4-29), which are those areas of groundwater recharge that support the flow of groundwater to ecologically sensitive features such as wetlands and creeks. Once identified, the Lake Simcoe Protection Plan directs municipalities to develop policies in their Official Plans to protect, improve, or restore these features.

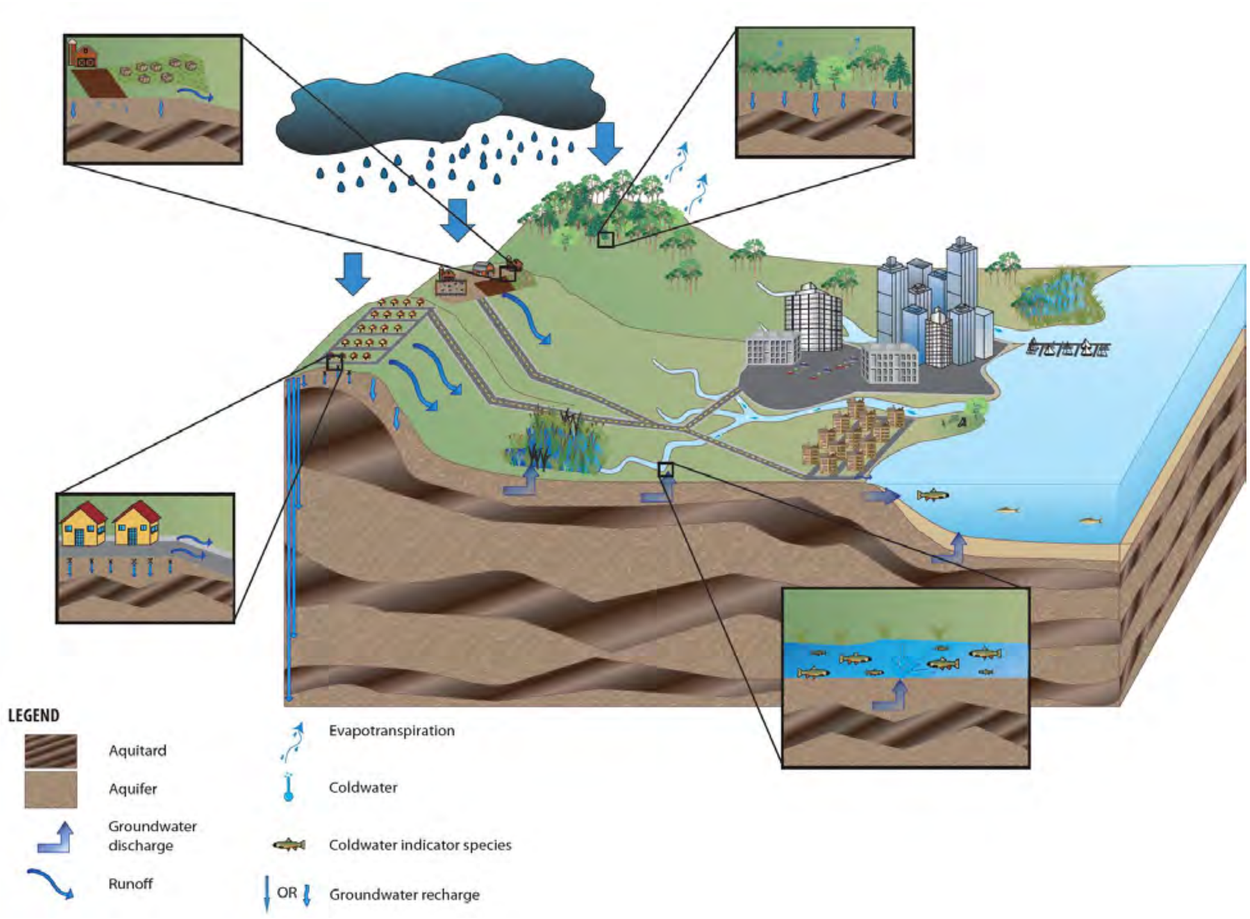


Figure 9-1: Groundwater interactions in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed

9.3 Rural and agricultural interactions - land use, streams, and aquatic wildlife

When rain falls and flows over soils on agricultural land, it can cause more erosion than in natural areas, due to a relative lack of vegetative cover, particularly in the spring when the fields are tilled and after harvest in the fall. Water quality can also be affected due to runoff picking up contaminants not present in natural areas. Soil particles eroded by stormwater in agricultural areas often have phosphorus adsorbed to them, particularly if the storm event happens relatively soon after a surface application of manure or fertilizer (Figure 9-2). As such, agricultural stormwater can contribute to both the sediment loads and phosphorus loads in receiving water bodies. In fact, historically, the conversion of much of the Lake Simcoe watershed to agricultural land in the mid-1800s caused a spike in phosphorus loadings to the lake (Wilson and Ryan, 1988). Agriculture remains a significant contributor of phosphorus to Lake Simcoe; it is the most prevalent land use in the study area, and modelling has estimated that it contributes close to one third of the phosphorus load in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed (Louis Berger Group, Inc., 2010). This includes contributions from crop land as well as the relatively high proportion of pasturing lands found in the subwatershed. In addition, septic systems, which are primarily found in rural and agricultural areas, are estimated to contribute 45% of the phosphorus load. Other contaminants, such as nitrates and metals, can also be washed off of agricultural lands and into nearby watercourses during runoff events.

The addition of contaminant-laden sediment to watercourses can have significant deleterious impacts to aquatic ecosystems. Suspended sediment in watercourses increases the amount of sunlight that is absorbed by the water, and thus can contribute to increasing water temperatures. At high levels, it can also clog or abrade fish gills, impeding their ability to breathe, and can also cloud the water, reducing the hunting efficiency of visual predators. As the sediment settles out of the water column, it can blanket the substrate, covering important spawning habitat. The addition of the phosphorus adsorbed to sediment contributes to the eutrophication cycle, which is of significant concern in the Lake Simcoe watershed. Phosphorus acts as a fertilizer in aquatic ecosystems, causing increased growth of aquatic plants and, most significantly in streams, algae. As the algae decompose, bacteria involved in the decomposition process remove dissolved oxygen from the water column. At high levels of algae, this respiration can cause the amount of dissolved oxygen in watercourses to decline to critical levels, making them less suitable as habitat for fish and other aquatic organisms (Figure 9-2).

An issue specific to the management of agricultural watersheds is agricultural drains, which constitute a large proportion of the watercourses in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed. These drains include both open ditches and tile drains, which are typically installed in areas with poor natural drainage, to improve agricultural productivity. Ditches, or open drains, are typically straightened to quickly remove water from the area and generally have limited amounts of riparian vegetation. To ensure that they continue to work properly, they require maintenance, which can involve the alteration or removal of remaining vegetation, and disruption and change to the substrate. In addition, their intended function of rapidly draining wet soil has the unintended consequences of changing the rate and timing of peak flows, and increasing the volume of phosphorus and sediment travelling from agricultural fields to Lake Simcoe. In cases where these drains bisect wetlands they can cause the water table to drop, decreasing the extent and hydroperiod of ephemeral wetland pools, which can lead to a loss of breeding habitat for frogs and salamanders and migratory habitat for waterfowl (Figure 9-2).

Another issue occurring in agricultural lands is the degradation of water quality and riparian areas where livestock have access to watercourses. The input of urine and manure directly into the water and onto low lying nearby fields, where it can be washed into the watercourse, affects water quality. The livestock can also trample streambanks, contributing to instability and erosion, as well as sedimentation in the stream; while livestock in the stream can destroy spawning habitat (Figure 9-2).

In addition to these issues from various farm practices, sewage from most of the residences in rural areas is treated by private septic systems. As they age, these systems can malfunction and fail, and can be a considerable source of nutrient and bacteria contamination to surface and groundwater (Figure 9-2). As an example, inputs from malfunctioning septic systems near the lake were found to be the most significant contributor to phosphorus loads in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershedunder the modelling completed by Berger and Associates in their 2010 report (Table 3-6).

The presence of natural vegetation along many watercourses flowing through agricultural land in (such as those areas coloured green in Figure 8-9) can help to buffer watercourses from these impacts. Riparian buffers act as an important last line of defence between farm fields and watercourses. The vegetation that they contain reduces the velocity of stormwater runoff, allowing sediment to be deposited within the buffer rather than in the creek; absorbs nutrients such as phosphorus and nitrogen; and binds the soil on the banks of the river, slowing the rate of erosion caused by stormwater runoff (Figure 9-2). As was noted in Chapter 8: Terrestrial Natural Heritage, it is recommended that a minimum of 75% of the riparian area within 30 m of a watercourse be in natural cover. The watercourses of the Whites Creek subwatershed fall short of this, with just over half of the riparian area having natural cover; however in the Talbot River subwatershed, 81% of the riparian buffers along its watercourses are in natural heritage cover. The higher levels of natural cover are mainly found in the swamp areas in the upper Talbot subwatershed. The remainder of the subwatershed’s watercourses, particularly where they flow through agricultural areas, are lacking in natural cover (Figure 8-9). In these areas, impacts on watercourses from agricultural land uses can be most significant, and can be associated with a shift in tributary fish communities.

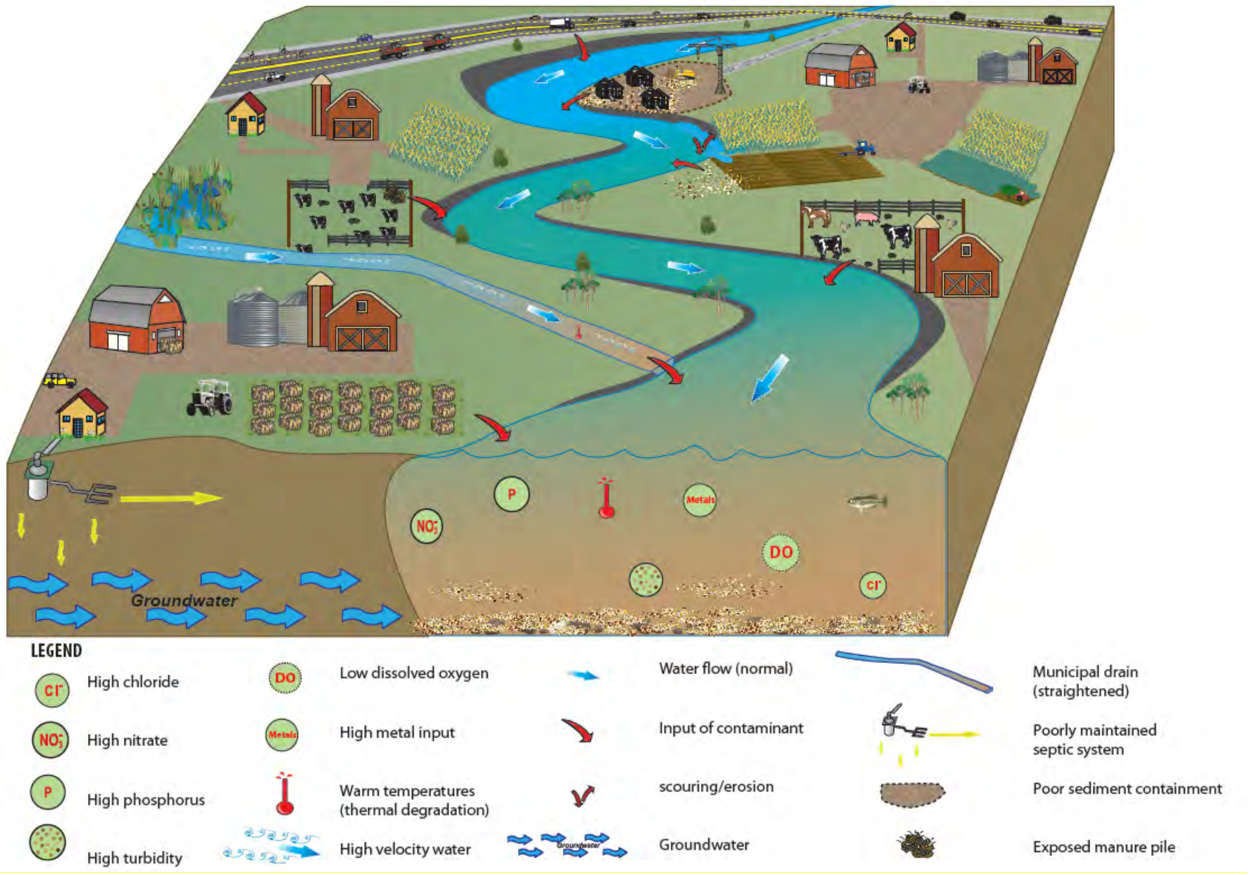


Figure 9-2: Influences of rural and agricultural land use on subwatershed health.

