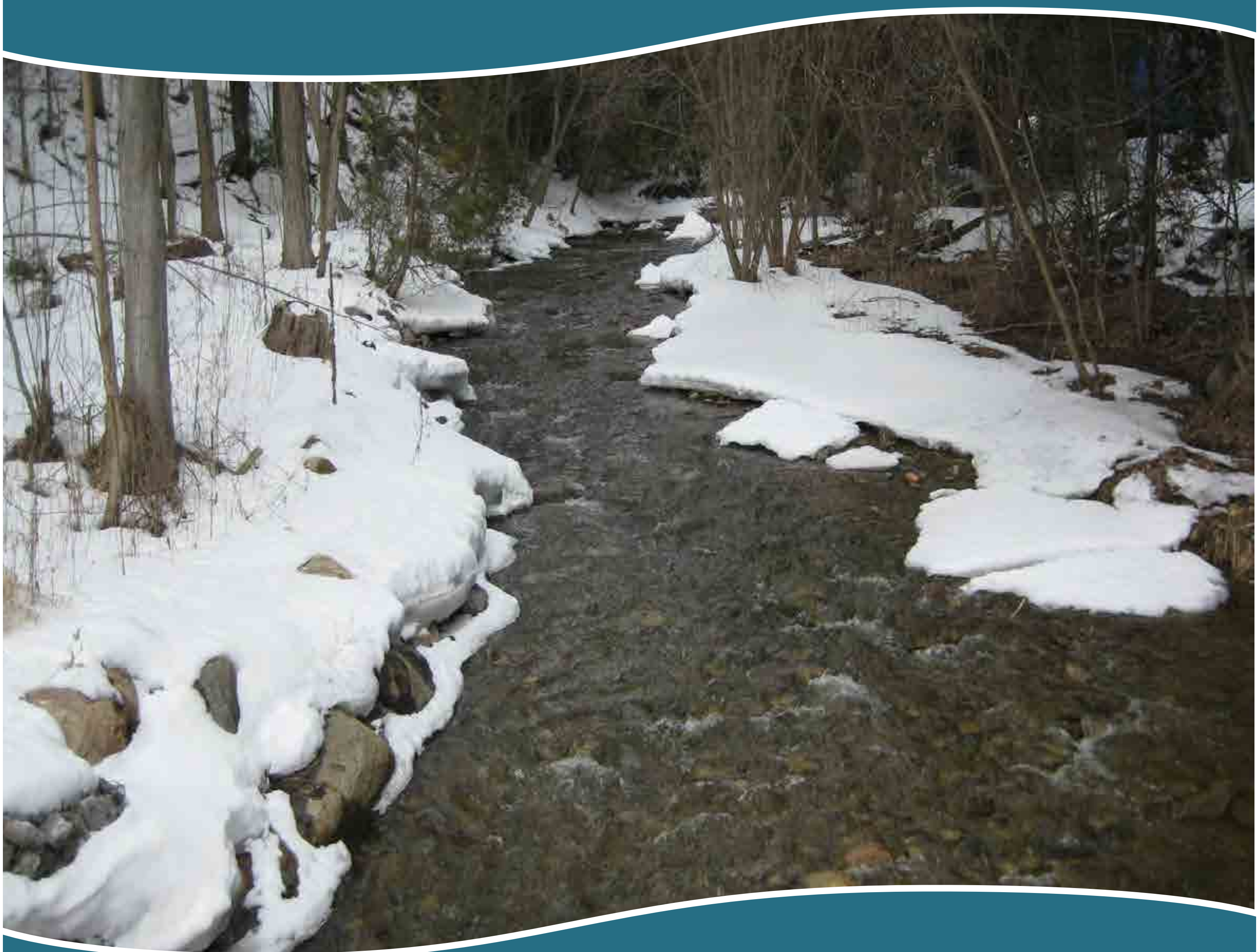
Oro and Hawkestone Creeks Subwatershed Plan



Lake Simcoe Region Conservation Authority

2013

The Oro and Hawkestone Creeks Subwatershed Plan

2013

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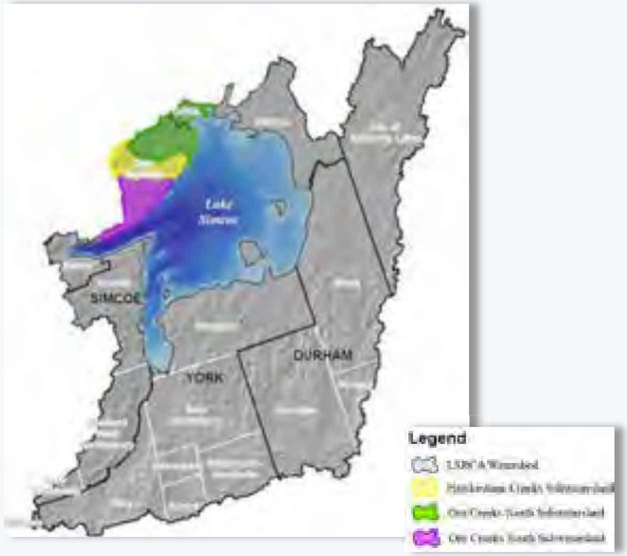
The Oro and Hawkestone Creeks Subwatershed Plan (2013) Executive Summary



WHAT IS A SUBWATERSHED PLAN?

Subwatershed planning is a process whereby the components of the environmental system are characterized, the stresses and demands on those systems 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
- 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 three separate, but fairly similar, subwatersheds lying in the northwest portion of the Lake Simcoe watershed, with their headwaters originating on the Oro Moraine: Oro Creeks North, Hawkestone Creek, and Oro Creeks South.

- The Oro Creeks North subwatershed is located in the northern portion of the watershed, to the west of the lake's outlet to Lake Couchiching. The majority of this 75 km^2 subwatershed lies within the Township of Oro-Medonte, with just over 20% falling within the City of Orillia. The six majority tributaries draining through this subwatershed into Lake Simcoe are Mill, Bluffs, Pointview, Cedarmount, and Carthew Creeks, and a series of small tributaries collectively referred to as the Oro Creeks North. Natural features, such as wetlands and forests, occupy the largest proportion of land use, at 46% of the subwatershed area. Agriculture occupies approximately 35%, and urban area represents just over 10%, with much of this concentrated in the City of Orillia.

- The Hawkestone Creek subwatershed lies just to the south of Oro Creeks North. It is 48 km^2 in size, and falls entirely within the Township of Oro-Medonte. The three major tributaries are Hawkestone Creek, Wriglew Creek, and Maplewood Creek. This subwatershed has one of the highest levels of natural cover in the Lake Simcoe watershed, occupying 57% of the subwatershed area. Agriculture occupies about 24%, with the remainder comprised of rural developments, small urban pockets, and golf courses.
- The Oro Creeks South subwatershed is the furthest south in the study area, and is also fully within Oro-Medonte. This 57 km^2 subwatershed is drained by 11 tributary streams: Simcoe Side, Allingham, Burls, Shelswells, Bradens, Barillia, Lakeview, Orolea, Pemberton, and Shanty Bay Creeks, as well as a series of small, direct-to-lake catchments referred to as the Oro Creeks South. Close to half of the subwatershed (46%) is occupied by natural heritage features, with the other major land uses being comprised of agriculture (38%) and urban land uses (10%).

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, released by the LSRCA in 2008, 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 Oro North, Oro South, and Hawkestone Creeks subwatersheds; these two reports are meant to complement each other.

<u>Approach</u>

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. This includes considerations of the movement of water through the system, land use, climate, geology, and local species. Everything is

State-pressure-response framework

intricately related, and changes in any one area can have significant effects on others

In this subwatershed plan, we include an analysis of water quality, water quantity, aquatic habitat, 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)*.

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 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 – There are two locations that we visit regularly, one on Bluffs Creek in the Oro Creeks North subwatershed, and one on Hawkestone Creek, to take samples of the water to be tested for a number of substances, such as phosphorus and suspended sediments, in the study area. The Hawkestone Creek station is the only station in this area where long-term data has been collected (since 1993); sampling in Bluffs Creek in the Oro Creeks North began in 2008. In addition, 'spot-check' samples were taken twice at seven locations around the study area in 2012 to give us some indication of the spatial distribution of water quality.

The data from the Hawkestone Creek station shows very few exceedances of relevant guidelines. For example, only 16% of the samples exceed the phosphorus guidelines in the current data; this is the parameter with the highest number of exceedances. Samples at four of the 'spot check' sites showed exceedances of phosphorus guidelines. Two of these stations were located in the Oro Creeks North, one was in Hawkestone, and one was in Oro Creeks South. Deposition from a construction site was thought to be a possible source at one site, but otherwise sources are not known. These samples tell us that the two long-term stations may not necessarily be representative of the entire study area, and that further study may be required to fully understand the variation of conditions across these subwatersheds, particularly in the Oro Creeks South subwatershed, which does not currently have a long-term monitoring station.

Water Quantity – Groundwater in the three subwatersheds generally flows from the topographic highs associated with the Oro Moraine towards the topographic lows associated with the major stream channels and Lake Simcoe. Research indicates that groundwater is a significant contributor to many of the subwatershed's tributaries, as indicated in many areas by the presence of the sensitive fish species such as brook trout; in the Hawkestone Creek subwatershed, groundwater is estimated to contribute more than half of the flow in a yearly basis. There is, however, little monitoring data with respect to flow in the subwatershed, a better understanding of the flow characteristics will be gained through the collection of additional data, such as the project currently being undertaken to estimate ecological flows for a number of Lake Simcoe subwatersheds.

Groundwater recharge is the process by which rain and melting snow percolates from the surface through the soil to replenish groundwater stores (which also corresponds to ensuring 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 features such as coldwater streams and wetlands, for the study area.

Fish Habitat – Fish communities in these subwatersheds vary, with the majority of sites showing fair conditions. Coldwater species, including mottled sculpin and brook trout, have been found in Bluff's, Mill, Hawkestone (in the upper and lower reaches), Lakeview, Allingham, Burls, and Braden's Creeks. Other sites show less pristine conditions, with fish species found that are less sensitive to environmental stresses, or no fish caught. Communities of benthic invertebrates (organisms that live at the bottom of rivers and lakes) also vary widely within the study area, from ratings of 'Excellent' in Mill Creek upstream of the urban area in the City of Orillia, Hawkestone Creek, and Allingham Creek, to 'Very Poor' in Cedarmount Creek. The healthiest sites, when looking at both fish and benthic invertebrates, are Mill Creek, the upper and lower reaches of Hawkestone Creek, Wriglew's Creek, Allingham Creek, and Lakeview Creek. Impacts to the aquatic communities in these subwatersheds can be attributed to a wide range of factors, such as barriers and other changes to streams, increasing water temperatures, water takings, the drying up of stream channels, uncontrolled stormwater run-off, invasive species, the removal of streambank vegetation, and agriculture. Conditions can be improved through stream rehabilitation, wetland protection, streambank planting, and treating stormwater run-off from both urban and agricultural areas.

The Terrestrial Natural Environment – These features include woodlands, wetlands, grasslands, and riparian (streambank) habitat, and account for approximately 46%, 57%, and 47% of the land area in Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively. Woodlands cover 36% of the Oro Creeks North subwatershed, 45% of the Hawkestone Creek subwatershed, and 38% of the Oro Creeks South subwatershed. These levels are above Environment Canada's guideline of 30%, as outlined in its '*How much habitat is enough*' document. This is seen as a minimum forest cover threshold (considered to be a 'high risk' approach that will not support the healthiest systems), but the Oro Creeks North and South subwatersheds both fall below what Environment Canada considers to be a 'medium risk approach' for forest cover, which is 40%. With respect to wetland cover, Hawkestone Creek has very healthy levels. Wetlands occupy 13.5% of the Oro Creeks North subwatershed, 21% of the Hawkestone Creek subwatershed, and 12% of the Oro Creeks South subwatershed; these are all healthy levels that are above Environment Canada's recommended wetland cover level. There are high levels of natural riparian cover along the watercourses of all three subwatersheds, with Hawkestone and Oro Creeks North both having 80%, and Oro Creeks South having 75%. Shoreline cover is significantly lower, however, with 29%, 9%, and 20% natural cover for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively. 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 75 recommendations in total, with some pertaining to all of the partners involved in the development of the plan, including the LSRCA, municipalities, and the provincial ministries of Natural Resources, Environment, and Agriculture and Food. Through policies in the Lake Simcoe Protection Plan, it is expected that municipal Official Plans will be consistent with these recommendations

These recommendations include:

- Continued implementation of on-the-ground stewardship projects to improve aquatic habitat and water quality, promote infiltration of precipitation, and broaden the extent of natural features
- Improved land use planning practices to minimize the impacts of development
- 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, and good practices for the use of road salt to minimize environmental impacts
- 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 (e.g. in the City of Orillia)
- Evaluating monitoring activities, and adjusting programs as necessary
- Striving to ensure that natural features lost through development are re-established in other parts of the watershed

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 Oro Creeks and Hawkestone Creek Subwatershed Plan is comprised of three separate subwatersheds: Oro Creeks North, Oro Creeks South, and Hawkestone Creek. The three subwatersheds have been included in a single subwatershed plan, as they are fairly similar in terms of land use, with the exception of the very urban area of Orillia in the Oro Creeks North subwatershed, and the majority of the area of the three subwatersheds falls within the jurisdiction of the Township of Oro Medonte. Figure 1-1 illustrates the location of these subwatersheds within the Lake Simcoe watershed.

The Oro Creeks North subwatershed is the northern-most subwatershed on the west side of the Lake Simcoe watershed and is roughly 75 km^2 in size, comprising approximately 2.9% of the watershed area. Tributaries in the Oro Creeks North subwatershed include Mill Creek, Bluff's Creek, Cedarmount Creek, Carthew Creek, Pointview Creek, and Oro Creeks North. None of these creeks form a confluence, and all six drain into Lake Simcoe separately. Some of the tributaries of Mill Creek and Bluffs Creek originate in and flow through urban and residential areas. The rest of the tributaries mainly originate near the subwatershed boundaries, many flowing off of the base of the Oro Moraine, a significant geological feature in the northwest of the Lake Simcoe watershed. Most originate in natural areas, aside from one of the major tributaries of Bluffs Creek, which originates in an agricultural area. The tributaries mainly flow through natural areas, with some sections of agriculture along their lengths. The majority of the subwatershed (78.1%) is located within the Township of Oro-Medonte, including the community of Forest Home, with the remaining 21.9% in the northern portion of the subwatershed occupied by the City of Orillia. Natural heritage and agriculture are the most significant land covers in this subwatershed, occupying close to 80% of its area. Ten percent of the subwatershed area is occupied by urban land use, the majority of this is found within the City of Orillia.

To the south of the Oro Creeks North subwatershed lies the Hawkestone Creek subwatershed, which, at approximately 48 km^2 in area, comprises 1.9% of the total area of the Lake Simcoe watershed. As in the Oro Creeks North subwatershed, the headwaters of this subwatershed also originate at the base of the Oro Moraine. Tributaries include Maplewood Creek, Wriglew Creek, and 12th Line Creek. While natural areas dominate the land use around the tributaries, there are some stretches that flow through agriculture and urban land uses. The tributaries of this subwatershed do not form a confluence and flow into the lake separately. The entire subwatershed is located within the boundaries of the Township of Oro-Medonte, including the community of Hawkestone. This subwatershed has a high level of natural cover, at 57%, and agriculture also occupies a significant portion of the area, with 34% of the land cover.

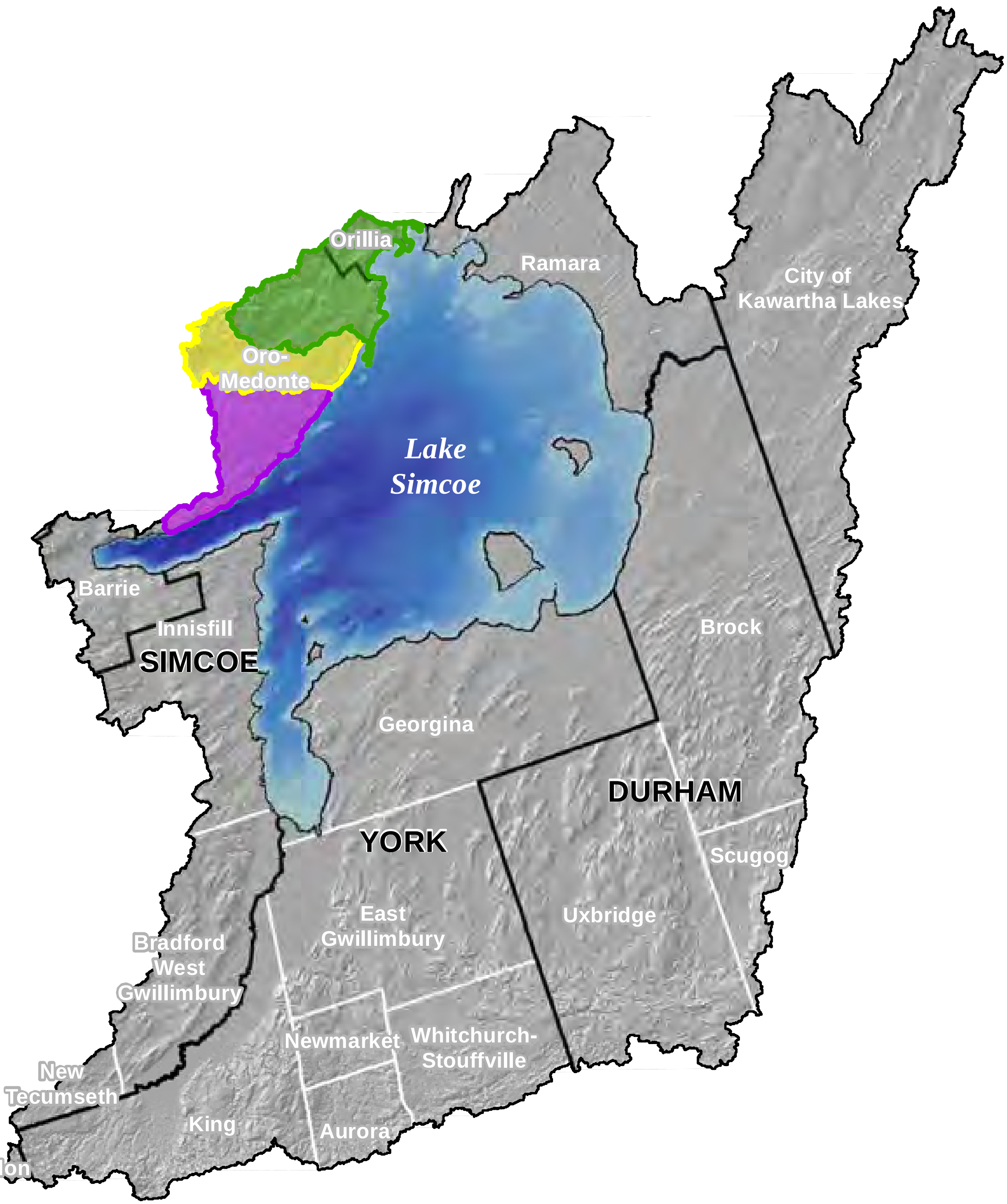
Furthest south in the study area is the Oro Creeks South subwatershed. This subwatershed occupies an area of approximately 57 km^2, or 2.3% of the area of the Lake Simcoe watershed. The subwatershed also falls entirely within the boundaries of the Township of Oro-Medonte, and includes the community of Oro Station. The tributary streams found within the subwatershed include Allingham Creek, Barillia Creek, Bradens Creek, Burls Creek, Lakeview

Creek, Orolea Creek, Pemberton Creek, Shanty Bay Creek, Shelswells Creek, and Simcoe Side Creek. None of these creeks form a confluence, and all flow into the lake independently. Many of the tributaries originate and flow through natural areas; however, many sections also flow through agricultural areas and, to a lesser extent, developed areas.

Natural heritage and agriculture account for 85% of the land cover, at 47% and 38%, respectively.

In the Lake Simcoe watershed, the various land uses have had considerable impacts on water quality and quantity, and 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. These plans provide a framework for the implementation of remedial activities and a focus for community action. More importantly, they 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 initiated in 2009 and Durham Region (includes the Beaver River and Pefferlaw Brook subwatersheds) in 2010. 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 2012. The evaluation of these subwatersheds will reflect the goal, objectives and targets of the Lake Simcoe Protection Plan and will be tailored to the needs and local issues within each.



Location of the Oro Creeks North, Oro Creeks South and Hawkestone Creek subwatersheds

Figure 1-1

Legend

- LSRCA Watershed
- Hawkestone Creeks Subwatershed
- Oro Creeks North Subwatershed
- Oro Creeks South Subwatershed
- Lower Tier Boundary
- Upper Tier Boundary

Lake Simcoe Region conservation authority

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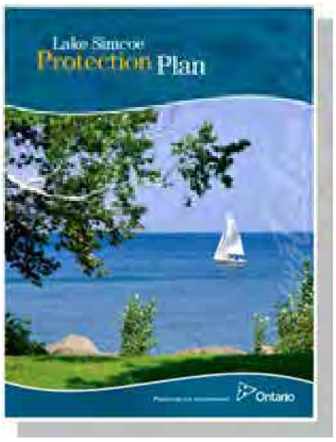
This product was produced by the Lake Simcoe Region Conservation Authority and some information depicted on this map may have been compiled from various sources. While every effort has been made to accurately depict the information, data / mapping errors may exist.
This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT dc created April 2012.

1.2 Oro Creeks and Hawkestone Creek Subwatershed Planning Process

1.2.1 Lake Simcoe Protection Plan



The Lake Simcoe Protection Plan, 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. 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 (OMOEE 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.

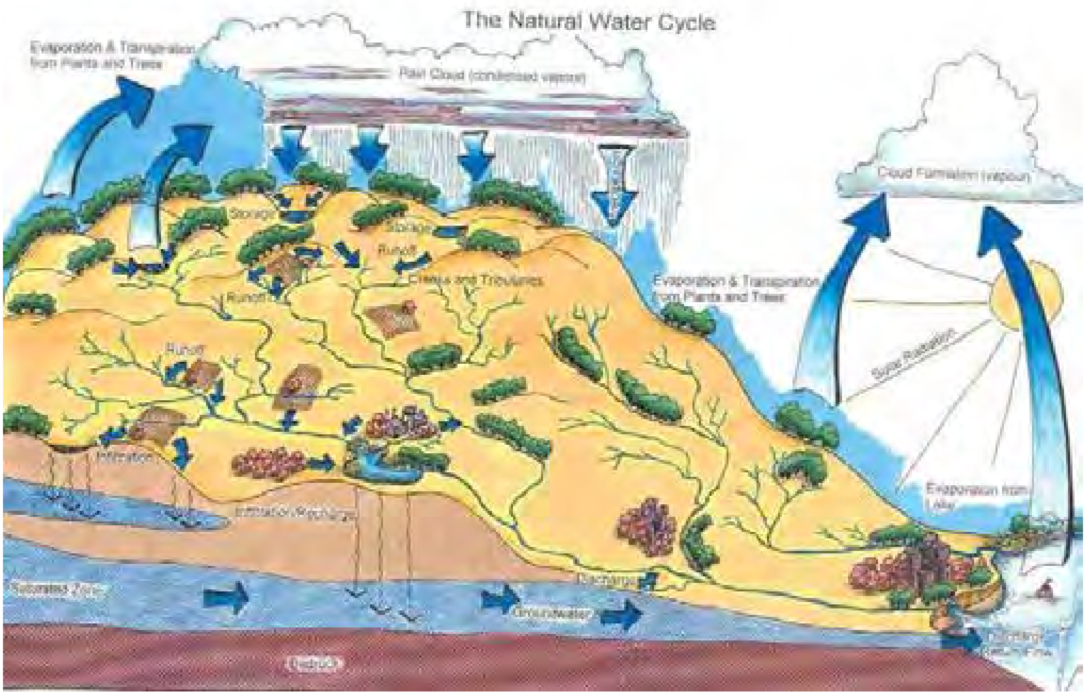


Figure 1-2: The hydrological cycle (image courtesy of Conservation Ontario).

1.2.2 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 (2008) and the Lake Simcoe Phosphorus Reduction Strategy (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.

1.2.3 Subwatershed Planning Process

Preliminary Consultation

Start-up meetings were had with the municipal staff to map out 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.

Characterization

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 representative from the Township of Oro-Medonte, City of Orillia, Simcoe County, MOE, MNR, MAFRA, and a landowner representative from the agriculture sector. 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 convenes every few months, and held one meeting in 2012 (November 29), and two meetings in 2013 (March 27 and June 13). A final meeting was held in September 2013 to initiate the Subwatershed Implementation Plan (discussed further in following sections). 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.

Public Consultation

Public consultation is scheduled to occur in the fall of 2013, and is intended to educate residents within the subwatersheds about the area where they live, what the current conditions are of their local natural areas, what the immediate stressors are and how the recommendations will be carried out.

1.2.4 Subwatershed Implementation Process

Implementation Plan

Once the subwatershed plan is completed and approved by the LSRCA Board of Directors, 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 partners' 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

Implementation of recommendations will be the responsibility of the agencies and organizations identified in the implementation plans. In many cases implementation will require collaboration between different partners to achieve the required outcomes, and will also be funding dependent.

To ensure that this subwatershed plan remains current and relevant, it has been developed using an adaptive management framework. As such, it is proposed that the subwatershed plan be updated every five years to ensure that it contains the best available science and monitoring data reflecting the health of the subwatershed and associated environmental stressors. Between updates to the plan, 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.