The release of sediment and phosphorus from farm fields can also be reduced through the use of cover crops, by minimizing and/or properly timing fertilizer application, by fencing streams to prevent livestock access, through enhancement of riparian buffers, and with the preservation of remnant wetlands and forests. The release of phosphorus and other contaminants from barn yards can be reduced through the proper storage and spreading of manure, and the proper storage and disposal of milkhouse waste (Figure 9-3).

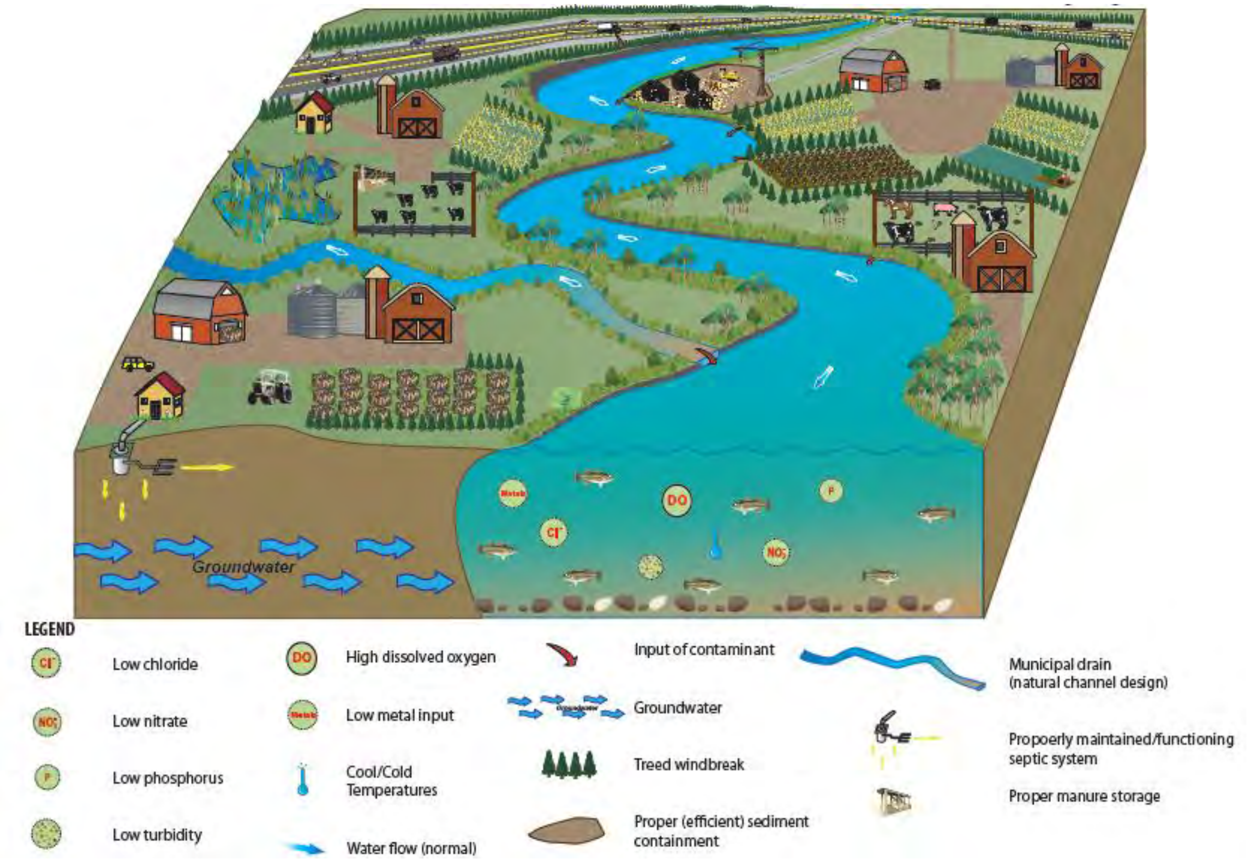


Figure 9-3: An agricultural landscape with appropriate best management practices implemented to protect subwatershed health

A number of stewardship programs have been provided by various government agencies, with the intent of engaging private landowners in undertaking these types of stewardship projects, through increasing awareness of the importance of these actions, and by providing technical and financial assistance to help these voluntary actions. Through such programs, the Lake Simcoe Region Conservation Authority, Kawartha Conservation, Ontario Soil and Crop Improvement Association, and their partners have implemented extensive projects in the agricultural areas of the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed, primarily related to stream bank fencing, establishment of riparian buffers and other tree planting projects, and improved management of manure and milkhouse waste (Figure 9-4). In addition to the projects shown here, there have also been several septic system repairs and/or upgrades completed in the subwatershed.

Despite this effort, many more opportunities to increase the amount of stream bank vegetation, reduce barnyard runoff, and restrict livestock access still remain in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed. In addition, there are likely many more septic systems that will require repairs or upgrades to prevent them from contributing phosphorus to ground and surface water as they age.

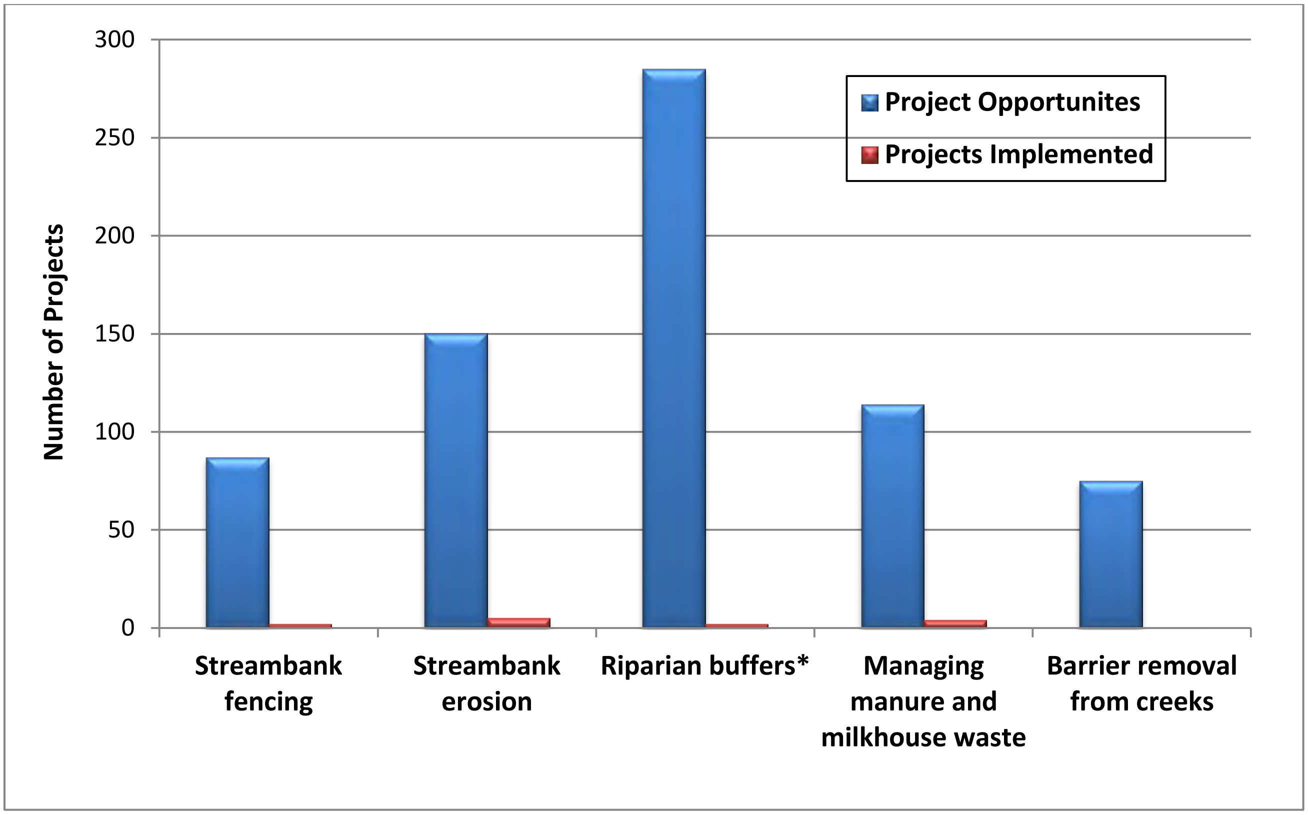
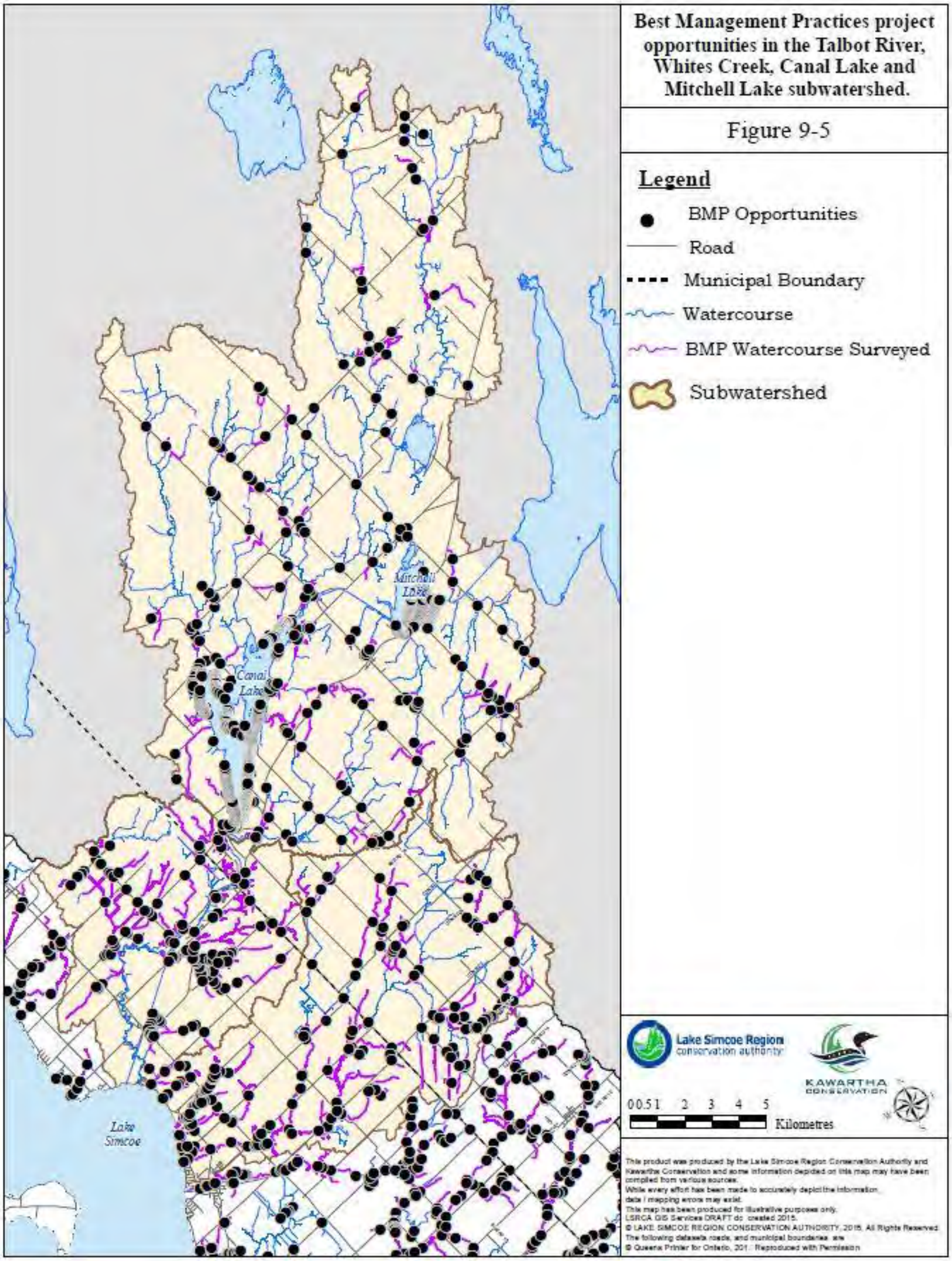