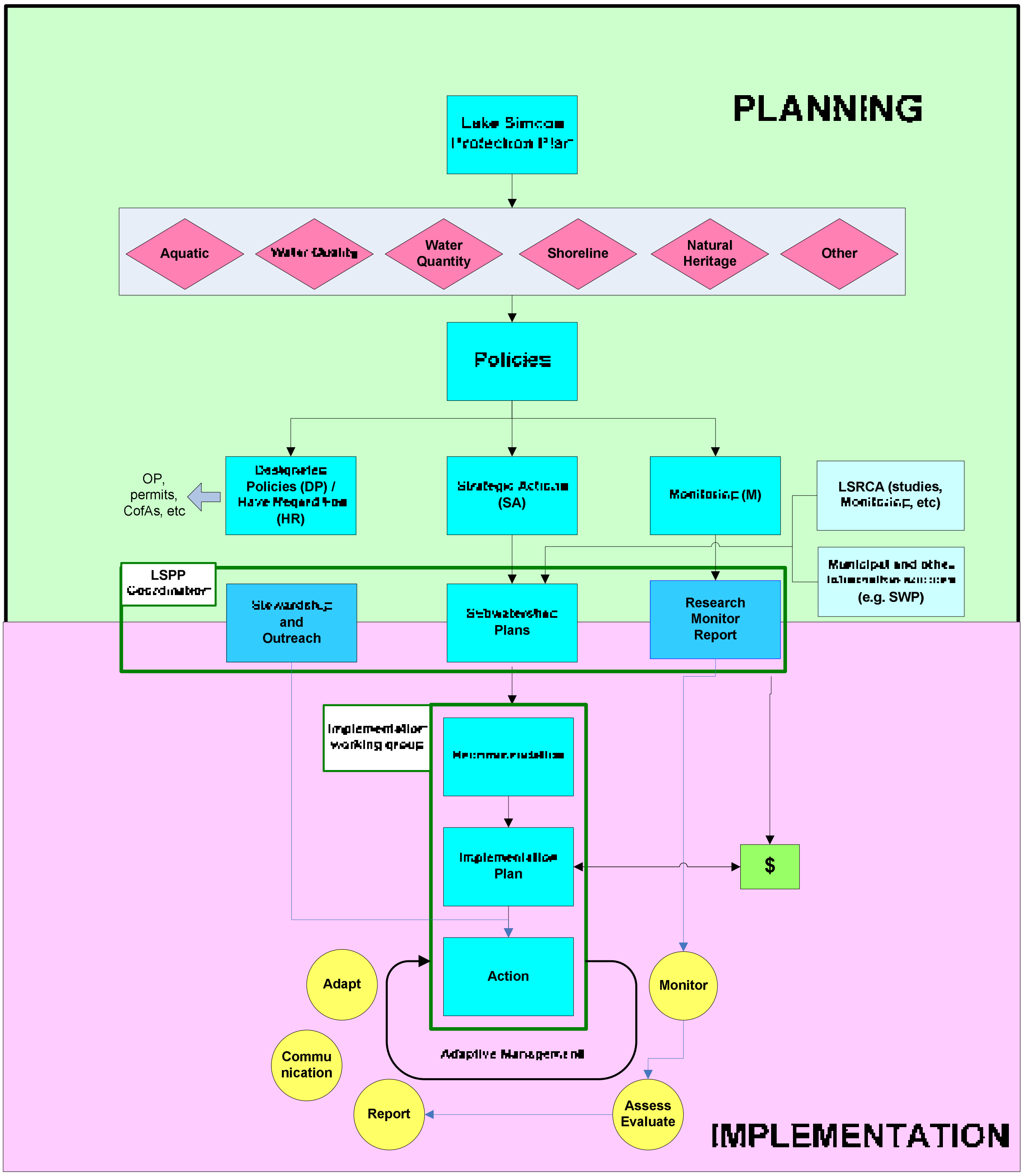


Figure 1-3: Subwatershed planning context

1.3 Current Management Framework

The goals and management recommendations offered in this plan have been developed in context of the Lake Simcoe Protection Plan (LSPP) and other existing legislation and their associated plans and policies. There are many regulations related to the protection and restoration of Lake Simcoe and its subwatersheds, and although each of these acts and associated plans differ, although in some cases policies do overlap. The manner in which regulations differ include: (1) the number and types of watershed activity they have authority over. For example some regulations have a very broad mandate, regulating many activities (e.g. the LSPP) while others are very specific (e.g. The Endangered Species Act); (2) the legal effect of policies they contain; (3) the geographic area they represent; and (4) the degree of implementation–many aspects of more recent legislation, such as the Lake Simcoe Protection Plan, still need to be acted upon. Each chapter of this subwatershed plan provides a more detailed assessment of the legislation and associated polices related to that particular subwatershed element e.g. water quantity or aquatic habitat).

The key pieces of legislation, regulations and plans that form the planning framework in the subwatershed are described below. This is not a comprehensive list of all of the pieces that apply in the subwatershed, but rather those that are most influential of environmental conditions in the area.

1.3.1 Lake Simcoe Protection Plan

As part of the Ontario government's overall strategy to protect and restore the ecological health of the Lake Simcoe watershed, the Lake Simcoe Protection Act was introduced and passed by the legislature in 2008, receiving Royal Assent in December of that year. This Act provides authority for the establishment of and amendments to a Lake Simcoe Protection Plan. The Lake Simcoe Protection Plan, which was released in June 2009, contains a wide variety of objectives to achieve their vision of a healthy lake with healthy communities and people as well as a healthy economy. These objectives, as set out in the Lake Simcoe Protection Act, include:

- Protecting, improving or restoring the elements that contribute to the ecological health of the watershed, including water quality, hydrology, key natural heritage features and their functions, and key hydrologic features and their functions;
- Restoring a self-sustaining coldwater community in the lake;
- Reducing loads of phosphorus and other nutrients of concern and reducing the discharge of pollutants;
- Responding to the effects of invasive species and, wherever possible, preventing their introduction into the watershed;
- Providing for ongoing research and monitoring in the watershed;
- Improving conditions for environmentally sustainable recreation activities, and promoting these activities; and

- Building on the protections offered by existing legislation in the watershed.

The Plan contains policies related to a number of critical issues: restoring the health of aquatic life in the watershed; improving water quality, maintaining water quantity; improving the health of the ecosystem by protecting and rehabilitating important areas such as shorelines and natural heritage; and addressing the impacts of invasive species, climate change, and recreational activities. The Plan takes a subwatershed approach to the activities that will need to be undertaken to improve conditions in the watershed. This approach will help to determine priorities in different areas of the watershed, depending on the conditions and issues in each subwatershed.

In addition to prescribing the development of the Lake Simcoe Protection Plan, the Lake Simcoe Protection Act established two advisory committees, the Lake Simcoe Science Committee and the Lake Simcoe Coordinating Committee, to facilitate the development and implementation of the Lake Simcoe Protection Plan.

The Lake Simcoe Science Committee is composed of scientific experts in watershed protection issues, who are responsible for reviewing and advising on the ecological health of the Lake Simcoe watershed, current and potential threats, as well as identifying scientific research that should be undertaken to support the implementation of the Plan. This committee may also be asked to advise on the design and implementation of monitoring programs to track whether the Plan is meeting its objectives; proposing amendments to the Plan; and proposing regulations made under the Lake Simcoe Protection Act.

The functions of the Lake Simcoe Coordinating Committee will include:

- Providing advice to the Minister on Plan implementation and any issues or problems related to Plan implementation
- Providing advice to the Minister on the types of measures that could be taken to deal with threats to the ecological health of the watershed
- Assisting in monitoring progress on Plan implementation.

This committee is comprised of representatives from across the watershed, including representatives from municipalities, Aboriginal communities, the LSRCA, the Province, the agricultural, commercial and industrial sectors, interest groups, environmental organizations, and the public.

1.3.2 Provincial Policy Statement

The Provincial Policy Statement (PPS), issued under the authority of Section 3 of the Planning Act (1990), provides direction on matters of provincial interest related to land use planning and development, and promotes the provincial “policy-led” planning system. The PPS recognizes the complex inter-relationships among economic, environmental and social factors in planning and embodies good planning principles. It includes policies on key issues including the efficient use and management of land and infrastructure; protection of the environment and resources;

and ensuring appropriate opportunities for employment and residential development, including support for a mix of uses.

The PPS was updated in 2005, with the intent of providing strong, clear policy direction on land-use planning to promote strong communities, a clean and healthy environment, and a strong economy.

1.3.3 Nutrient Management Act

The Nutrient Management Act, approved by the Ontario legislature in 2002, was developed by the Ministries of the Environment and Agriculture and Food and Rural Affairs as part of the provincial government's Clean Water Program. Its intent is to provide for the management of materials containing nutrients in ways that will enhance the protection of the natural environment and provide a sustainable future for agricultural operations and rural development. The NMA specifies requirements for the development of Nutrient Management Plans or Strategies for farms that generate and/or store over 300 'nutrient units' of manure. These plans include information on how and where the manure is stored, how it is applied, as well as contingency plans for issues that may arise, such as inclement weather preventing the spreading of manure on fields. The implementation of these plans will help to protect water quality from contamination from nutrients, particularly phosphorus, as well as bacteria such as *E. coli*.

1.3.4 Environmental Protection Act

The purpose of the Environmental Protection Act (EPA), approved by the Ontario legislature in 1990, is to provide for the protection and conservation of the natural environment. The EPA contains policies and restrictions around the discharge of contaminants and pollution, and the management of waste and litter. It gives the Ministry of the Environment a number of powers, such as requiring an operation to have in place equipment and/or controls in order to prevent the release of contaminants or minimize the impacts from such a release, and issuing control orders in the case of a release of a contaminant in levels above that specified by the regulations.

1.3.5 Ontario Water Resources Act

The purpose of this Act is to provide for the conservation, protection and management of Ontario's waters and for their efficient and sustainable use, in order to promote Ontario's long-term environmental, social and economic well-being. This is accomplished through policies around activities including the construction of wells, stormwater and sewage works, preventing the impairment of water quality, water takings, and water transfers. It is through this Act that the Ministry of the Environment issues Permits to Take Water for non-domestic water takings over 50,000 L/day and Certificates of Approval for stormwater management facilities and sewage treatment plants.

1.3.6 Growth Plan for the Greater Golden Horseshoe

The Growth Plan for the Greater Golden Horseshoe was prepared under the Places to Grow Act (2005). The Growth Plan provides a framework for implementing the government of Ontario's vision for building stronger, prosperous communities by better managing growth in the Greater Golden Horseshoe to 2031. The Growth Plan is aimed at avoiding the negative aspects of growth, such as deteriorating air and water quality and the disappearance of agricultural lands and natural resources. The plan provides improvements in the ways in which our urban areas will grow over the long term, and guides decisions on a wide range of issues such as transportation and infrastructure planning, land-use planning, urban form, and natural heritage and resource protection, all in the interest of promoting economic prosperity.

The Growth Plan builds on the Greenbelt Plan, Planning Act reform, and the PPS. It works within the existing planning framework to provide growth management policy direction for the area.

This plan seeks to address the challenges of urban sprawl through policy directions that:

- direct growth to built-up areas;
- promote transit supportive densities and community infrastructure to support growth;
- ensuring sustainable water and wastewater services are available to support future growth;
- identify natural systems and prime agricultural areas, and enhance the conservation of these resources; and
- supports the protection and conservation of water, energy, air, and cultural heritage, as well as integrated approaches to waste management.

The Guiding Principles of the Growth Plan are to:

- Build compact, vibrant and complete communities
- Plan and manage growth to support a strong and competitive economy
- Protect, conserve, enhance and wisely use the valuable natural resources of land, air and water for current and future generations
- Optimize the use of existing and new infrastructure to support growth in a compact, efficient form
- Provide for different approaches to managing growth that recognize the diversity of communities in the GGH
- Promote collaboration among all sectors – government, private and non-profit –and residents to achieve the vision.

1.3.7 Clean Water Act

The Clean Water Act (CWA), approved by the Ontario legislature in 2006, was developed to protect drinking water at its source, as part of the Province's overall commitment to safeguard human health and the environment. It was established to implement the recommendations of the Walkerton Inquiry, in which Justice Dennis O'Connor set out the concept of a multi-barrier approach to safe drinking water. 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 of the multi-barrier approach, 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.

This Act is being implemented on a watershed scale, with most areas using existing conservation authority boundaries. The LSRCA is leading the initiative for the South Georgian Bay-Lake Simcoe Source Protection planning region. The Source Protection process involves four stages:

- Stage 1: establishing source protection authorities and committees, and negotiating a terms of reference
- Stage 2: conducting an identification and assessment of the threats to drinking water in the source protection region and preparing an assessment report
- Stage 3: the preparation of a source protection plan, which will include policies to address significant threats to drinking water
- Stage 4: implementation of the source protection plans, including inspection and enforcement of the plan's policies, monitoring and reporting on progress, and reviewing the plan

It is expected that the process will be completed in 2012.

1.3.8 Endangered Species Act

The Endangered Species Act was approved by the Ontario legislature in 2007 and came into effect in 2008. This Act provides protection to Ontario's species at risk – those identified on the Species at Risk in Ontario list as extirpated, endangered, threatened or special concern. The Act recognizes the ecological, social, economic, cultural and intrinsic value of biodiversity, and that it is often human activities that put these species at risk. The Act provides protection to the species and their habitats, and also requires the development of recovery strategies once a species has been identified as being at risk. The implementation of these recovery strategies will help to protect the important habitats of these species, and enhance biodiversity in the subwatershed.

1.3.9 Conservation Authorities Act and the Role of the LSRCA

The Conservation Authorities Act, approved by the Ontario legislature in 1946, was developed to address the concerns of agricultural, naturalist and sportsmen's groups over the 'unhealthy state' of much of the provinces natural resources. This Act presented the opportunity for the province to join with the municipalities of Ontario to form a Conservation Authority within a watershed and to carry out programs to manage the natural resources. The legislative mandate of a Conservation Authority, as set out in Section 20 of the Conservation Authorities Act, is "to establish and undertake, in the area over which it has jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals"(R.S.O. 1990, c.C27, s.20). To ensure the success of managing natural resources in this manner, there are three fundamental concepts of the Act:

- **Local Initiative:** The formation of a Conservation Authority only occurs when residents request the Ontario government to form an Authority. By doing this, residents must be willing to accept the responsibility of running the Conservation Authority as a corporate body, similar to the running of a municipality, as well as contributing financially to support the Authority. It also means that resolutions to local problems will come from the Authority, not above government, and only so far that it can do so economically, culturally and democratically.
- **Cost Sharing:** Both the Ontario government and local municipalities are to share the costs of projects. Municipalities with enthusiastic, involved and committed residents, who are willing to support projects financially, help to build a stronger and more productive Authority.
- **Watershed Jurisdiction:** Conservation Authorities have jurisdiction over one or more watersheds and are to cover all aspects of conservation in the area. The Authorities' ability to establish regulations, such as those for flood control, have allowed it to protect life, property, and natural heritage features within the watershed.

Within Ontario there are currently 36 Conservation Authorities, each involved in a different array of activities based on the specific needs and conditions of their watershed(s). The Lake Simcoe Region Conservation Authority was first created in 1951 (named Upper Holland Valley Conservation Authority at the time) and has since expanded as new municipal and regional partners have joined the watershed. The Towship of Oro-Medonte was added to the watershed in 2001. In total, over 1300 stewardship projects have been completed within the watershed since 2004, of which 116 were in Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. LSRCA has had a long history within the watershed and adheres to the Conservation Authority mandate through four main pillars:

- **Science and Research:** To advance understanding of the watershed ecosystem, science and research are needed in order to predict, assess and help adapt to change. This is can be accomplished through programs such as:
  - Environmental monitoring of fish and benthic invertebrates, water quality and quantity stream assessments, the nearshore and open water of Lake Simcoe and tracking of invasive species.
  - Hazard, land and natural heritage management through Low Impact Development (LID) that maintains and enhances natural methods of reducing pollutants in stormwater runoff; studies and implementation of water reuse methods that reclaim or reuse treated water from sewage treatment plants for certain allowable uses; and engineered wetlands to treat stormwater runoff by removing phosphorus and other pollutants.