Figure 9-4: Approximate number of stewardship projects (completed by the LSRCA) and stewardship opportunities in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed. *Projects implemented in this category may include both riparian and upland tree plantings

The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2014) was completed to identify opportunities to complete restoration projects in the watershed. The BMP inventory covered 43% of the watercourses in the Talbot River subwatershed, including the shorelines of Canal and Mitchell Lakes, and 67% of the Whites Creek subwatershed. A total of 1945 project opportunities were identified in the study area, including 694 in Whites Creek and 1251 in the Talbot River (Figure 9-5).



This product was produced by the Lake Simcoe Region Conservation Authority and Kawartha Conservation and some information depicted on this map may have been compiled from various sources.
While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT dc created 2015.
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The following datasets roads, and municipal boundaries are
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Figure 9-5: Best Management Practices project opportunities in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed

9.4 Urban interactions - land use, streams, and aquatic wildlife

When stormwater flows over urban areas, it may pick up more contaminants than in other types of land use (Figure 9-6). Urban areas can generally be found in small pockets of development throughout the study area, with the largest areas being the towns of Beaverton and Kirkfield, as well as the shorelines of the Talbot River and Canal and Mitchell Lakes. Urban areas, and the stormwater associated with them, have been found to be significant contributors to the phosphorus load in Lake Simcoe. While urban areas are not the most significant contributor to the phosphorus load in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed, they undoubtably contribute some phosphorus to the system. With some expansion of the urban area expected in this subwatershed, the proportion of the load attributed to this land use is expected to increase, if appropriate best management practices are not undertaken (Table 4-6).

While limited, there is some urban development expected in the subwatersehd; many of the stresses associated with urban land use may also become more extensive, including a projected increase in loading of phosphorus and chloride in watercourses, and a further increase in water temperature. In addition to the impacts associated with built urban areas, there are also a number of issues associated with the building phase of new development. Development sites are often stripped of vegetation well in advance of development in an effort to reduce costs as the development is built in phases. These bare soils are then subject to erosion by both wind and water.

As in agricultural landscapes, the contribution of sediment and phosphorus can have deleterious impacts on species living in nearby streams by increasing water temperatures, decreasing levels of dissolved oxygen, and disturbing spawning sites. Other contaminants that occur in stormwater runoff from the urban parts of these subwatersheds, however, include phenolics, metals, and organic compounds (Figure 9-6). At high levels, these contaminants can interfere with enzyme activity in aquatic organisms, leading to changes in behaviour, movement, predator avoidance, feeding rates, reproduction, reduced growth rates or even death. At this point, effects due to the presence of these contaminants in the more urban areas of the subwatershed are unknown due to limited monitoring information in the area; however with the lack of stormwater controls it can be assumed that they are having some impact on subwatershed health.

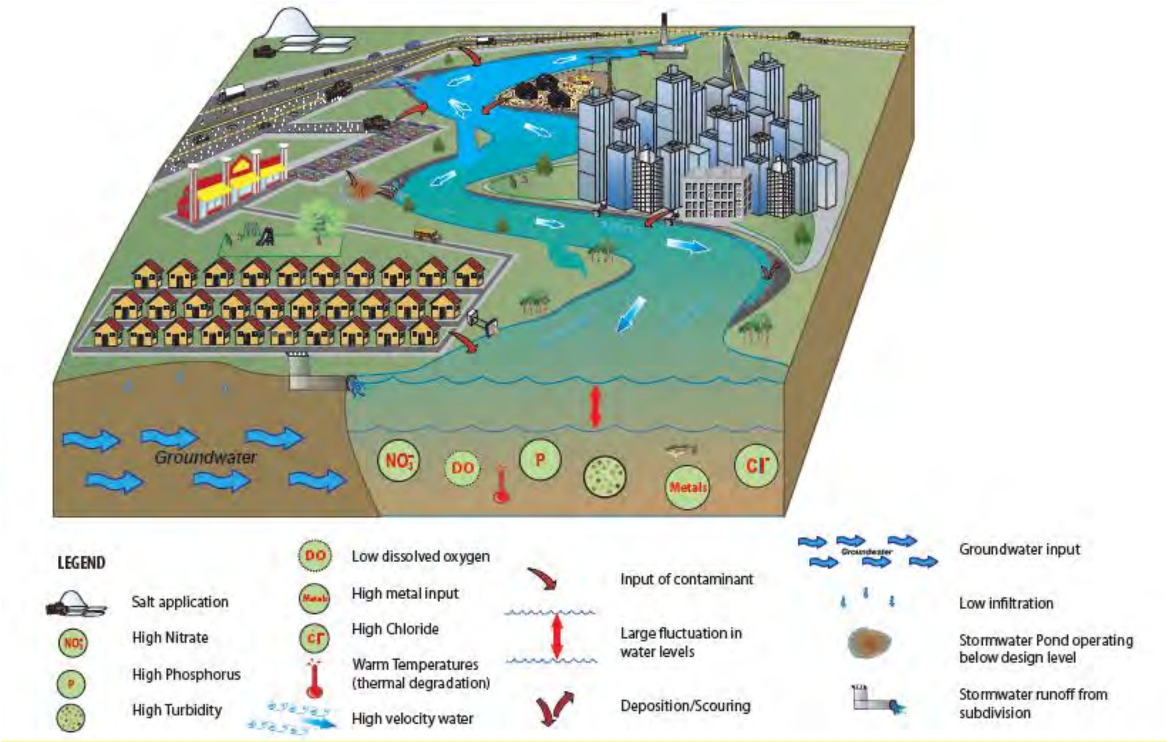

Figure 9-6: Influences of urban land use on subwatershed health

Complicating matters further is our management of snow. Where, historically, snow would accumulate in the forest, melt, and form a spring freshet, providing flooded areas along the banks of rivers which act as spawning sites for species such as northern pike or muskellunge, it is now diligently cleared from city streets, parking lots and sidewalks, and often relocated to designated disposal sites to improve mobility and decrease the risk of injury or car accidents. In many cases, salt is also applied to roads and parking lots to decrease the temperature at which ice freezes. The result of this snow removal, however, is a significant change to the timing, volume, location, and chemical composition of the spring freshet (Figure 9-6). Increasing concentrations of chloride in watercourses can decrease feeding and growth rates in fish and, if they reach acute chloride concentrations, can lead to widespread mortality in fish and other aquatic organisms. Chloride concentrations at all monitoring sites fall well below the guideline for chronic exposure, and the most recent trend analysis (2005-2014) shows a decreasing chloride trend at both Talbot River long-term water quality stations. However, given that the majority of other Lake Simcoe water quality stations, and areas throughout the province and beyond, are displaying increasing trends in chloride concentrations, it is possible that chloride concentrations in the subwatersheds could increase in the future with increased development and changes in winter precipitation resulting from climate change. Additional monitoring around the study area, in a wider varity of land use types, would give us a better understanding of chloride concentrations in the subwatershed, and could potentially identify chloride ‘hot spots’ that should be targeted for chloride reduction activities.

Other methods of reducing salt application on roads include carefully calibrating the application of salt to the temperature of the road, ensuring that snow meltwater does not drain directly into storm sewers, or using treatment measures other than chloride in areas that are particularly sensitive to contamination.

Additionally, as stormwater flows over urban areas, it tends to reach creeks more quickly than it would when flowing over natural areas. As a result, streams can exhibit both a decrease in baseflow levels and an increase in flow rate and volume during high flow events. Both of these stresses can make aquatic environments less suitable as habitat for resident fish, due to a loss of habitat during low flow periods, and an increase in the energy necessary to manoeuvre through the creek during high flow events. This increased velocity also can increase the rate of erosion of exposed soil or streambanks, increasing the amount of sediment that gets deposited in the creek, and can increase the transport of contaminants. The flow of stormwater over hardened urban surfaces such as roads, parking lots, sidewalks, and asphalt shingles also tends to increase its temperature. As such, urban stormwater can increase the temperatures in urban creeks, making them unsuitable habitat for more sensitive species (Figure 9-6). While the subwatershed remains a largely agricultural area, it is important to bear this in mind for the existing urban areas, as well as those that will be built into the future.

While it is difficult to identify a particular source of nutrient enrichment, the area of dense plant growth and relatively high sediment phosphorus levels in Lake Simcoe between the discharge of the study area subwatersheds and Thorah Island and (Figures 7-5 and 7-11) may be a result of nutrient inputs from the urban areas along the lake shore in this area. This area is one of several areas around the lake which have one or more conditions that make them favourable for aquatic plant growth – these are generally sheltered bays with soft substrates and sufficient quantities of available nutrients to encourage the dense growth of plants. Further research in this area may help to further identify the sources of phosphorus that are contributing to this plant growth.

As in agricultural landscapes, the preservation of native vegetation along watercourses plays an important role in slowing the velocity of stormwater, collecting sediment, capturing phosphorus and nitrogen, and binding the soil on the banks of the river (Figure 9-7). The preservation of native vegetation along roadsides also plays an important role in protecting the health of urban watersheds, as windbreaks of this sort help reduce the accumulation of blowing snow on highways, thus reducing the need to apply sand or salt to roads (Figure 9-7). In addition, the presence of vegetation directly alongside waterways, such as the Talbot River and along the lake shores, will discourage the use of those areas by waterfowl, which contribute to water quality issues.