  - Drinking Water Source Protection through technical Assessment Reports that map and characterize threats to municipal drinking water and Source Protection Plans that include policies and strategies to manage or reduce existing risks and ensure that new land uses are compatible with the outline vulnerable areas.
  - Reducing the phosphorus load into Lake Simcoe through understanding how phosphorus loading occurs, how this changes with land use changes and development of new ways to reduce the amount going into the Lake.
  - Subwatershed planning, which forms the basis of integrated watershed management, takes an adaptive ecosystem-based approach to assess current health, existing and predicted stressors, and actions to reduce impacts to the natural environment.
- **Protection and Restoration:** To create a healthier watershed, where people and property are protected from flooding and erosion, and where land and water are conserved and restored, a commitment to protection and restoration is needed. Programs that work toward this include:
  - Upgrading and maintaining the quality of Conservation Areas for public enjoyment
  - Securing land either through purchasing or donations to conserve and protect
  - Provide comprehensive planning services to residents, the development industry and government to ensure that proposed development is undertaken with the environment and safety at the forefront. Under the Act, Conservation Authorities administer regulations that require technical reviews and permits for development proposals and projects involving activities adjacent to watercourses, wetlands and hazardous lands, as well as any activities that cause interference with a watercourse, wetlands or shoreline.
  - Flood forecasting and warnings
  - Helping landowners become stewards of their local environments by providing support with restoration projects (such as the LSRCA Landowner Environmental Assistance Program)
  - Restoration projects throughout the watershed
- **Education and Outreach:** To ensure environmental awareness and understanding with local residents, community connections and partnership need to be strengthened through education and outreach. This can be accomplished through:
  - Outdoor education with students
  - In-class presentations at schools
  - Engaging the community through fairs, festivals and community events
  - Creating Conservation Awards to recognize individuals and organizations that have shown dedication to protecting and restoring the watershed

  - Producing media releases to keep communities informed

- **Program Support:** To back up the programs of the previous three pillars, leadership and innovation, business excellence, stakeholder value and financial stability is needed. Sectors involved in program support include:
  - Human Resources: Includes qualified personnel knowledgeable in the needs of environmental protection and restoration, a strong executive management team, up to date Human Resources policies, and an ongoing investment in health and safety training.
  - Board of Directors and Office of the CAO: Includes strengthening partnerships, both at a local and global level, and enabling the success of watershed work.
  - GIS & Information Technology: Includes supporting the needs all programs and departments.
  - Geomatic Services: Includes providing information critical to the delivery of programs through a wide range of mapping, analysis, and modeling that helps to better understand both current conditions and potential changes.
  - Finance: Includes providing timely and useful information to decisions makers to respond to the dynamic financial needs to achieve sustainability and support good governance activities. Innovative solutions can help to minimize costs and improve service delivery levels.

1.3.10 Township of Oro-Medonte Official Plan

The stated purpose of the Township of Oro-Medonte Official Plan is to provide the basis for protecting the Township's natural heritage system while managing growth that will support and emphasize the Township's unique character, diversity, civic identity, rural lifestyle and cultural heritage features and to do so in a way that has the greatest positive impact on the quality of life in Oro-Medonte (Township of Oro-Medonte OP, 2007). This includes the protection and enhancement of significant natural heritage features and related ecological functions within the Town. This takes into account the protection of the functions of significant recharge areas (such as the Oro Moraine) and areas of natural, agricultural, and open space.

Among the Plan's objectives is the use of an "Environment First" principle, which recognizes that the environment is the base upon which all land use activities take place and that it should be considered in all land use planning decisions. It recognizes the importance of the natural features within the subwatershed and the functions they perform, and contains a number of policies aimed at maintaining, restoring and where possible, enhancing or improving them. The OP also identifies the need to protect certain landforms within the Townships wide-ranging natural heritage system. These include the Oro Moraine and all wetlands, stream and valley systems located within the Township.

1.3.11 City of Orillia Official Plan

The City of Orillia's Official Plan provides the basis for managing change in the City to 2031. The vision of the plan is to guide future growth and development in a manner that creates a complete community, promoting a City with, among other things, clean air, land, and water; a vibrant downtown with strong connections to the waterfront; and green spaces, recreation facilities, trails and shorelines that promote active, healthy living. The Plan is written to direct change in accordance with Provincial policy, with a new emphasis that includes intensification and environmental responsibility. The Plan includes four main Principles, with the first being 'Manage Growth in a Responsible and Efficient Manner', and the third being 'Ensure the Sustainability and Integrity of the Environment'.

Through its policies around Environmental Protection and Open Space areas, the City recognizes the important contribution that natural systems and their related ecological and hydrological functions, in conjunction with the public open space system, make to the creation of a vibrant, livable City. Among the objectives of these policies is to achieve a balanced relationship between development and nature by preserving significant natural heritage features and areas, functions and ecological systems, conserving natural resources, and protecting people and property from natural hazards; protecting, maintaining, and enhancing the ecological integrity of the identified natural heritage system; working to minimize the loss or fragmentation of natural heritage features and areas; and ensuring that proposed changes in landuse have no negative impact on the natural heritage system, with particular attention to the water quality of Lake Simcoe.

1.3.12 Simcoe County Official Plan

The stated purpose of the County of Simcoe Official Plan is to provide a policy basis for exercising the approval authorities for local municipal Plans and amendments, and applications for subdivision of land. It is designed to assist in growth management in a County expected to experience rapid growth in population and urban development over the next twenty years. It attempts to achieve a balance between the demands for economic development, community building and environmental conservation and provide a framework for coordinated planning with adjacent municipalities, agencies, and other levels of government (County of Simcoe OP, 2007). The OP's environmental goal is to protect, conserve, and enhance the County's natural heritage.

The County includes sixteen towns and townships and is a broad policy document that is executed through municipal official plans, zoning bylaws, and subdivisions approvals. This is further augmented with long term transportation, sewer, water, and waste management Plans, environmental assessments, watershed management plans, financial programs, capital budgets, economic development initiatives, and human service plans.

The County has identified and mapped key ecological features and functional elements, known as "Greenlands", as well as Lakes Simcoe and Couchiching and Georgian Bay, with the natural functions including groundwater recharge, stream/river baseflow, wildlife movement and biotic diversity. As such, there are policies within the Plan that require the analysis and protection of the features and functions of County Greenlands and local natural heritage systems through local Official Plans.

1.4 Guiding Documents

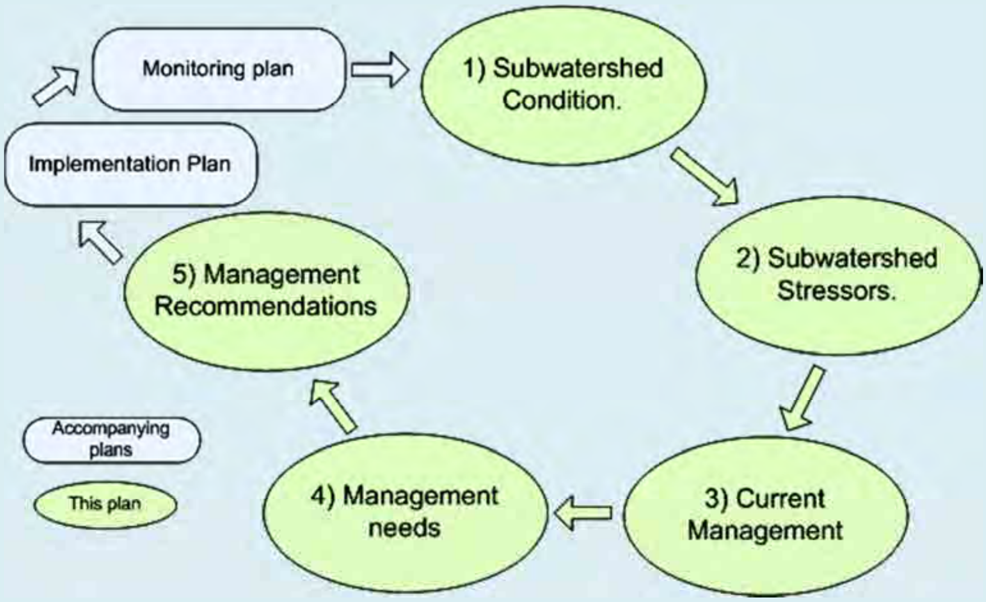
A number of documents and studies have been prepared with information and recommendations pertinent to the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds and how to ensure their environmental health into the future. These documents cover a wide range of issues, and have influenced the formation of this subwatershed plan. They include:

- Lake Simcoe Basin Stormwater Management and Retrofit Opportunities (LSRCA, 2007)
- 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 Reports (LSRCA, 2004-2006)
- 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 Analysis and Water Quantity Stress Assessment for the Oro North and South and Hawkestone Creeks Subwatersheds (Earthfx, 2013)
- Ecologically Significant Groundwater Recharge Area Assessment for the Oro North, Oro South, and Hawkestone Creeks Subwatersheds (Earthfx, 2013)
- 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)

- Delineation of Priority Areas for Restoration in the Lake Simcoe Watershed (Draft: MNR, 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, aquatic natural heritage, 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: The Oro Creeks and Hawkestone Creek subwatersheds

2.1 Location

All of the lands within the Lake Simcoe watershed ultimately drain into Lake Simcoe, via one of the tributary subwatersheds. The Oro Creeks North, Oro Creeks, South and Hawkestone Creek subwatersheds are three of the 18 subwatersheds that make up the Lake Simcoe watershed. All three drain into the northwestern portion of Lake Simcoe, with some of the Oro Creeks South catchments draining into the northern part of Kempenfelt Bay (Figure 2-1).

The Oro Creeks North falls almost entirely within the boundaries of the Township of Oro-Medonte, with only a small portion (22%) of the Oro Creeks North being located within the City of Orillia. As discussed in Chapter 1, there are six major tributaries draining separately into Lake Simcoe. The tributaries referred to as Oro Creeks North and the northern tributary of Mill Creek flow through the urban area of Orillia, the most densely populated area within the subject subwatersheds, and one of the tributaries of Bluffs Creek flows through the community of Forest Home. This subwatershed covers an area of 75 km^2, and has a total watercourse length of 104 km, which is approximately 2.5% of the combined watercourse length of the entire Lake Simcoe watershed.

The Hawkestone Creeks subwatershed lies to the south of the Oro Creeks North subwatershed, with the entire subwatershed area falling within the Township of Oro-Medonte. There are three major tributaries draining separately into the lake; Hawkestone Creek, Maplewood Creek, and Wriglew Creek. The extreme lower sections of all three tributaries flow through land designated as urban along the lakeshore, and the lower end of Hawkestone Creek flows through an urban area in the community of Hawkestone. The subwatershed occupies an area of 48 km^2, and has a combined total watercourse length of 88.4 km, or approximately 2.1% of the combined length of Lake Simcoe’s watercourses.

Finally, the Oro Creeks South subwatershed is the southernmost in the study area. Its 11 tributary streams flow in a southeasterly direction, mainly through forests, wetlands, and agricultural areas, before reaching more urban spaces along the lakeshore. This subwatershed, which is 57 km^2 in area, has a total watercourse length of 96 km, which is approximately 2.3% of the watercourse length of the Lake Simcoe watershed.

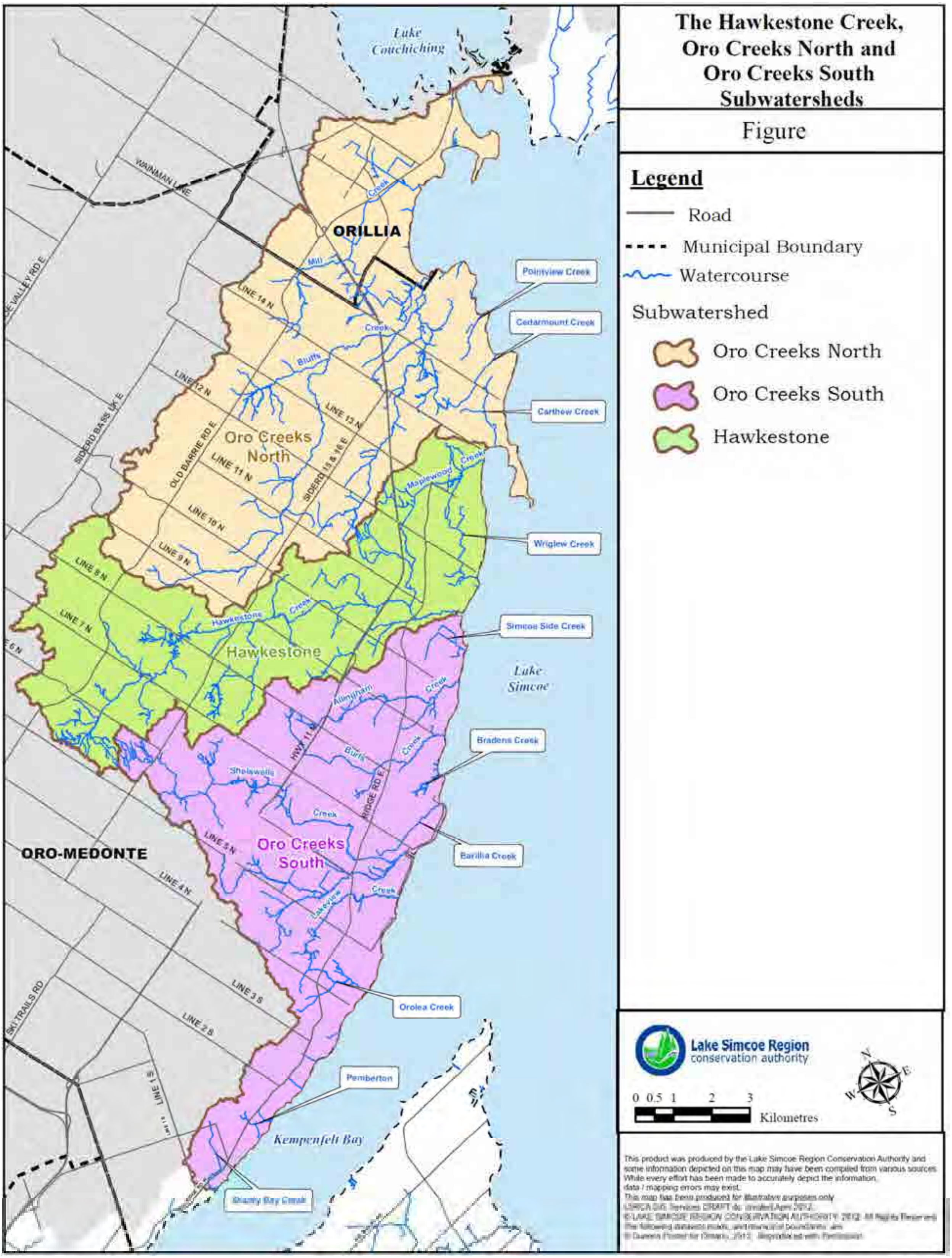


Figure 2-1: The Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

2.2 Human Geography

2.2.1 Population and Municipal Boundaries

Because the subwatershed boundaries and the municipal boundaries are not the same, the subwatersheds contain residents from multiple municipalities. The Oro Creeks North subwatershed contains the portion of the City of Orillia that lies within the Lake Simcoe watershed, with the other portion found in the Lake Couchiching watershed, as well as the northern portion of the Township of Oro-Medonte. Both the Oro Creeks South and Hawkestone Creek subwatersheds are found entirely within the Township of Oro-Medonte.