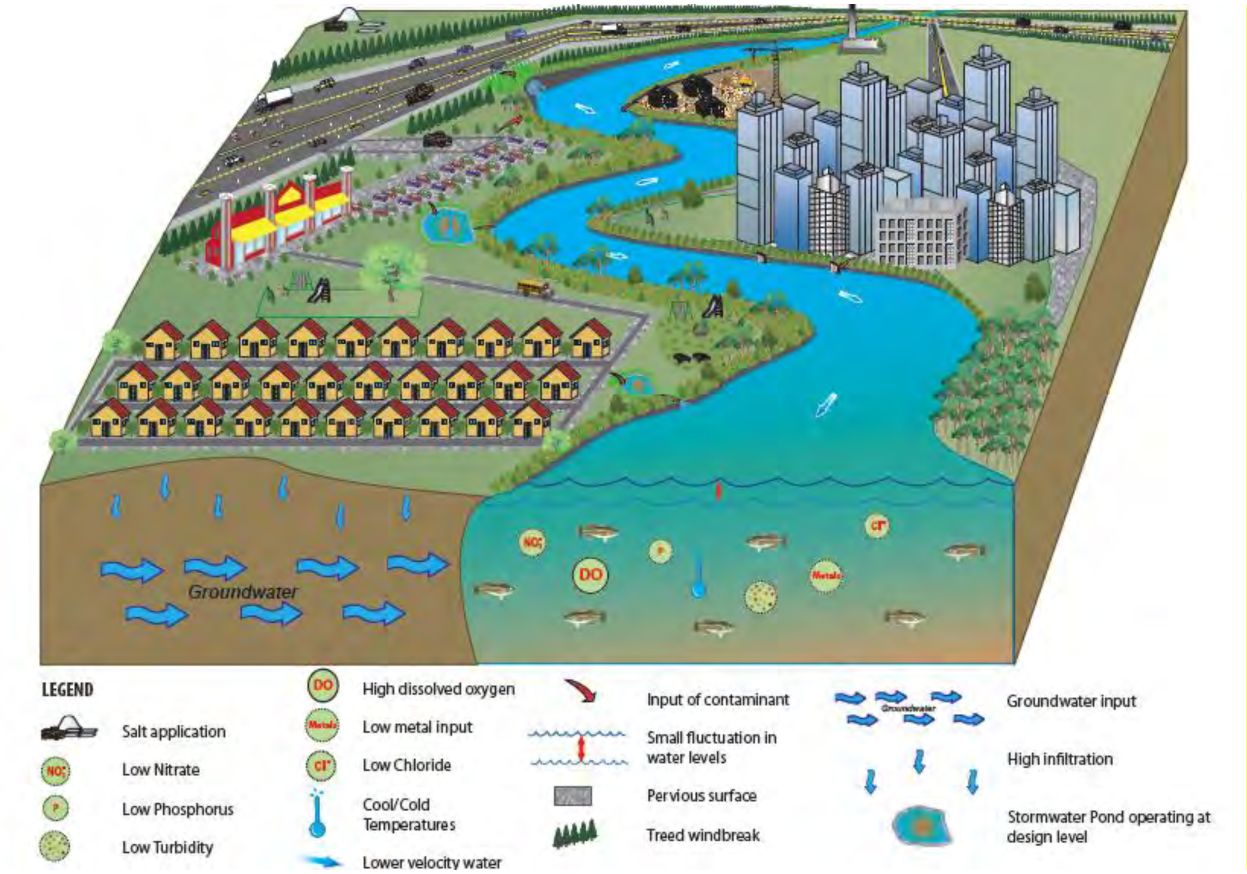

Figure 9-7: An urban landscape with appropriate best practices implemented to protect subwatershed health

One of the standard ways of addressing the concerns associated with urban stormwater runoff is the use of stormwater ponds. Stormwater ponds are designed to trap sediments to improve the quality of the stormwater, which is ultimately released back into the watershed. Without proper maintenance, however, stormwater ponds can operate below their designed efficiency, and can contain sediments which have high concentrations of phosphorus, chloride, heavy metals, and petrochemicals. In extreme cases, during high flow events, some un-maintained stormwater ponds can actually act as a source of contaminants to nearby watercourses. As well, the large surface area of stormwater ponds tends to contribute to an increase in water temperature. As such, stormwater ponds have the potential to negatively impact the thermal regime of nearby watercourses, decreasing habitat quality for sensitive fish species. Poorly maintained stormwater ponds can also be detrimental to bird and amphibian populations, which often utilize them as breeding habitat as wetlands are lost from urbanizing landscapes. However, if the stormwater ponds are hypoxic, surrounded by unsuitable habitat or roads, or have high concentrations of other contaminants, they can cause reductions in reproduction rates and overall survival for these species (Figure 9-6). There are few stormwater facilities in the Talbot River, Whites Creek, Canal Lake and Mitchell Lake subwatershed, and these issues are therefore limited in scope; however it is important to ensure that existing facilities are maintained so that they function as designed, and don't contribute to water quality issues in the subwatershed.

The best way to manage stormwater runoff in urban areas is to reduce the volume of run-off through the use of Low Impact Development. Low Impact Development (LID) is a term that refers to a suite of innovative design solutions that can be incorporated into new developments, with the goal of increasing the amount of stormwater that infiltrates into the ground and decreasing the amount that flows over land. Tools in the LID toolbox include green roofs, infiltration swales, permeable pavement, and a greater focus on retaining urban forest cover. Other, secondary treatments include proper site control during construction, ongoing maintenance of stormwater ponds, the upgrade of stormwater ponds built with earlier technology, and the establishment and preservation of riparian buffers (Figure 9-7). Despite the challenges to watershed health associated with the limited amounts of stormwater control in the study area, there remain significant opportunities both in existing areas, and with new development, for the implementation of innovative low impact development techniques, as well as to use innovative design for stormwater management ponds and retrofits.

Stewardship projects have generally been limited to agricultural areas in this subwatershed, but there are also a number of opportunities to improve conditions in the urban areas, such as increasing the extent of riparian buffers and upgrading and/or retrofitting stormwater ponds (Figure 9-4, Figure 9-5).

9.5 In-stream interactions - activities in and near creeks, water quality, and aquatic wildlife

In addition to actions being undertaken across the watershed as whole, actions in or near creeks can have even more direct impacts to hydrologic and ecologic systems. The riparian buffers along the edges of watercourses or the lake make important contributions to aquatic wildlife, as the plant debris that is dropped into the water body provides an important food source for aquatic invertebrates, which form the base of aquatic food webs. The shade provided by vegetation along the banks, particularly for small streams like many of the tributaries in this subwatershed, plays an important role in reducing water temperature in mid-summer, which is a particularly important factor in providing habitat for more sensitive species. Riparian vegetation also makes an important contribution to terrestrial wildlife, acting as a productive source of food for many species, and acting as a migration corridor through landscapes that are often otherwise lacking in native vegetation. In fact, given the fragmentation of habitat by roads, agriculture, and urban communities in parts of this subwatershed, riparian zones can provide some of the best opportunities to maintain and increase connectivity for wildlife.

When this vegetation is cleared, these benefits are lost. The impacts of lost riparian vegetation can be exacerbated by other more extreme interventions such as stream channelization, bank hardening, or converting free-flowing streams to underground pipes. These types of interventions remove habitat for aquatic species, and increase the velocity of water, causing an increase in erosion downstream of the hardened or enclosed site, or in areas where the hardening begins to fail, which in turn increases sedimentation and phosphorus inputs (Figure 9-8). In the case of agricultural drains, periodic maintenance intended to promote efficient draining prohibits the establishment of trees along one (or both) sides of the drain, and causes disturbance to fish habitat and water quality while maintenance is occurring.

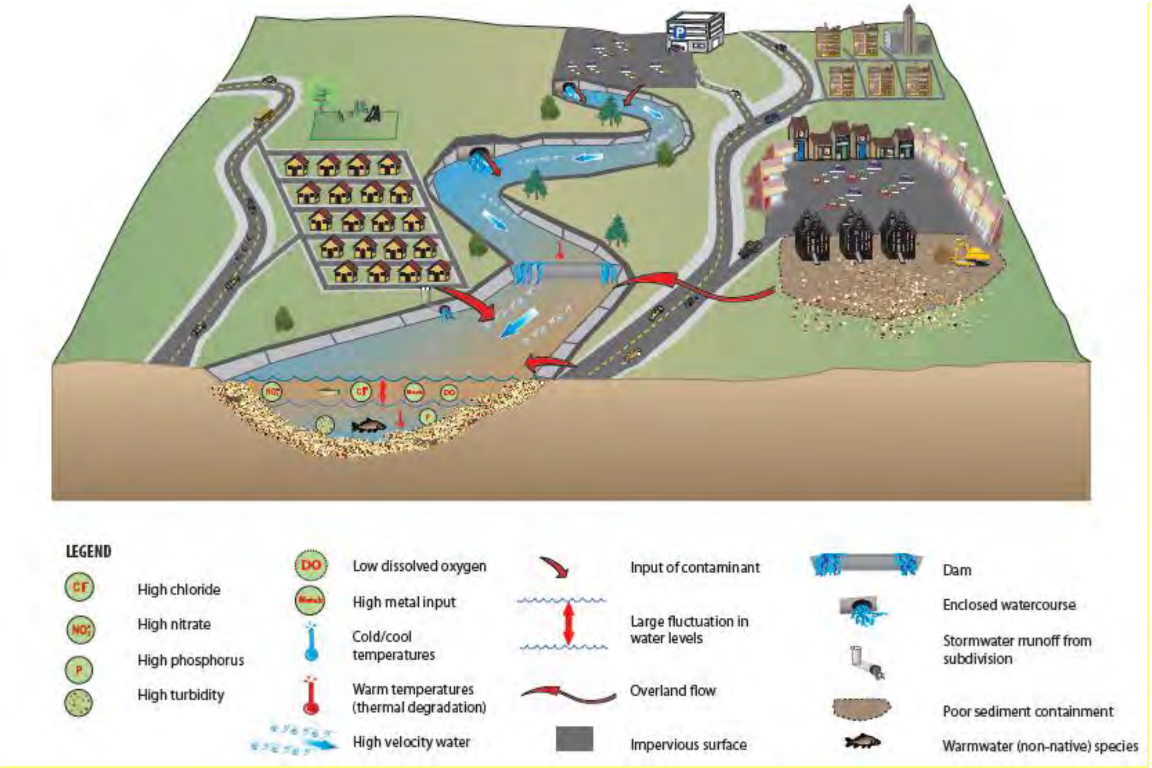

Figure 9-8: Influences of riparian land use on subwatershed health

These impacts can also be worsened in ponds or reservoirs created by barriers on creeks. The ponds created by these barriers increase the amount of area exposed to the sun, and as such increase water temperature, potentially encouraging the enhanced growth of aquatic plants, algae, and bacteria, and a decrease in oxygen levels when these plants and algae decompose. Barriers erected on creeks also fragment fish habitat, impeding the seasonal travel of migrant spawners such as white sucker, and impeding the ability of other species to disperse through the drainage network. Over time, barriers can lead to a loss in fish biodiversity, as isolated stream reaches become more vulnerable to local extinctions (Figure 9-8). Septic systems, which support many of the rural residences in this subwatershed, can also be a source of phosphorus to nearby watercourses and can impact water quality, if they are not properly maintained.

Creek-based stewardship activities beyond the establishment of additional riparian vegetation can be difficult however, as projects related to channel restoration can be extremely expensive, and in agricultural or developed areas, options to establish a naturally meandering channel can be extremely constrained due to conflicting land uses. Despite that, the Lake Simcoe Region Conservation Authority and a number of community partners have been able to undertake a number of projects in the Talbot River and Whites Creek subwatershed in recent years to improve fish habitat, reduce temperatures, and reduce phosphorus loading. Many more opportunities to remove barriers from creeks and naturalize creeks which have been channelized remain in this subwatershed, where adjacent land uses permit (Figure 9-4, Figure 9-5).

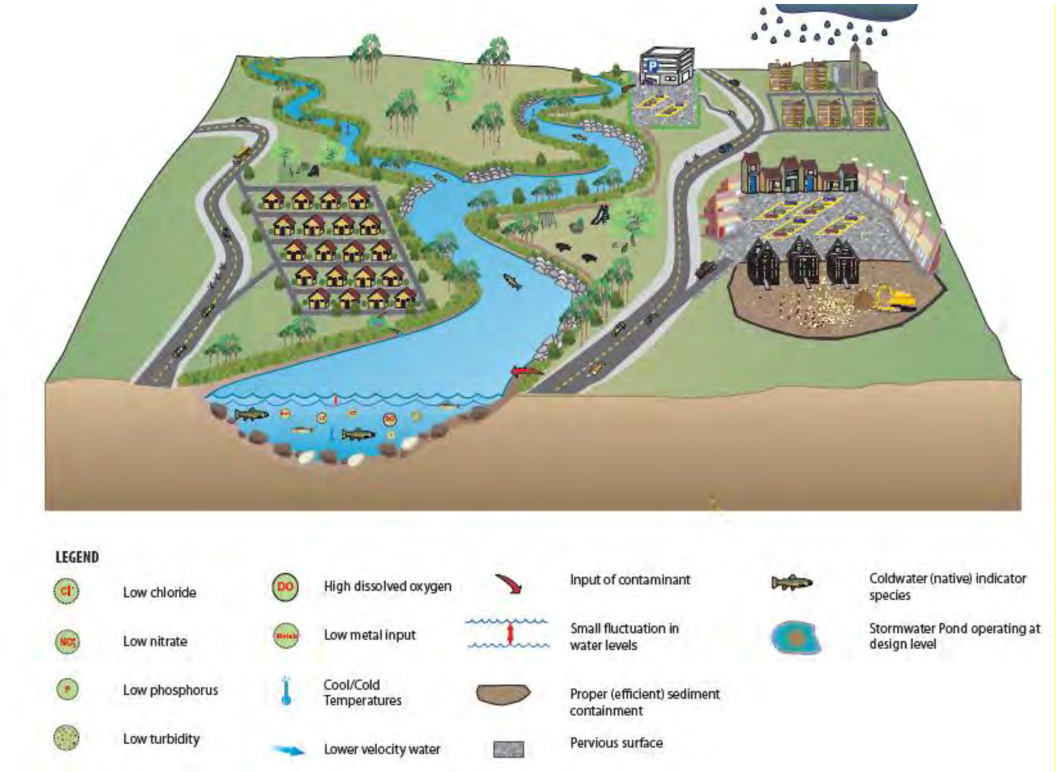

Figure 9-9: Riparian area with appropriate best practices implemented to protect subwatershed health

9.6 Shoreline interactions - activities in and near the lakeshore, water quality, and aquatic wildlife

Of particular importance to this subwatershed is the role played by the shorelines of Lake Simcoe, Canal Lake and Mitchell Lake. The shorelines along these lakes have been the focus of development and public use for nearly a century, which has led to an increase in the extent of impervious surfaces and hardened banks, and increased population levels (Figure 9-10). A large proportion of the native vegetation has been removed from the shorelines in this subwatershed, and what is left is often mowed right to the water's edge.

The loss of shoreline vegetation has negative impacts on nearshore aquatic communities, through an increase in water temperature and sediment input, and a decrease in input of woody debris (which is an important component of habitat for many aquatic organisms). Unfortunately, the impacts of this loss of vegetation ares often exacerbated by other works along the shoreline, such as the installation of concrete, steel, or gabion baskets as retaining walls to prevent erosion or to make the shoreline more conducive for recreation. The loss of the natural shoreline and associated aquatic vegetation associated with this construction means a loss of spawning and feeding habitat for native fish (Figure 9-10).

This type of shoreline development, in combination with an increase in impervious surfaces, also increases the amount of contaminants in runoff. Increased nutrients and an increase in temperature create an ideal growing situation for algae and aquatic plants, which can be a nuisance to swimmers and boaters, and can also create anoxic conditions for aquatic communities. Shoreline areas are also disproportionately important for terrestrial wildlife as well, as the clearing of shoreline areas for cottages or homes leads to loss of habitat for songbirds, amphibians, turtles, and small mammals.

Although the development of individual shoreline properties may seem small in nature, the cumulative effect of all of these small developments can add up to significant impacts. The Talbot River and Whites Creek subwatershed's shoreline along Lake Simcoe, which represents 2.5% of the total lakeshore, has already had close to 60% of its length developed in some way. In addition, approximately 24% of the shoreline of Canal Lake, and 16% of the shoreline of Mitchell Lake have been altered in some way.

Stewardship options for shoreline properties are quite similar to those for riparian areas, and include septic system repairs, shoreline naturalization, erosion control projects, and tree planting (Figure 9-11). Financial and technical support for these types of projects is provided by the MNRF, LSRCA and Kawartha Conservation.

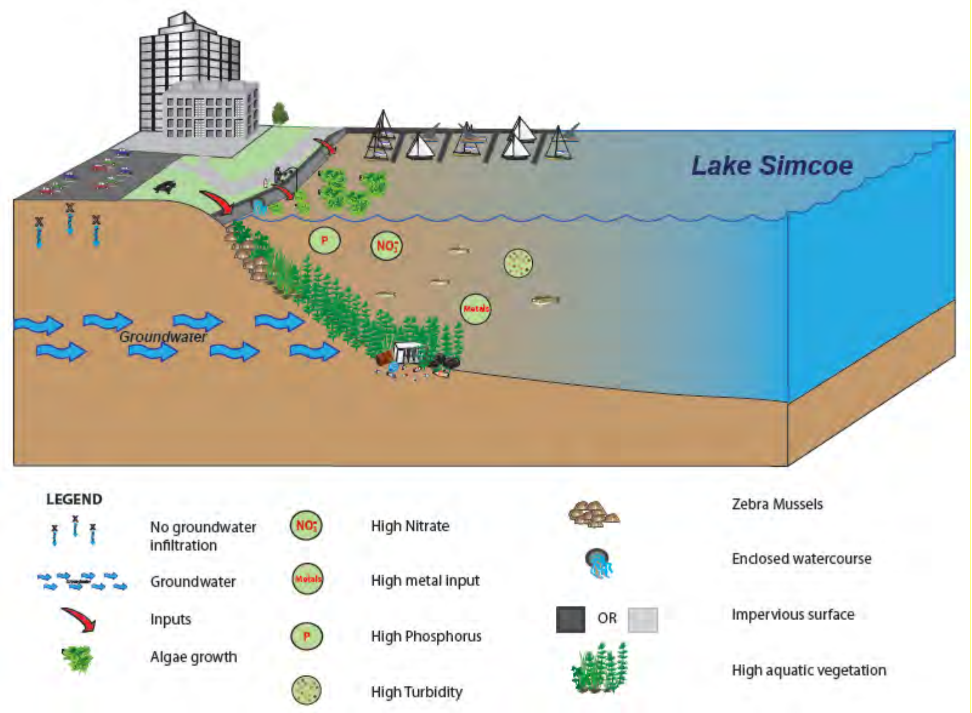

Figure 9-10: Influences of shoreline land use on subwatershed health

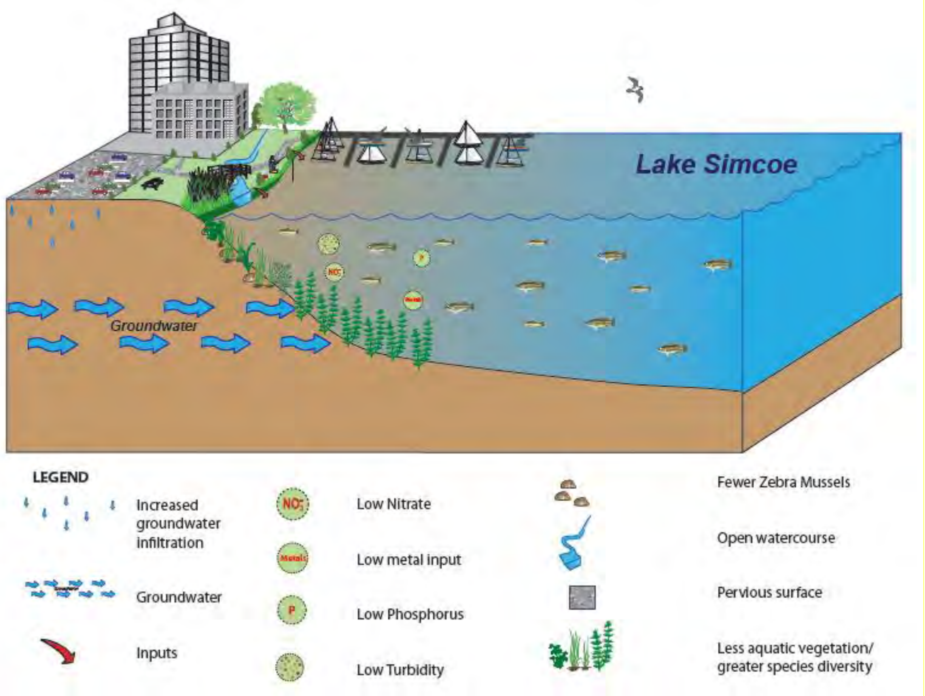

Figure 9-11: Shoreline area with appropriate best practices implemented to protect subwatershed health

9.7 Developing an implementation plan

The Canal and Mitchell Lakes, Talbot River, and Whites Creek Subwatershed Plan includes an assessment of the current state of the environment in the subwatershed, the stressors upon its health, and the current management framework to address those stressors. As a result of that assessment, the subwatershed plan has developed a list of recommended actions which, if implemented, would provide additional guidance on the protection and restoration of that subwatershed.

Achieving these recommendations will require the coordinated response of multiple government agencies, and many individual landowners, working together in a multifaceted approach to protecting and improving subwatershed health. To ensure these actions are fostered and coordinated, this subwatershed plan will be complemented with a Subwatershed Implementation Plan, as well as a Subwatershed Implementation Working Group.

The Subwatershed Implementation Plan is a brief document, intended to provide the necessary support and direction to achieve a short list of priority recommendations within five years of the completion of this subwatershed plan. To meet that goal, the implementation plan is written with more specific detail on timelines, deliverables, and the specific steps necessary to achieve those priority recommendations.