The population of the Township of Oro-Medonte was estimated to be 20,078 in 2011. This is an increase of 0.2% over the five year period since the 2006 census, where the population was 20,031. This is a fairly low rate of growth, significantly lower than the national average of 5.9%. The median age of Oro-Medonte in 2011 was 45.3, up from 42.5 in 2006. This is much higher than both the national and provincial median ages, 40.6 and 40.4, respectively. This higher median age could be reflective of the draw of a lakeside community as a retirement residence. Its distance from larger centres such as York Region and the City of Toronto may also prevent some people from settling here, as the commute would be well over an hour to travel to jobs in these areas, which could mean that younger families are settling in areas further south, such as Barrie or Innisfil. The median before-tax income for all census families in 2010 was $84,129, above the provincial median income of $66,358 (Statistics Canada, 2013). The projected population for the Township is 27,000, an increase of 28% (Places to Grow Act, 2012).

The City of Orillia saw a somewhat larger growth rate than did Oro-Medonte, with the population growing from 30,259 in 2006 to 30,586 in 2011, an increase of 1.1%. The median age of the City is just slightly lower than that of Oro-Medonte, at 45.2, which is up from 42.7. Again, the distance of the City from other large employment centres could prevent some from residing here, as it is even further north than Oro-Medonte. The median income of Orillia residents in 2010 was $48,972, lower than the provincial median of $66,358 (Statistics Canada, 2013). The anticipated population for the City is 41,000, an increase of 34% (data provided by the City of Orillia).

Municipal population from each municipality and total population density for each of the subwatersheds is presented below in Table 2-1.

Table 2-1: Population and population density within the Oro Creek North, Oro Creek South, and Hawkestone Creek subwatersheds (Data Source: Statistics Canada, 2011 Community Profiles)

Subwatershed	Subwatershed Area (ha)	Municipality	Total Municipal Population	% Municipality in Subwatershed	Estimated Municipal Population (2011) within subwatershed	Estimated Total subwatershed population (2006)	Estimated Population Density (persons/km^2)
Oro Creeks North	7,526	City Orillia	30,586	57	17,434	19,421	258
		Township of Oro-Medonte	20,078	9.9	1,987		
Oro Creeks South	5,739	Township of Oro-Medonte	20,078	9.7	1,948	1,948	34
Hawkestone Creek	4,784	Township of Oro-Medonte	20,078	8	1,606	1,606	34

The level of education attained by a person can influence both their career choice and income level. Table 2-2 lists the percentage of the City of Orillia and Township of Oro-Medonte populations, 15 years and over, and their educational attainment compared to provincial standings.

Table 2-2: Educational attainment for the Township of Oro-Medonte and City of Orillia (Statistics Canada, 2011).

	Township of Oro-Medonte	City of Orillia	Province of Ontario
No certificate; diploma or degree	15%	23%	19%
High school certificate or equivalent	27%	29%	27%
Apprenticeship or trades certificate or diploma	12%	10%	7%
College; CEGEP or other non-university certificate or diploma	25%	23%	20%
University certificate or diploma below the bachelor level	3%	2%	4%
University certificate; diploma or degree	18%	13%	23%

2.2.2 Land Use

Land use within the Oro Creeks and Hawkestone Creek subwatersheds have been divided up into 11 classes including intensive and non-intensive agriculture, rural development, industrial, and natural heritage features (Figure 2-2 to Figure 2-4). For ease of viewing, land uses with less than 1% coverage in a subwatershed are not labelled on the pie charts below.

Natural heritage features (46%) and intensive and non-intensive agriculture (34%) occupy the largest areas of land in the Oro Creeks North subwatershed. Urban land use comprises only 14% of the land use, and the smallest land uses are commercial (0.3%), and estate residential (0.3%).

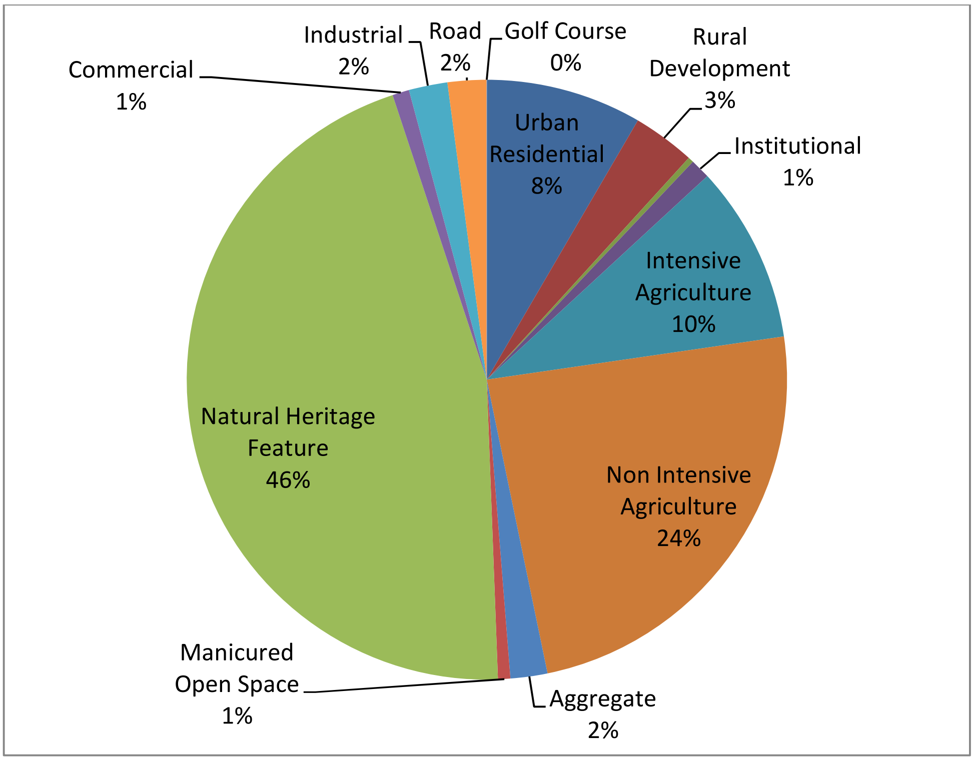


Figure 2-2: Land use distribution within the Oro Creeks North subwatershed.

Similiar to the Oro Creeks North subwatershed, the largest areas in the Oro Creeks South subwatershed are occupied by natural heritage features (46%) and intensive and non-intensive agriculture (39%). This subwatershed also has a small percentage of urban land use (9%); some of the other, less significant land uses include commercial (0.1%), industrial (0.2%), and institutional (0.3%).

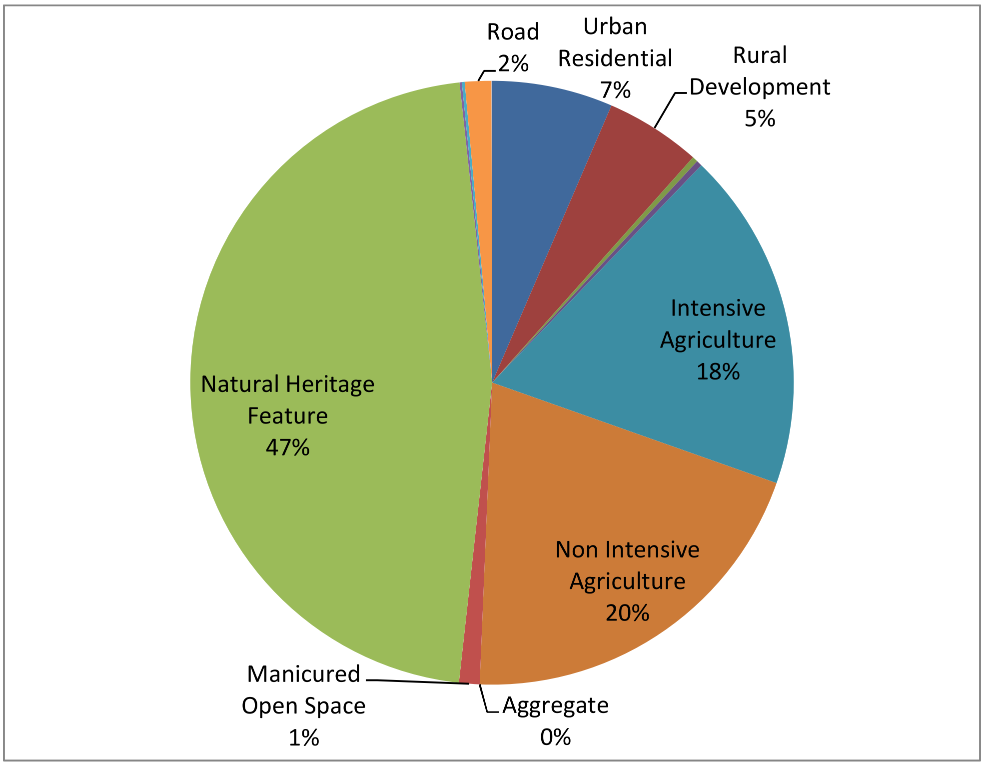


Figure 2-3: Land use distribution within the Oro Creeks South subwatershed.

Lastly, the Hawkestone Creek subwatershed contains the highest percentage of natural heritage features in the Lake Simcoe basin with approximately 57%. Intensive and non-intensive agriculture is the next highest land use at 35%. The smaller landuses are urban (3% combined), including institutional (0.02%), manicured open space (0.1%), commercial (0.3%), and estate residential (0.3%).

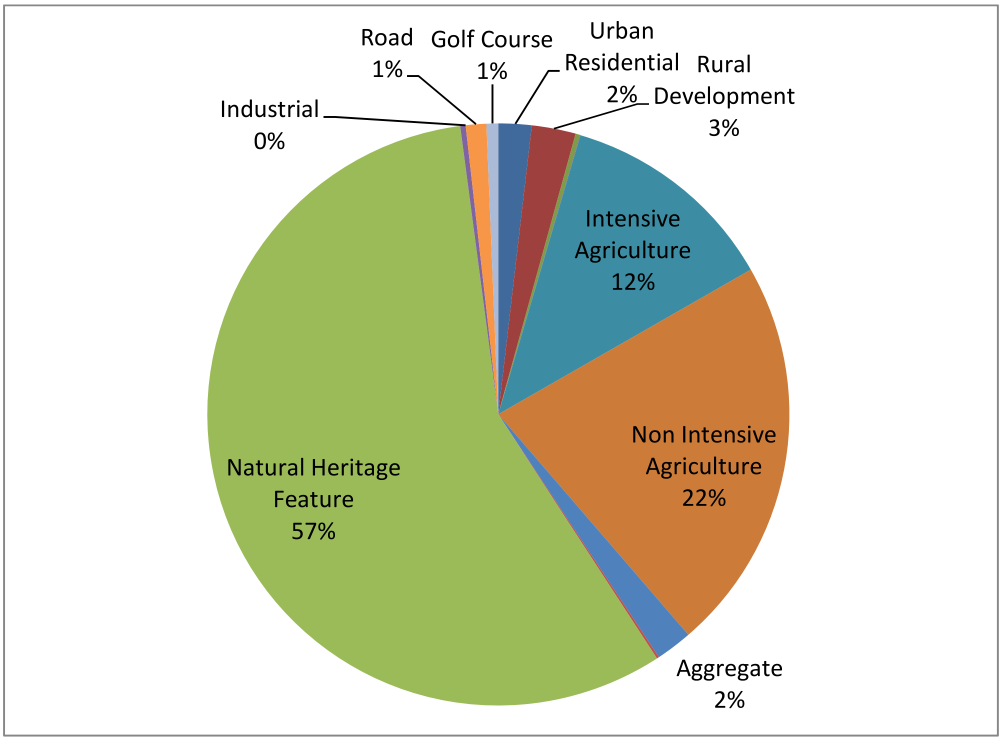


Figure 2-4: Land use distribution within the Hawkestone Creek subwatershed.

The distribution of land uses within the three subwatersheds can be seen in Figure 2-5.