This implementation plan will also form the basis of periodic meetings of the Subwatershed Implementation Working Group, a watershed-wide group comprised of upper and lower tier municipalities where subwatershed plans have been completed, provincial Ministries of the Environment and Climate Change, Natural Resources and Forestry, and Agriculture, Food, and Rural Affairs as well as Kawartha Conservation, the Lake Simcoe Region Conservation Authority, and other relevant stakeholders. These representatives, who are the primary lead agencies on the recommendations developed in this and other implementation plans, will meet periodically to coordinate and report on implementation of the priority recommendations. This group will also assist in periodic review and updates to this subwatershed plan.

10 Combined Recommendations

This chapter provides a compiled list of the recommendations identified in the detailed technical chapters of this subwatershed plan. These recommendations have been brought forward and prioritized in the development of an implementation plan for the Canal and Mitchell Lakes, Talbot River, and Whites Creek subwatersheds. Those recommendations that were carried forward into the implementation plan have been highlighted in grey.

The recommendations in this chapter have been grouped into categories of similar issues. Thus, for example, recommendations derived from the terrestrial natural heritage chapter may be grouped with recommendations derived from the water quality chapter, in cases where they address shared issues. In such cases, the numbering system will allow the reader to trace the recommendation back to the chapter where it originated.

Recommendations in the following list are numbered as chapter number – recommendation number. In cases where a recommendation originated from more than one chapter, it is numbered based on its first occurrence, with all other occurrences listed in parentheses.

It is recognized that many of the undertakings in the following set of recommendations are dependent on funding from all levels of government. Should there be financial constraints, it may affect the ability of the partners to achieve these recommendations. These constraints will be addressed more fully in the implementation phase.

Under Policy 6.19 of the Lake Simcoe Protection Plan, the Talbot River subwatershed is to be regulated under Section 28 of the Conservation Authorities Act. Upon such a time as that Regulation comes into force, the two Conservation Authorities will revisit and clarify their roles and responsibilities in implementing recommendations in this subwatershed plan.

10.1 Protection and Policy

10.1.1 Official Plan consistency

Recommendation 8-1 - That the LSRCA, Kawartha Conservation, and relevant provincial agencies assist the City of Kawartha Lakes and the Townships of Brock and Ramara in ensuring their official plans are consistent with the recommendations presented in the Talbot River, Whites Creek, Canal and Mitchell Lakes Subwatershed Plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with the City of Kawartha Lakes, the Townships of Brock and Ramara, the subwatershed plan working group, and the general public, as outlined in the *Guidelines for developing subwatershed plans for the Lake Simcoe watershed* (May, 2011).

10.1.2 Protecting Natural Heritage

Recommendation 6-13 - That the study area municipalities, in partnership with the LSRCA and Kawartha Conservation, mitigate perched culverts through the design and implementation of routine road maintenance works.

Recommendation 6-14 - That the LSRCA, Kawartha Conservation, MNRF, and the Trent-Severn Waterway investigate the impacts of the Trent-Severn locks and other major barriers located in the study area to the movement of fish. Further that the partners explore the feasibility of mitigating these impacts, perhaps through the installation of fishways. Any potential mitigation activity would consider, at a minimum, the potential for the introduction and/or spread of invasive species.

Recommendation 6-15 - That the MNRF, LSRCA, Kawartha Conservation, and the Trent Severn Waterway, in partnership with organizations such as the Ontario Federation of Anglers and Hunters (through its invading species awareness program) continue to implement strategies to prevent the introduction and spread of invasive species through the study area subwatersheds. This could include, but would not be limited to, the continuation of education and outreach works, and the development and distribution of additional materials as new species of concern arise; implementing measures such as boat and equipment sanitization, and conducting research on how the ecosystem responds to the introduction of invasive species.

Recommendation 6-16 - That the MNRF, LSRCA, Kawartha Conservation, DFO and the Trent Severn Waterway, examine ways of preventing the spread of novel invasive species between the Lake Huron and Lake Ontario basins via the Trent Severn Waterway.

Recommendation 8-2 – That the MNRF, MOECC, and LSRCA review the terrestrial natural heritage data provided by the comprehensive monitoring program, when it becomes available, to define site level characteristics or indicators of ‘high quality’ natural heritage features, and provide policy recommendations to subwatershed municipalities (as necessary) to ensure high quality natural heritage features are adequately protected from development and site alteration.

Recommendation 8-3 – That Kawartha Conservation develop policies around the *Kawarthas, Naturally Connected Natural Heritage Systems Strategy* in order to achieve its implementation. Wherever possible, these policies should be consistent with those of the *Lake Simcoe Natural Heritage System to ensure ease of implementation for municipalities*.

Recommendation 8-4 – That the City of Kawartha Lakes, Region of Durham, and Townships of Brock and Ramara incorporate the protection and restoration of areas of critical ecological significance identified through the *Lake Simcoe Natural Heritage System* and/or the *Kawarthas, Naturally Connected Natural Heritage Systems Strategy* into their official plans. Further, that the LSRCA and Kawartha Conservation partner to facilitate this implementation by determining how to mesh the features protected under the two systems, for municipalities that fall within multiple conservation authority jurisdictions.

Recommendation 8-6 - That the LSRCA and Kawartha Conservation, in partnership with subwatershed municipalities and other interested stakeholders, develop policies for municipal official plans that would provide mitigation and restoration for development and site alteration within natural heritage features that are not defined as “key” by the Lake Simcoe Protection Plan or as “significant” under municipal official plans, to ensure no net loss in overall natural vegetative cover as a result of development.

Recommendation 8-7 - That the LSRCA, Kawartha Conservation, and subwatershed municipalities promote the use of programs such as the Managed Forest Tax Incentive Program to provide landowners with financial incentives to preserve the natural features on their properties.

Recommendation 8-8 – That, after the development of the Provincial Grassland Stewardship Initiative, that LSRCA and Kawartha Conservation review their stewardship programming, in consultation with the agricultural roundtable or other representatives of the agricultural industry, to assess if there are additional ways that the Conservation Authorities can support interested landowners in maintaining endangered species on their properties.

Recommendation 8-9 – That the MNRF, MOECC, and LSRCA, consider including only woodland and wetland habitats, which would be commonly found throughout the Lake Simcoe watershed, within the LSPP target of 40% high quality natural heritage cover, and set additional for some of the other unique habitat types found in the watershed, such as native grasslands and alvars. The historical representation, as well as current cover levels of these features, should be considered to determine the appropriate targets.

10.1.3 The adaptive watershed planning process

Recommendation 10-1 - That the LSRCA, Kawartha Conservation and other relevant and interested stakeholders establish an implementation working group to assist in coordinating the implementation priority recommendations to address the most significant threats in these subwatersheds.

Recommendation 10-2– That the LSRCA and Kawartha Conservation, with the assistance of the other government agencies and stakeholder groups involved in implementing the recommendations of this subwatershed plan, report on the progress of this implementation annually.

Recommendation 10-3 – Within five years of the completion of this subwatershed plan, that the LSRCA and Kawartha Conservation, in collaboration with MOECC, MNRF, subwatershed municipalities, and other interested and relevant stakeholders, review progress on achieving its recommendations and update the subwatershed plan accordingly.

10.1.4 Reducing impact of land use – groundwater recharge and discharge

Recommendation 5-3 – That the subwatershed municipalities, in the context of LSPP Policy 6.37-SA, adopt the ‘Guidance for the protection and restoration of significant groundwater recharge areas in Lake Simcoe’ document. Further, that the municipalities utilize this document to incorporate policies around significant groundwater recharge areas into their official plans, as per LSPP Policy 6.38-DP.

Recommendation 5-4 – That the LSRCA provide updated mapping of significant groundwater recharge areas to the subwatershed municipalities and ensure they are updated periodically, at a minimum of every five years.

Recommendation 5-5 – That the subwatershed municipalities adopt the new stormwater volume reduction and quality control guidance provided in both the draft Lake Simcoe Watershed Model By-law and LID SWM Guidelines for Municipalities. Further, that the Municipalities utilize these documents to incorporate policies around stormwater management into their official plans, as per LSPP Policy 4.7-DP.

Recommendation 5-6 – That the MOECC amend the Environmental Compliance Approvals application form and Guide to recognize the importance of protecting Significant Groundwater Recharge Areas.

10.1.5 Incorporating LSPP objectives in Environmental Assessments

Recommendation 8-10 – That the proponents and reviewers of all Environmental Assessments recognize the intent and targets of the Lake Simcoe Protection Plan when developing and assessing alternatives to the proposed undertaking.

Recommendation 8-11 – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, MTO, LSRCA, Kawartha Conservation, and MOECC (when reviewing such documents), give due consideration to the preservation of barrier-free connectivity for wildlife between nearby wetland and upland habitats. This should include due consideration of alternate route configuration, the use of appropriate wildlife crossing structures, and/or the use of traffic calming measures (such as signage, including the use of electronic signs at peak migration times; road re-design; and speed bumps) in critical locations.

Recommendation 8-12 - Where roads have already been constructed and wildlife crossing structures are not viable options, seasonal road closures should be considered by subwatershed municipalities where possible to minimize wildlife mortality, particularly during peak breeding seasons.

10.1.6 Improving stormwater management

Recommendation 4-3 - That the Townships of Brock and Ramara, and the City of Kawartha Lakes, in cooperation with the LSRCA and Kawartha Conservation, promote the increased use of innovative solutions to address stormwater management and retrofits. This could include an assessment of potential retrofit opportunities, as well as the promotion of practices including requiring enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls; improving or restoring vegetation in riparian areas; rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways; enhance urban tree cover; where conditions permit, the use of soakaway pits, infiltration galleries, permeable pavement and other LID solutions; the on-going inventory, installation and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where this is appropriate; and where practical and feasible, enhance measures to control TSS.

Recommendation 4-4 - That the MOECC approve the Lake Simcoe Phosphorus Offsetting Program, to provide a private-sector source of funding for the maintenance, construction and /or retrofit of stormwater facilities and/or Low Impact Development practices as identified in Stormwater Management Master Plan relevant to the subwatersheds.

Recommendation 4-6 - That the LSRCA and its partners recognize that while the construction and/or retrofit of quality control facilities is extremely important, quantity control may be a consideration in some areas of the Talbot River and Whites Creek subwatersheds; therefore, quantity control facilities should be constructed in those areas where geographical space is limited or other LID options are not feasible. In these situations, federal and provincial governments should provide financial incentives to allow the Township to complement quantity control storm water ponds with an enhanced street sweeping program.

Recommendation 4-15– As new or retrofit stormwater facilities are constructed, LSRCA will work with municipalities to reduce potential thermal impacts of those stormwater ponds and to recognize the importance of LID uptake in relation to maintaining stream temperature.

10.1.7 Promoting Low Impact Development

Recommendation 4-1 - That the LSRCA provide training to municipal staff and stormwater engineering consultants on the design, construction, operation, and maintenance of Low Impact Development technologies.

Recommendation 4-2 – That the LSRCA assist subwatershed municipalities in developing a funding model to support the construction and maintenance of Low Impact Development approaches to stormwater management.

Recommendation 4-5 - That the Townships of Brock and Ramara and the City of Kawartha Lakes promote Low Impact Development (LID) approaches to stormwater management for private landowners within their jurisdictions, where sites are suitable.

10.1.8 Improving construction and maintenance practices

Recommendation 4-7 - That the LSRCA and Kawartha Conservation, the Townships of Brock and Ramara, and the City of Kawartha Lakes promote and encourage the adoption of best management practices to address sedimentation and erosion controls during construction and road development. This may include, but will not be limited to, more explicit wording in subdivision agreements detailing what is required in this regard.

Recommendation 4-8 – That the Townships of Brock and Ramara, City of Kawartha Lakes and LSRCA review and, where necessary, revise current monitoring, enforcement, and reporting on site alteration and tree cutting by: 1) undertaking a review of the current programs and actions, 2) encouraging the allocation of adequate resources for the improvements, and 3) monitoring and reporting on results.

Recommendation 6-19 - That municipalities, in consultation with the LSRCA, consider roadside 'ditch cleanout' practices which leave existing vegetation in place to increase water infiltration, reduce ditch maintenance costs, and reduce nutrient inputs into Lake Simcoe, against the increases in road maintenance costs associated with imperfectly draining road beds and other liabilities; further to develop a strategy to reach a balance between environment and roads maintenance, and construction costs and public liability on adjacent lands

Recommendation 7-8 - That the subwatershed municipalities, OMAFRA, conservation authorities, and the construction industry work to implement effective sediment and erosion control measures and other practices to prevent contaminants from reaching local watercourses during road work, agricultural drainage, and other construction projects.

10.1.9 Land securement by public agencies

Recommendation 8-13 – That the LSRCA and subwatershed municipalities should continue to secure outstanding natural areas for environmental protection and public benefit, through tools such as land acquisition or conservation easements, and should support the work of Land Trusts doing similar work. Priority areas identified by LSRCA's Land Securement Strategy in the Talbot River and Whites Creek subwatersheds include the Grass Creek and Corben Creek Wetlands, and the Beaverton Alvar and Wetland ANSI.

Recommendation 8-14 – That the LSRCA and subwatershed municipalities, with the assistance of the MNRF, continue to refine their land securement decision processes to ensure that they are securing natural areas that are critical to the health of the watershed (or securing and restoring areas which have the potential to become critical to the health of the watershed), but which are otherwise vulnerable to loss through incompatible land uses.

Recommendation 8-15 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding, and that the study area municipalities utilize their parkland dedication process, to support securement of notable natural areas.

10.2 Restoration and remediation

10.2.1 Managing water demand

Recommendation 5-1 - That the MOECC continue to improve the Water Taking Reporting System by integrating the Permit To Take Water (PTTW) database with the Water Well Information System (WWIS) database, and connecting those takings to wells / aquifers to facilitate impact assessment (i.e. the PTTW database needs to be connected to the WWIS database).

Recommendation 5-2 – That the MOECC and MNRF require the LSPP Tier 2 integrated model be used to simulate proposed dewatering activities associated with aggregate operations near the Whites Creek and Talbot River subwatersheds, and the impacts they would have on stream and wetland features in the subwatershed prior to issuing or renewing Permits to Take Water or aggregate permits. When reviewing aggregate applications, the MOECC is encouraged to collect the most up to date extraction, pumping, and groundwater level data, and use the data to update the integrated model.

10.2.2 Managing agricultural impacts

Recommendation 4-12 - That the LSRCA and Kawartha Conservation continue to participate in the Kawartha Farm Stewardship Collaborative, and continue to pursue new and innovative ways of engaging the agricultural community in undertaking voluntary projects focused on protecting and enhancing watershed health.

Recommendation 4-13 - That the recently developed spatially-explicit prioritization tool be used by all subwatershed stakeholders to properly allocate stewardship resources, so that funds are provided in locations where maximum phosphorus reduction can be achieved. These tools should be updated continually by the LSRCA to reflect updated information and the completion of projects.

Recommendation 4-14 - Given the anticipated lack of offset opportunities in using stormwater pond retrofits to offset phosphorus loading from projected growth areas in the Whites Creek and Talbot River subwatersheds, that the LSRCA assess the feasibility of expanding the Lake Simcoe Phosphorus Offsetting Program (LSPOP) to support phosphorus-reduction projects on agricultural land in these subwatersheds.

Recommendation 6-18 – That LSRCA and Kawartha Conservation work with the subwatershed municipalities, OMAFRA, and landowners to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using principles of natural channel design.

10.2.3 Dealing with indirect impacts to natural areas

Recommendation 8-24 – That the MNRF and its partners provide outreach to garden centers, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 8-25 – That the City of Kawartha Lakes and the Townships of Brock and Ramara, with support from the LSRCA and Kawartha Conservation, make information available to residents on the impact of human activities on natural areas. Priority issues include the dangers of invasive species, the importance of keeping pets under control, and the importance of staying on trails while in natural areas.

Recommendation 8-26 – That the study area municipalities give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands.

10.2.4 Increasing uptake of stewardship programs

Recommendation 6-1 – That the LSRCA and Kawartha Conservation, along with interested stakeholders and stewardship groups, develop an adaptive stewardship strategy to identify, implement and track stewardship projects in the study area subwatersheds. The development of this strategy should incorporate recommendations 6-2 through 6-12 as well as recommendations 8-16 through 8-21.

Recommendation 6-2 – That MNRF, MOECC, OMAFRA, LSRCA, and Kawartha Conservation continue to implement stewardship projects in the Talbot River and White's Creek subwatersheds, and encourage other interested organizations in doing the same.

Recommendation 6-3 – Governmental and non-governmental organizations should continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as existing networks (including Environmental Farm Plan coordinators), a simple web portal, or other, locally appropriate avenues.

Recommendation 6-4 – That MOECC, MNRF, LSRCA, Kawartha Conservation and other members of the Lake Simcoe Stewardship Network are encouraged to regularly compile and synthesize completed stewardship projects to allow efficient tracking, coordinating, and reporting of stewardship work accomplished.

Recommendation 6-5 –That the City of Kawartha Lakes, Simcoe County and Region of Durham enhance existing funding to the LSRCA and Kawartha Conservation to ensure continued delivery of stewardship programs.

Recommendation 6-6 - That partnerships and funding opportunities with other organizations (e.g. Ducks Unlimited Canada, TD Friends of the Environment, Royal Bank of Canada, local businesses, etc.) be pursued to implement stewardship projects (eg. monitoring, pilot restoration projects, etc.).

Recommendation 6-7 – That the LSRCA create and/or publicize link to a website that provides information and contact information on available funding programs for stewardship works, and ensure that this site is kept current.

Recommendation 6-8 – That the MOECC, MNRF, OMAFRA, LSRCA, and Kawartha Conservation continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. local radio, Chamber of Commerce, 4H clubs, high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction, and/or including inserts in tax or utility bills). Results of these efforts should be shared with the Lake Simcoe Stewardship Network.

Recommendation 6-9 – That the MOECC, MNRF, OMAFRA, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in this subwatershed, and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 6-10 - That the conservation authorities work with organizations within the study area, including Couchiching Conservancy, Trent Matters, Farms at Work, the Kawartha

Farm Stewardship Collaborative, and Ontario Soil and Crop, to better engage area residents and enhance uptake of available stewardship programs.

Recommendation 7-1 - That the LSRCA, Kawartha Conservation, and the subwatershed municipalities work to implement lot-level measures such as reducing fertilizer use, increasing infiltration, capturing stormwater runoff, and other practices that conserve water and reduce pollution in targeted urban areas and waterfront communities. An example of this is the Township of Ramara's bylaw restricting the use of fertilizers containing phosphorus on non-agricultural lands, and associated rebate program.

Recommendation 7-2 - That the LSRCA, Kawartha Conservation, and the subwatershed municipalities work with property owners to implement a natural landscaping approach along shoreline properties, with particular focus on decommissioning hardened shorelines and addressing severely eroded/ice-damaged sections.

Recommendation 7-3 - That the subwatershed municipalities, community groups, and other beach stewards enhance community enjoyment of public beaches and parks by deterring geese, conducting regular maintenance, and increasing public access to shorelines. The results of the Rewilding project being undertaken at Centennial Beach on Canal Lake should be evaluated, and the feasibility of downscaling project features such that individual shoreline landowners can undertake them should be explored.

Recommendation 7-4 - That the City of Kawartha Lakes manage ditch run-off from the municipal roads that end at the shorelines of Canal and Mitchell Lakes with rock check dams, and/or the use of vegetation, bioretention areas, or other methods, to reduce the export of phosphorus, sediment, and other contaminants to the lakes.

Recommendation 7-5 – That the LSRCA and Kawartha Conservation, in partnership with the Trent Severn Waterway and Trent Matters, develop and profile communication materials that describe the natural processes of aquatic plants in Canal Lake and Mitchell Lake, for shoreline residents and lake users.

Recommendation 7-6 – That Trent Matters and the Trent Severn Waterway work to ensure that more information is made available and accessible to shoreline residents and lake users regarding aquatic plant control options that are permissible within the lakes, and that current aquatic plant management policies be reviewed.

Recommendation 7-7 – That shoreline residents, with support from Parks Canada and other regulatory agencies, consider various direct in-lake approaches that would provide immediate control of aquatic plants in areas where lake use has been significantly impacted by prolific aquatic plants.

Recommendation 8-16 – That the MNRF, MOECC, OMAFRA, LSRCA, and Kawartha Conservation continue to implement stewardship projects in these subwatersheds, and work collaboratively with other interested organizations, through the Lake Simcoe Stewardship Network, to do the same. Wherever possible, emphasis should be placed on catchments and projects identified as priorities through the aforementioned best management practices prioritization exercise, to ensure the greatest benefit to watershed health.

Recommendation 8-17 – That governmental and non-governmental organizations continue to improve coordination of programs to: (1) avoid inefficiencies and unnecessary competition for projects, and: (2) make it easier for landowners to know which organization they should be contacting for a potential project, using tools such as a simple web portal, or other, locally appropriate avenues.

Recommendation 8-18 – That the Federal, Provincial, and Municipal governments be encouraged to provide consistent and sustainable funding to ensure continued delivery of stewardship programs. Further, that partnerships with other organizations (e.g. Ducks Unlimited Canada, TD Friends of the Environment, Royal Bank of Canada, local businesses) be pursued.

Recommendation 8-19 – That MOECC, MNRF, LSRCA and other members of the Lake Simcoe Stewardship Network, as well as Kawartha Conservation, are encouraged to document completed stewardship projects in a common tracking system to allow efficient tracking, coordinating, and reporting of stewardship work accomplished. This could also involve engaging 'project champions' to promote the projects that they have completed and encourage others to do the same.

Recommendation 8-20 – That the MOECC, MNRF, OMAFRA, LSRCA, Kawartha Conservation, and other interested members of the Lake Simcoe Stewardship Network support research to determine public motivations and barriers limiting uptake of stewardship programs in this subwatershed and share these results with other members of the Lake Simcoe Stewardship Network, to enable agencies and stakeholders to modify their stewardship programming as relevant. This research should include a review of successful projects to determine what aspects led to their success, and how these may be emulated.

Recommendation 8-21 – That the MOECC, MNRF, OMAFRA, LSRCA, and Kawartha Conservation continue to investigate new and innovative ways of reaching target audiences in the local community and engage them in restoration programs and activities (e.g. 4H clubs, high school environmental clubs, through Facebook groups, hosting a Lake Simcoe Environment Conference for high schools/science community interaction). Results of these efforts should be shared with the Lake Simcoe Stewardship Network.