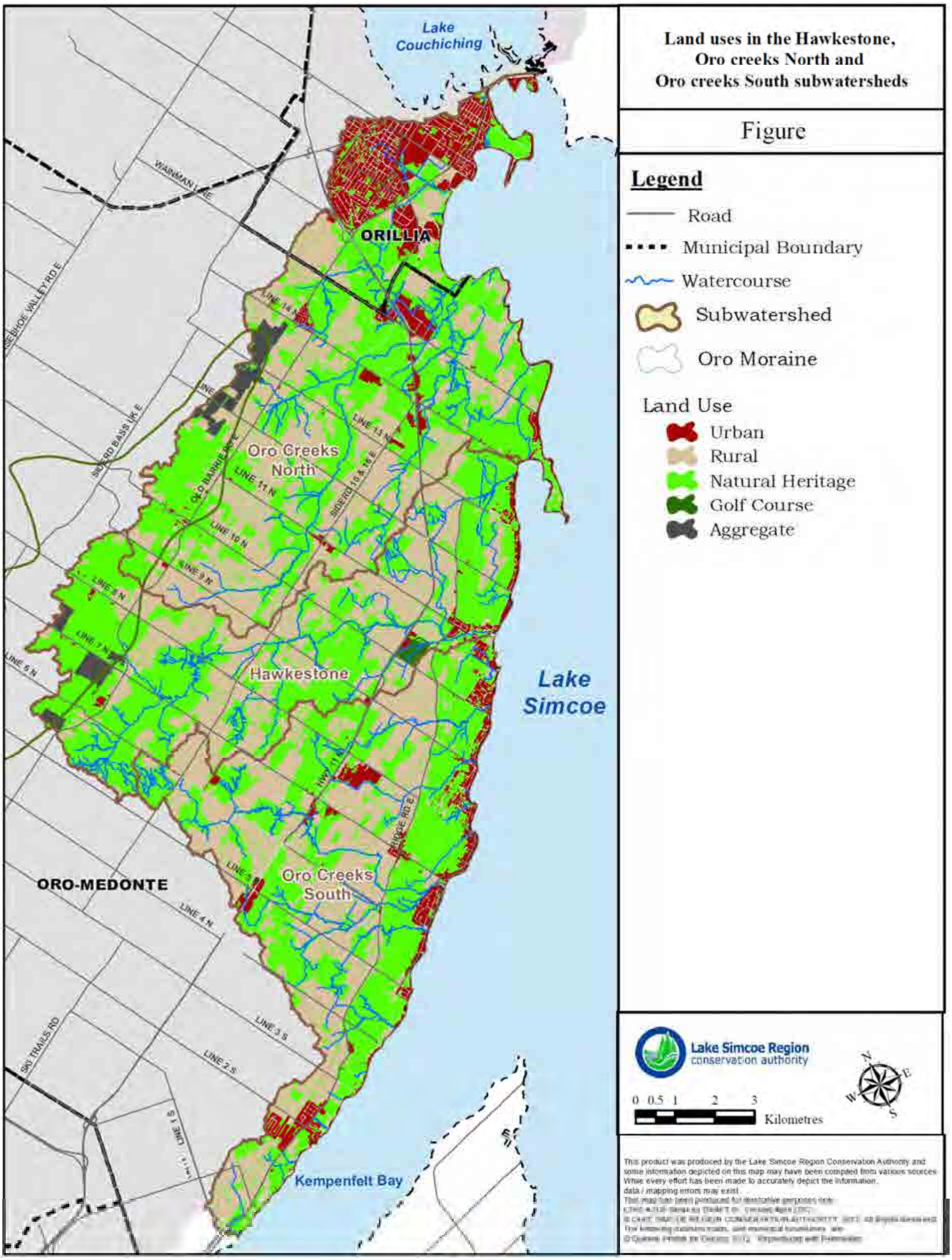


Figure 2-5: Land uses in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

To see how these three subwatersheds compare to the other subwatersheds within the Lake Simcoe watershed Figure 2-6 to Figure 2-8 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 Oro Creeks (North and South) and Hawkestone Creek subwatersheds are outlined in black.

As can be seen in Figure 2-6, the Barrie Creeks has the highest percentage (63%) of urban land use, while the Whites Creek subwatershed in the eastern part of the watershed has the lowest (1%). Oro Creeks North and Oro Creeks South have the seventh and eighth highest levels of urban area, with 9.5% and 6.5%, respectively; while Hawkestone Creek, at 1.7%, has the fourth lowest urban cover in the watershed, exceeding only the Talbot River, Beaver River, and Whites Creek subwatersheds.

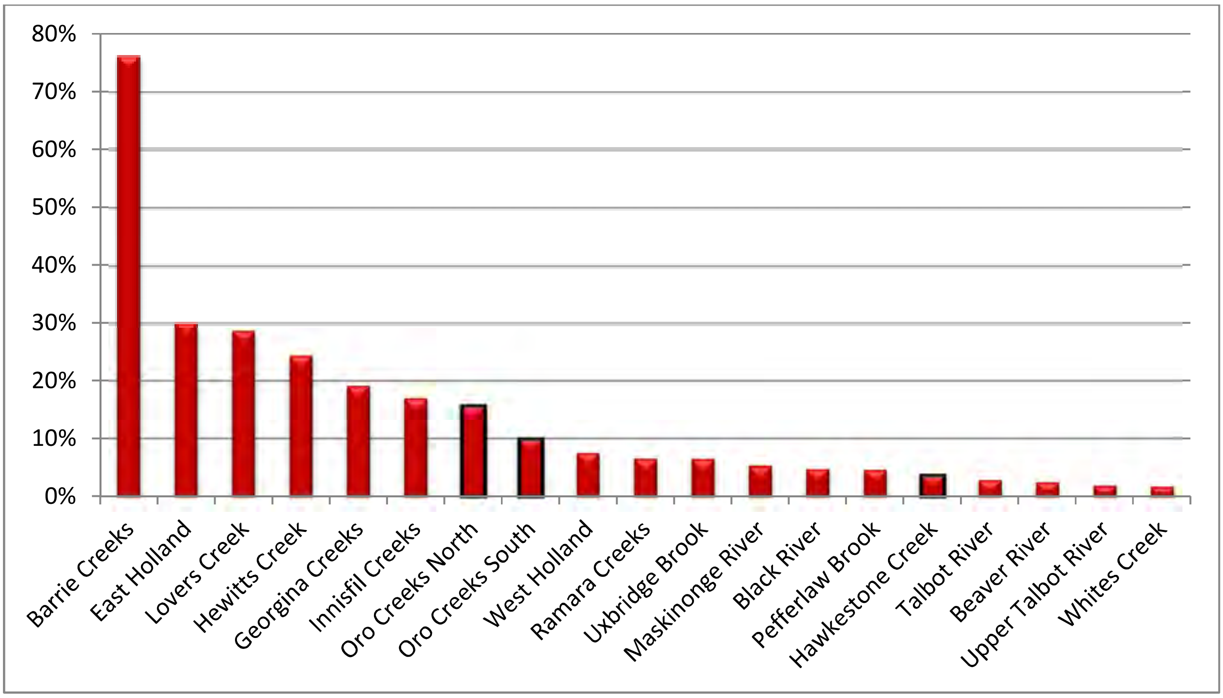


Figure 2-6: Urban land use in the Lake Simcoe subwatersheds.

The Oro and Hawkestone Creeks subwatersheds fare very well with respect to the proportion of natural heritage cover in comparison to other Lake Simcoe subwatersheds. Hawkestone Creek has the highest percentage of natural heritage cover (57%), while Oro Creeks South (46%) ranks third in the watershed and Oro Creeks North (46%) ranks fifth. 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 2-7).

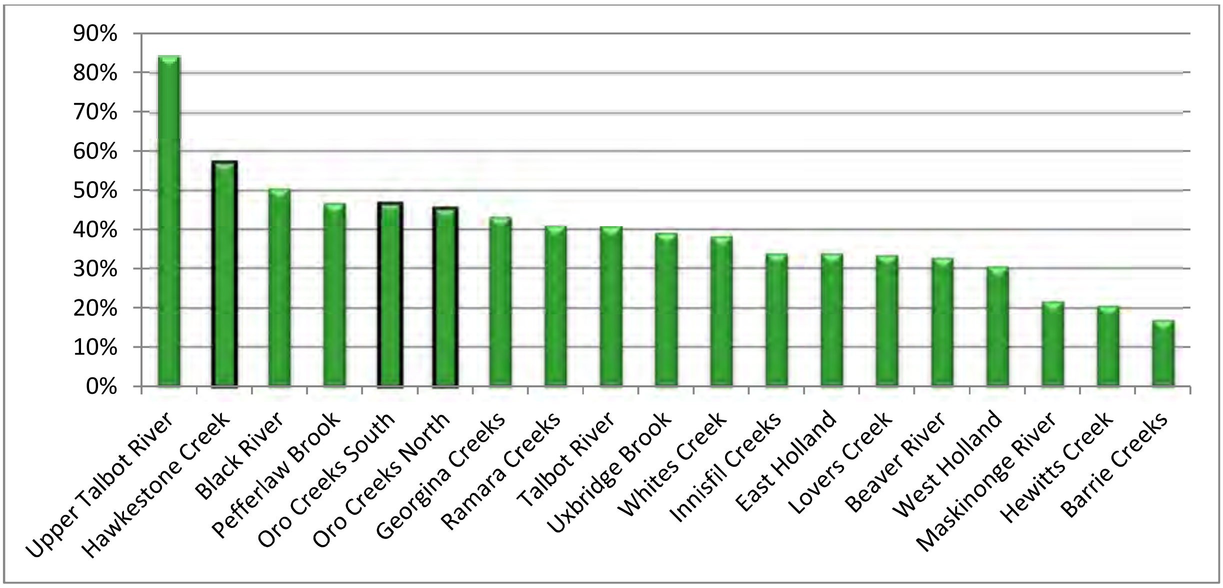


Figure 2-7: Natural heritage land cover in the Lake Simcoe subwatersheds.

Figure 2-8 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 it and of the second lowest subwatershed (East Holland subwatershed) which has 34%. The Oro Creeks South, Oro Creeks North, and Hawkestone Creek subwatersheds have the third, fourth, and fifth lowest levels of rural land use in the watershed, with 43%, 39%, and 37%, respectively. This indicates that agricultural land use is not likely having as large an impact in these systems as it would in subwatersheds with higher levels.

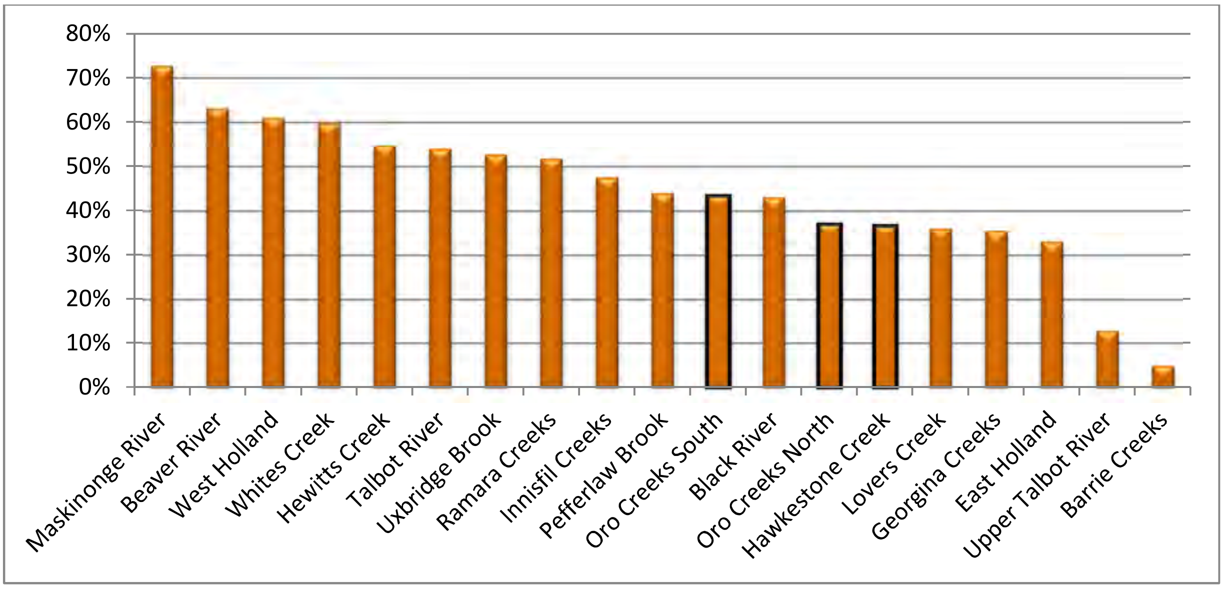


Figure 2-8: Rural land use in the Lake Simcoe subwatersheds.

2.2.2.1 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) [1]. 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 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

[1] 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.

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.

None of the subwatersheds in this plan are above the upper limit. However, both Oro Creeks North and Oro Creeks South are above the 10% guideline with 20% and 14% impervious surfaces, respectively. As these subwatersheds are still below the upper threshold, there is still room through mitigative action and careful development practices to reduce or at least maintain these numbers. The Hawkestone Creek subwatershed, on the other hand, has the lowest percentage of impervious surface of all three subwatershed with 8% impervious cover; this is among the lowest levels in the Lake Simcoe watershed. Land use managers should strive to maintain this low level of impervious area in order to help preserve the health of the subwatershed.

Figure 2-9 illustrates the impervious cover within these subwatersheds.