Recommendation 8-23 - That, given the amount of shoreline area on Lake Simcoe, Canal Lake, and Mitchell Lake, and the level of development adjacent to these shoreline areas, that part of LSRCA and Kawartha Conservation's stewardship efforts be targeted to addressing shoreline stewardship practices, including implementing natural landscaping and decommissioning hardened shorelines.

10.2.5 Prioritizing stewardship projects

Recommendation 6-11 – That specific focus be directed towards protecting and enhancing spawning habitat for species such as walleye within the lakes and tributaries of these subwatersheds.

Recommendation 6-12 – That the LSRCA and Kawartha Conservation, along with interested stakeholders and stewardship groups integrate the prioritized restoration areas identified through the recently developed tool into a stewardship plan that ensures prioritized restoration opportunities are undertaken as soon as feasible. This stewardship plan needs to incorporate the outcomes of recommendations to improve uptake identified in Recommendations 6-2 through 6-11. Further, that consideration be given to providing additional funding to projects deemed priorities, where feasible.

10.2.6 Reducing salt use

Recommendation 4-9 – The LSRCA has recently undertaken an exercise to identify areas in the Lake Simcoe watershed, including watercourses within the Whites Creek and Talbot River subwatersheds, which are vulnerable to road salt (as outlined by Environment Canada). This assessment may be refined through further examination of relative salt tolerance of local biota. As outlined in Environment Canada's Code of Practice for the Environmental Management of Road Salt, municipalities should examine alternate methods of protecting public safety while reducing environmental impacts in these areas. These methods should be utilized in the salt vulnerable areas identified through the LSRCA exercise in addition to those areas identified in the municipalities' Salt Management Plans.

Recommendation 4-10 - That the LSRCA, in coordination with the municipalities, develop and undertake a program to raise the awareness of property owners, property managers and snow removal contractors on salt application and its environmental impacts. Particular emphasis may be given to those who own or manage property in salt vulnerable areas. The program should reflect BMPs for salt storage and application, as well as appropriate snow disposal.

Recommendation 4-11 – That the LSRCA and Kawartha Conservation investigate the inputs of calcium chloride into the study area waterbodies, given the amount of rural area and unpaved roads.

Recommendation 8-5 - That the City of Kawartha Lakes develop a tree cutting bylaw, in order to address the removal of important features such as hedgerows and trees used as windbreaks.

Recommendation 8-27 – That the Ministry of Transportation, City of Kawartha Lakes, Townships of Brock and Ramara, Region of Durham and the County of Simcoe, in partnership with the Simcoe County Federation of Agriculture, LSRCA, Kawartha Conservation and MNRF, promote and implement, where appropriate, the use of treed windbreaks and/or 'living snowfences' along roadsides to prevent impacts from wind and blowing snow. The creation of a 'living snowfence' involves selectively harvesting crops in order to leave a specified amount of plant material standing along a roadway to facilitate snow accumulation.

10.3 Applied science

10.3.1 Establishing instream flow targets

Recommendation 6-17 –That the LSRCA, with assistance from MNRF and MOECC and in partnership with the Trent-Severn Waterway, establish ecological flows (instream) targets for each main tributary. These instream flow targets should be based on the framework established for the pilot project being undertaken in Lover's Creek. Once these targets are established, a strategy should be established to achieve them. This strategy should also protect baseflow and location of upwellings in order to maintain thermal stability.

10.3.2 Increasing our understanding of climate change

Recommendation 4-16 -That the LSRCA and Kawartha Conservation work with their federal, provincial and municipal partners to refine the anticipated impacts of climate change in the Lake Simcoe watershed. This information can then be used to develop management strategies to address these impacts. Emphasis at this time should be placed on building ecological resilience in vulnerable subwatersheds through stream rehabilitation, streambank planting, barrier removal, and the implementation of other BMPs, in conjunction with the protection of current hydrologic functions.

Recommendation 5-13 – That the Trent Severn Waterway consider the possible impacts of climate change on fish spawning, and include mitigation considerations (e.g. the possibility of mimicking a natural freshet flow) in their annual water level management.

Recommendation 5-14 - That the LSRCA expand the environmental monitoring network to include a climate station in the Whites Creek and Talbot River subwatersheds; reliable meteorological baseline data will improve climate change predictions and allow for the improved identification of vulnerable areas.

Recommendation 5-15 - That the LSRCA and Kawartha Conservation, in partnership with the province and municipalities, develop management strategies to address the predicted impacts of climate change. Emphasis at this time should be placed on building ecological resilience in the Whites Creek and Talbot River subwatersheds through promoting recharge by increasing natural cover in the SGRAs/ESGRAs.

Recommendation 8-22 – That the members of the Lake Simcoe Stewardship Network be encouraged to build into their projects relevant provisions for the anticipated impacts of climate change, such as the need to recommend native species which will be tolerant of future climate conditions, and the likelihood of an increase in invasive plants, pests, and diseases which may further limit the success of traditional stewardship approaches.

10.3.3 Monitoring and assessment

Recommendation 4-17- That the LSRCA and Kawartha Conservation develop an environmental monitoring strategy for Canal Lake, Mitchell Lake and the Talbot River subwatershed. This strategy should identify parameters of watershed health to be monitored, frequency of monitoring, lead agencies, and potential funding sources. The strategy should also address identified limitations and gaps of the current monitoring program, which could include:

- Undertaking periodic monitoring of toxicants such as pesticides and pharmaceuticals;
- Spatial coverage of monitoring stations relative to addressing key monitoring questions such as the relationship between changes in land use cover and changes in water quality and quantity;
- Monitoring additional parameters that are key indicators of ecosystem health and restoration progress;
- Monitoring the Carden Alvar; and
- Monitoring additional lakes within the subwatersheds, including Talbot and Raven Lakes.

Recommendation 4-18 –That the MNRF, LSRCA, Kawartha Conservation, and MOECC follow the data management recommendations in the Comprehensive Monitoring Strategy to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program.

Recommendation 4-19 – That the LSRCA, Kawartha Conservation, MNRF, and MOECC analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs regularly, and further that the LSRCA use the information to update the LSRCA Watershed Report Card and Key Performance Indicators website. Further, stakeholders should be made aware when updates are available, and be provided access to the monitoring data collected via a web portal, to increase distribution and communication of this data.

Recommendation 4-20 That the LSRCA and Kawartha Conservation, in collaboration with MNRF, MOECC, and OMAFRA, develop a program for assessing efficacy of new stormwater facilities, stewardship best management practices, and restoration projects, to improve understanding of the effectiveness of stewardship efforts.

Recommendation 6-20 – That the MNRF, LSRCA, and Kawartha Conservation review and refine (as necessary) timing windows for proposals under the Fisheries Act in light of watercourse temperature data collected during this study.

Recommendation 6-21 – That LSRCA and Kawartha Conservation, with support from the subwatershed municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish, benthic invertebrate and aquatic plant indicators. There is a particular lack of data noted for the upper portion of the Talbot River subwatershed; it is recommended that additional sites be added in this area, acknowledging that additional data would also be useful for the lower Talbot River and Whites Creek. Citizen science should be a pursued as a means for obtaining some of this data, as should partnerships with local groups, such as Couchiching Conservancy and Trent Matters.

Recommendation 6-22 – That LSRCA and Kawartha Conservation, in partnership with other Conservation Authorities, characterize fish-habitat and invertebrate-habitat relationships in central Ontario, and use that information to develop improved indices of aquatic system health.

Recommendation 7-9 - That local communities, with support from agencies and/or academic institutions, undertake small-scale pilot projects to test the effectiveness of practical, affordable, and/or innovative approaches to aquatic plant control through scientific studies and quantitative reporting.

Recommendation 7-10 – That the LSRCA, Kawartha Conservation, MOECC, and MNRF implement a coordinated lake monitoring program that regularly tracks key indicators of lake watershed health including nutrients, aquatic plant cover, fish communities, and oxygen levels. There could also be a substantial role for citizen scientists in conducting this monitoring; the partners should explore this option through the development of the program.

Recommendation 7-11 – That the LSRCA incorporate data on the health of Canal and Mitchell Lakes into their forthcoming Key Performance Indicators reporting.

Recommendation 7-12 – That the LSRCA, Kawartha Conservation, MOECC, and LSRCA conduct research to identify how the lake ecosystem responds to stressors such as cumulative development, climate change, and invasive species.

Recommendation 7-13 – That the LSRCA and Kawartha Conservation expand their monitoring network to include Raven and Talbot Lakes.

Recommendation 8-28 – That the MNRF, with the assistance of LSRCA, Kawartha Conservation and MOECC, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 8-29 – That the MNRF, LSRCA, and OMAFRA update the existing land cover map for the watershed, as defined by the LSPP, and incorporate data available on alvar communities from the MNRF and Nature Conservancy of Canada.

Recommendation 8-30 – That, when completed, the updated land cover map be compared with existing data, to assess the extent and type of land use change within these subwatersheds.

Recommendation 8-31 – That the MNRF and LSRCA take advantage of data that is already available, by developing a biodiversity database that can collate information reported in EIS and EA reports, information reported in natural area inventories, plot-based data collected in the watershed-wide Vegetation Survey Protocol that is underway, plot-based data collected by citizen-scientists for the Breeding Bird Atlas, and other data as may be available.

Recommendation 8-32 – That the MNRF, with the assistance of the LSRCA, take advantage of this soon-to-be compiled data, and develop lists of watershed-rare taxa, and policies to support their protection.

10.3.4 Improving data management

Recommendation 6-23 – That LSRCA and its partners work to create a centralized location for reports and resources pertaining to Lake Simcoe and its watershed such that information can be accessed by all interested stakeholders.

Recommendation 8-33 – That the MNRF, LSRCA, Kawartha Conservation and MOECC develop a framework to allow effective and efficient management and sharing of data before implementing the comprehensive monitoring program. This framework may include the designation of one agency as the curator of all monitoring data collected in the Lake Simcoe watershed.

10.3.5 Additional research needs

Recommendation 5-7 – That the LSRCA and Kawartha Conservation, in partnership with Trent Severn Waterway, expand the surface water monitoring network to the manmade canal that connects the Talbot River watershed with the Balsam Lake watershed, and the canal that connects Mitchel Lake with Canal Lake in order to monitor water volume transferred between Great Lakes basins.

Recommendation 5-8 – That the Trent Severn Waterway initiate a surface water monitoring network to monitor surface and groundwater flows through the Talbot River.

Recommendation 5-9 – That the Trent Severn Waterway enhance flow monitoring and flow calculations where already exist and that the data collected be used to enhance subwatersheds water budgets.

Recommendation 5-10 –That the LSRCA and expand the surface water monitoring network to the headwaters portion of the Talbot River subwatershed, and that the data collected be input into the integrated model to improve the understanding of surface and groundwater flows and interactions.

Recommendation 5-11 - That the MOECC, in partnership with the LSRCA and Kawartha Conservation, expand the PGMN network in the subwatershed to improve understanding of groundwater flows and levels in the deeper bedrock system; new wells should be screened in the deeper aquifer units and situated away from the influence of lakes, canals, and other pumping wells.

Recommendation 5-12 – That water quantity data from aggregate pits be made available to watershed municipalities and to the LSRCA and Kawartha Conservation for watershed management.

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