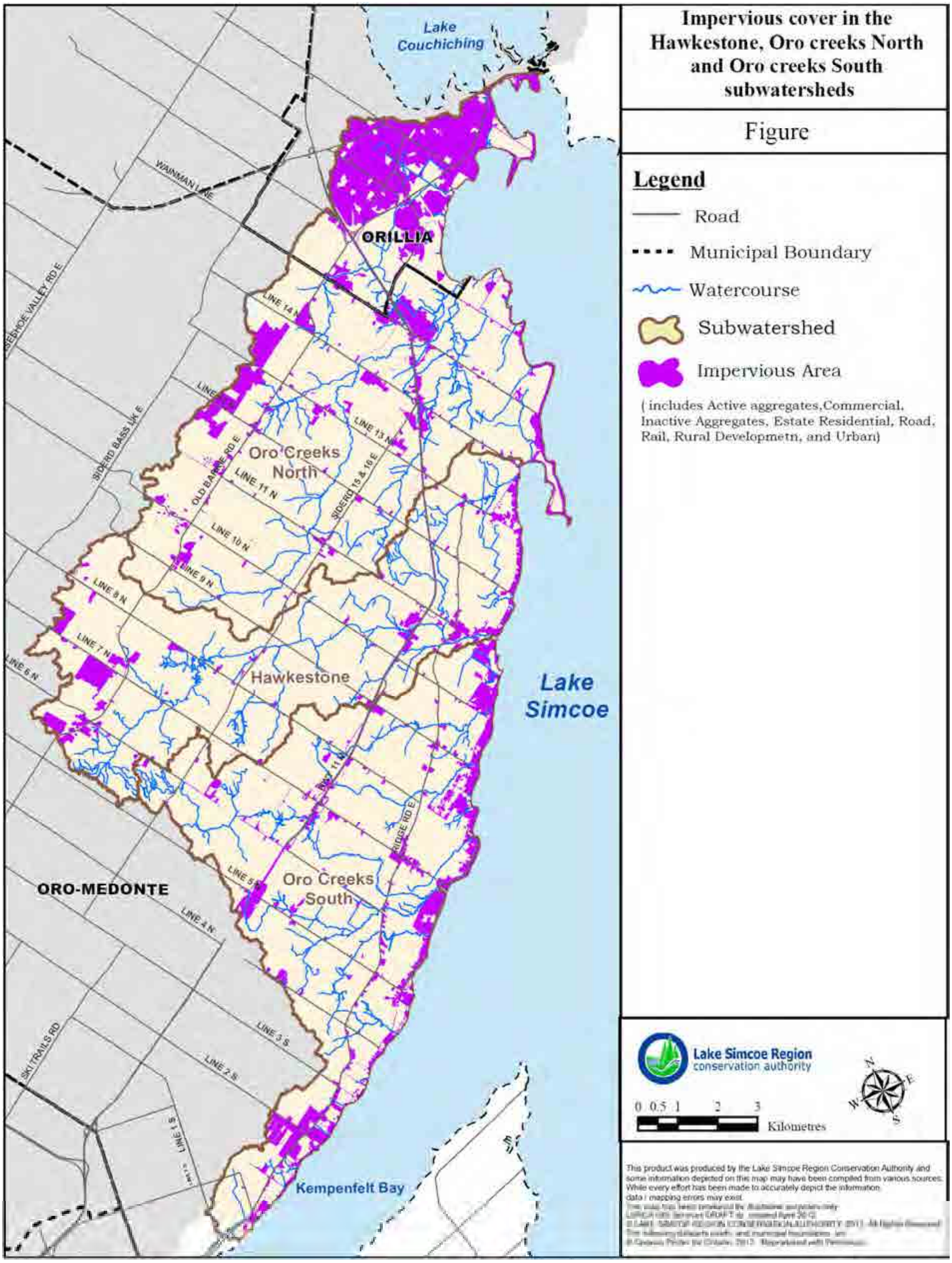


Figure 2-9: Impervious cover in Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

2.2.2.2 Settlement Areas

The City of Orillia is the major urban area falling within the study area, occupying 1,647 ha of the northern portion of the Oro Creeks North subwatershed to the west of the lake's outlet into Lake Couchiching. Other built up areas within the subject subwatersheds include the village of Forest Home, in the Oro Creeks North subwatershed, the village of Hawkestone in the Hawkestone Creeks subwatershed, and the village of Oro Station in the Oro Creeks South subwatershed. All of these communities fall within the Township of Oro-Medonte. There are also a number of small built up areas along the Lake Simcoe shoreline in all three subwatersheds. Population growth in this area is not as significant as in areas further south, such as the City of Barrie, Town of Innisfil, and York Region, however the City of Orillia is identfied in the province's Growth Plan for the Greater Golden Horseshoe as containing Primary Settlement Areas, which are subject to minimum intensification levels, and its population is expected to grow from its current 30,586 residents (as of the 2011 census) to 41,000 residents by 2031. In the portion of the City that falls within the Lake Simcoe watershed, a number of development areas are identified in the City's Official Plan, including several intensification areas, new residential developments, and a number of business, industrial, commercial, and institutional areas. The Township of Oro-Medonte experienced very slight growth in the number of private dwellings between the 2006 and 2011 census, with only 0.2% more private residences in the period. Orillia experienced a 6.1% growth, growing to 12,980 private dwellings.

Even with a growing population, there are still a large number of residents who work outside their municipality, county, and even province and Canada. Approximately 60% of the residents of the City of Orillia work within the City and the others work outside of it or have no fixed work address (40%). 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 Oro-Medonte is a good example of this, with only 19% of the total employed labour force working within the municipality (Table 2-3).

Table 2-3: Place of work status in the City of Orillia and Township of Oro-Medonte (Data Source: Statistics Canada, 2011).

Place of Work Status	City of Orillia		Township of Oro-Medonte	
	Population	Pop. Percentage (%)	Population	Pop. Percentage (%)
Worked at home	860	6	1285	12
Worked outside Canada	70	<1	45	<1
No fixed workplace address	1315	9	1595	14
Worked in census (municipality) of residence	7830	54	805	7

Place of Work Status	City of Orillia		Township of Oro-Medonte	
	Population	Pop. Percentage (%)	Population	Pop. Percentage (%)
Worked in different census subdivision (municipality) within the census division (county) of residence	3960	25	6520	57
Worked in different census division (county)	815	6	965	9
Worked in different province	20	<1	15	<1
Total employed labour force	**14,610**	**100**	**10,960**	**100**

The Township of Oro-Medonte's economy is varied, with employment across a number of different sectors (Table 2-4). Service jobs constitute a large percentage of the employment, with close to 17% in business services, nine percent in health care and social services, nine percent in educational services, and 22% in 'other' services. Manufacturing (11.6%), construction (10%), and retail trade (10%) are the other significant industries in the Township.

The most significant employment sectors in the City of Orillia are retail trade, at close to 14%, business services (12%), and health care and social services (11%) (Table 2-4). 'Other services' account for 31% of the employment in the City.

Table 2-4: Occupations in the City of Orillia and the Township of Oro-Medonte (Data Source: Statistics Canada, 2011)

Industry	Orillia	Oro-Medonte	Industry	Orillia	Oro-Medonte
Agriculture, forestry, fishing and hunting	50	270	Real estate and rental and leasing	405	200
Utilities	95	190	Professional, scientific, and technical services	655	790
Construction	885	1200	Administrative and support, waste management and remediation services	635	515
Manufacturing	1065	865	Educational services	760	925
Wholesale trade	450	490	Health care and social assistance	1800	1435
Retail trade	2105	1210	Arts, entertainment and recreation	1545	445
Transportation and warehousing	465	470	Accommodation and food services	1450	650
Information and cultural	180	180	Other services (except public	525	350

Industry	Orillia	Oro-Medonte	Industry	Orillia	Oro-Medonte
industries			administration)		
Finance and insurance	470	255	Public administration	860	885
Industry – not applicable	515	130	**Total labour force**	**14925**	**11465**

2.3 Human Health and Wellbeing

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 2-10 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 wellbeing to watershed management.

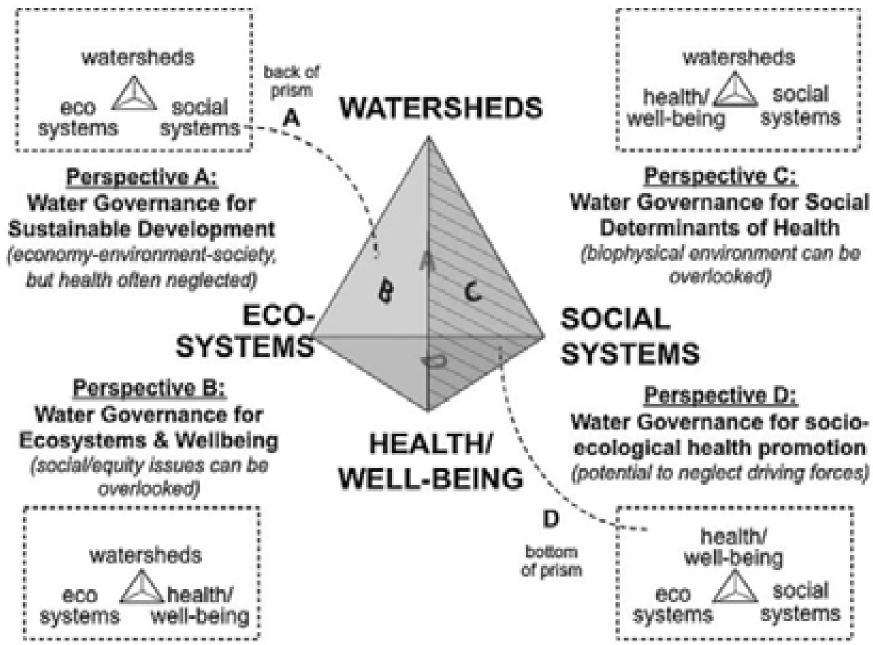


Figure 2-10: Watershed Governance Prism (Parkes *et al*. 2010).

The management of the Lake Simcoe watershed 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.

2.3.1 Outdoor Recreation and Human 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.

2.3.1.1 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). Obesity can also lead to a number of other diseases including Type-2 diabetes, hypertension, asthma and cardiovascular disease (National Environmental Education Foundation (NEEF)).
- Vitamin D Deficiency: Most common diseases resulting from a lack of Vitamin D include rickets (children) and osteoporosis later in life (NEEF).
- 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).

Both the City of Orillia and the Township of Oro-Medonte contain parks and trails within the Oro Creeks North subwatershed. The City of Orillia contains a number of parks, ranging from large Community Parks; to Neighbourhood Parks containing playgrounds, splashpads, and sports fields; to small parkettes. The City-owned Scout Valley park is a more natural area, with mature forests, watercourses, and hiking trails. Information on City of Orillia parks can be found at http://www.orillia.ca/en/livinginorillia/parks.asp. There are a number of trails within the City, including the Lightfoot Trail, which follows the Lake Simcoe shoreline for a short distance, and the trails within the Scout Valley Park. There are also a number of proposed trails within the City.

There is one Provincial Park in the study area; Bass Lake Provincial Park is located in the Oro Creeks North subwatershed. This park has camping facilities, as well as opportunities for hiking, boating, swimming, and winter activities such as skiing and snowshoeing. There are no Conservation Areas in these subwatersheds.

2.3.1.2 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.

2.3.1.3 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.

2.3.1.4 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, 2009), and decrease the amount of time such properties are on the market (Donovan and Butry, 2009). 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).

In addition to increasing property values, natural areas in or near residential neighbourhoods can act as a draw for white-collar workers working in high paying, creative jobs, who prefer to live in an urban setting that encourages their 'creativity', through a stimulating, diverse, cultural setting with easily accessible natural amenities for a healthy lifestyle. 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).

2.3.2 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 *E. 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.

2.3.2.1 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[2], 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:

- 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

[2] Information for the drinking water systems within the Oro Creeks and Hawkestone Creek subwatersheds can be found in the Approved Lakes Simcoe and Couchiching-Black River Source Protection Area Assessment Report, Part 1: Lake Simcoe. Chapter 11 of this Assessment Report is specific to the Township of Oro-Medonte.

- 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 watershed. There is one system in the Oro Creeks North subwatershed, three in the Oro Creeks South subwatershed, and one in the Hawkestone Creek subwatershed; all of these are groundwater supply systems. Table 2-5 breaks down the number of drinking water systems and municipal wells for each subwatershed.

Table 2-5: Number of drinking water systems, wells and surface water intakes.

Subwatershed	Number of Drinking Water Systems	Number of Municipal Supply Wells	Number of Municipal Surface Water Intakes
Oro Creeks North subwatershed	1	1	0
Oro Creeks South subwatershed	3	7	0
Hawkestone Creek subwatershed	1	2	0

Each of the drinking water systems in Table 2-5 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:

- 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

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.

The drinking water systems within these subwatersheds are located within the Township of Oro-Medonte and are only five of the 11 systems servicing the township. The other six are located in the Nottawasaga Valley (1) and Severn Sound (6) watersheds. With almost half of the systems within the Lake Simcoe watershed, and over 700 people (combined) relying on these water supplies as a source of safe drinking water it stresses the importance of maintaining and/or improving the quality (and quantity) of these supplies. Restoration efforts along streams draining into Lake Simcoe, or on the lake itself, benefit not only the local wildlife and natural habitats, but also all those who depend on the watershed and lake as a source of safe drinking water.

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

The Shanty Bay Well Supply consists of three wells located in the southern part of the Township of Oro-Medonte off of Ridge Road between the 2nd and 3rd Lines South, approximately 4.5 km east of the City of Barrie, and services approximately 157 residents. A total of 19 significant drinking water threats were identified in association with 19 land parcels. The majority of these threats are associated with individual sewage systems, and one was related to the handling and storage of fuel (SGBLS-SPC, 2011).

The Harbourwood Well Supply has two wells located in the southern part of the Township of Oro-Medonte on Lake Simcoe and services over 330 residents. A total of 18 significant drinking water threats were identified in association with 18 land parcels. The majority of these threats are associated with individual sewage systems; one is related to the handling and storage of fuel (SGBLS-SPC, 2011).

The third well supply in the Oro Creeks South subwatershed is the Canterbury Well Supply, with two wells located in the southern part of the Township of Oro-Medonte at #1 Somerset Blvd., approximately 180 metres north of Ridge Road and 12 metres west of Line 7 South. This system services just over 40 people and has a total of 20 significant drinking water threats indentified in association with 16 land parcels. The majority of these threats are associated with private individual sewage systems. The remaining threats are related to the application of agricultural source material to land (2), the application of commercial fertilizer to land (1), the application of pesticide to land (2), the handling and storage of fuel (1), and the use of land as livestock grazing or pasturing land, an outdoor confinement area, or a farm-animal yard (1) (SGBLS-SPC, 2011).

The Cedar Brook Well Supply consists of two wells located in the eastern part of the Township of Oro-Medonte in the community of Hawkestone, and services about 60 people. A total of 21 drinking water threats were identified in association with 20 land parcels. The majority of these threats are associated with individual sewage systems, with a few other related to the application of agricultural source material to land (1), the application of pesticide to land (1), and the handling and storage of fuel (1) (SGBLS-SPC, 2011).

Lastly, the Maplewood Estates Well Supply consists of one well located in the north-eastern part of the Township of Oro-Medonte, approximately four kilometres south of the City of Orillia and services over 120 people. A total of six significant drinking water threats were identified in association with six land parcels. The majority of these threats are associated with individual sewage systems, with one related to the handling and storage of fuel (SGBLS-SPC, 2011).

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 proposed plan was submitted to the Minister in 2012 and is expected to be approved in early 2014.

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 1: Lake Simcoe. The local vulnerable areas (Wellhead Protection Areas) for the drinking water systems located in each of the three subwatersheds within this report are shown in Figure 2-11.

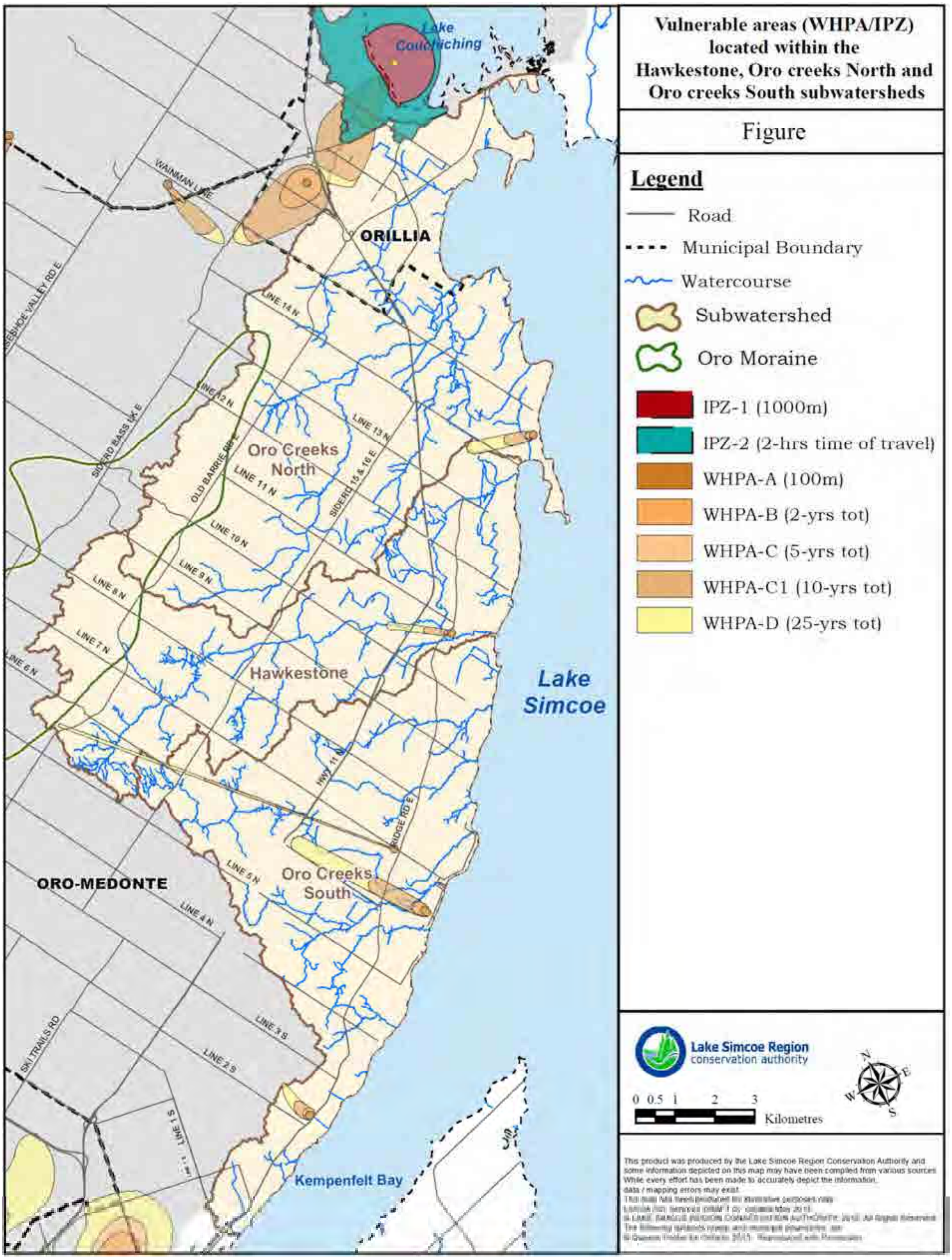


Figure 2-11: Vulnerable Areas (WHPA/IPZ) located within the Oro North, Oro South, and Hawkestone Creeks subwatersheds.

2.3.3 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. http://www.globalcanopy.org/eco-utility/benefits/overview).

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.

2.3.3.1 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 2-6 summarizes the value of the various ecosystem services by land cover type in the Oro Creeks North, Oro Creeks South and Hawkestone Creek subwatersheds, as well as for the whole Lake Simcoe watershed. All ecosystem service values have been updated to 2010 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 2-6: Summary of non-market ecosystem service values by land cover type (2010 values).

Land Cover Type	Total Oro Creeks North subwatershed value ($ million/yr)	Total Oro Creeks South subwatershed value ($ million/yr)	Total Hawkestone Creek subwatershed value ($ million/yr)	Total Lake Simcoe basin value ($ million/yr)
Cropland	0.92	0.95	0.60	50.07
Forest	9.36	7.50	6.42	190.97
Forest/ Wetlands*	7.77	6.76	11.67	428.59
Wetlands	3.90	2.49	2.87	162.33
Grasslands	0.56	0.36	0.42	20.66
Hedgerows/ Cultural Woodland	0.26	0.11	0.11	5.79
Pasture	1.27	0.68	0.76	38.39
Urban Parks	0.05	0.09	0.03	2.92
Water**	0.01	0.00	0.01	1.42
Total	**24.10**	**18.95**	**22.89**	**901.15**

* This includes treed swamps.
** This does not include the value of Lake Simcoe

As has been demonstrated, the natural systems of the Oro Creeks North, Oro Creeks South, and Hawkestone Creek 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 2010 values) for the Lake Simcoe watershed $980 million and at least $24.10 million for the Oro Creeks North subwatershed, $18.95 million for the Oro Creeks South subwatershed and $22.89 million for the Hawkestone Creek subwatershed. The most highly valued natural assets are the forests and treed swamps. For the Lake Simcoe watershed these were calculated to be worth $191 and $429 million per year, respectively. Oro Creeks North was $9.4 million and $7.8 million, Oro Creeks South $7.5 million and $6.8 million and Hawkestone Creek $6.4 million and $11.7 million for forests and treed swamps, 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 that while the value of Lake Simcoe is not included in the watershed total, it is of considerable value to all surrounding natural and human communities within the Lake Simcoe watershed. It is the focal point of many waterfront communities (such as the Township of Oro-Medonte and City of Orillia), provides a vast number of recreational opportunities for both locals and tourists alike, is a source of drinking water for seven municipal surface water intakes, supports a substantial fishery and, as well as being a significant natural heritage feature, provides people with beautiful scenery. As such, the preservation of the lake 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.

2.4 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.

2.4.1 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 Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds is provided. For more detailed information the reader is referred to Johnson *et al*. (1992), Armstrong (2000), and Easton and Carter (1991).

2.4.1.1 Bedrock Geology

The bedrock can be characterized as being from the Middle Proterozoic age which consists of primarily gneisses and forms part of the Central Gneiss Belt, which is a major division of the Canadian Shield (Easton and Carter, 1991). These rocks form the 'basement,' or the underlying bedrock formation, in this area. On a regional basis, the surface of this unit dips gently to the south-southwest (Armstrong, 2000). The Simcoe Group overlies the Precambrian 'basement' rock units that comprise the Canadian Shield and outcrop (present at the surface*)* north of the Lake Simcoe watershed. The Simcoe Group has been overlain by a sequence of sediments that have been deposited over the last 135,000 years by glacial, fluvial, and lacustrine environments. The Simcoe Group consists of four formations that dip gently towards the southwest, from oldest to youngest: Shadow Lake Formation, Gull River Formation, Bobcaygeon Formation, and Verulam Formation. However, the Bobcaygeon Formation is the only formation to subcrop throughout the study area with the Verulam Formation subcropping only in the south end of the study area.

Shadow Lake Formation

The Shadow Lake Formation is the oldest unit in the sequence and is composed of mainly poorly sorted sandstones and conglomerates, sandy shales and siltstones. The rocks are non-fossiliferous and colour ranges from red to maroon to green. The average thickness of this unit is about 6 m. The outcrop of this unit is very narrow and is mainly limited to the low escarpment formed by the Paleozoic/Precambrian contact.

Gull River Formation

The Gull River Formation consists of very thin to medium beds of very fine-grained limestone, dolomitic limestone, and dolostone. This unit consists of a lower and upper unit and the overall thickness of this formation is up to 25 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', which is found throughout Armstrong's (2000) north Lake Simcoe study area. Within the study area, the subcrop area of this unit is limited to a three kilometre (km) wide re-entrant or prominent indentation that extends to about five kilometres south of Moonstone (Earthfx, 2013a).

Bobcaygeon Formation

The Bobcaygeon Formation is the next unit in the sequence and is mainly limestone that is generally more fossiliferous and coarser grained than the underlying Gull River Formation. It is divided into three members. The rocks include fine to coarse-grained packstones and grainstones in the lower and upper members, and interbedded shale and fine- to medium-grained limestone in the middle member. The upper member is composed mainly of shale materials. In terms of areal extent, this formation is the most significant Paleozoic unit subcropping in the study area and extends up to about 36 m in thickness. This formation is represented on Figure 2-12 (Johnson *et al*., 1992).

Verulam Formation

The Verulam Formation is the youngest rock unit in the study area and is divided into two subgroups. The lower unit consists of interbedded calcareous shale and limestone and can be up to 40 m thick. The upper coarse-grained limestone unit, which is up to 10 m thick, subcrops in a three to six km wide band across the southern part of the study area. The depositional environment of the Verulam Formation was open marine shelf (Thurston *et al*., 1992). This formation is represented as green on Figure 2-12.

Barnett (1988) reported karst north of the study area, but the Ontario Geological Survey (OGS) boreholes showed no evidence of karst development within the study area. Karst topography refers to limestone regions with underground drainage and cavities such as sinkholes caused by the dissolution of limestone rock.

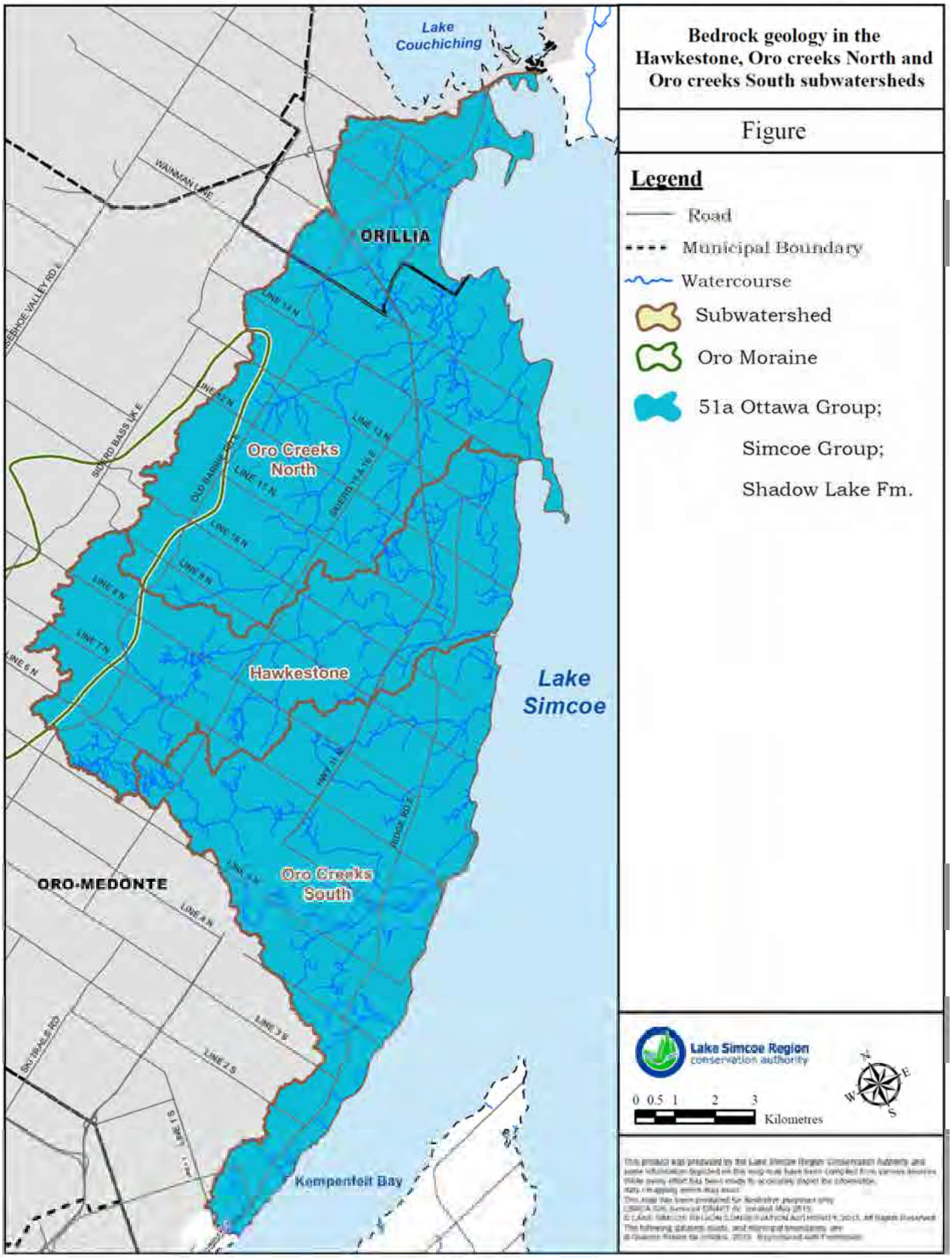


Figure 2-12: Bedrock geology in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

2.4.1.2 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 2-13, the bedrock surface of the subwatersheds has a general elevation range of 110 to 240 mASL. (Earthfx, 2013a). The highest elevation of the bedrock surface coincides with the eastern portion of the Oro Creeks North subwatershed with gradually declining elevations towards the southernmost portion of the study area in the vicinity of Shanty Bay.

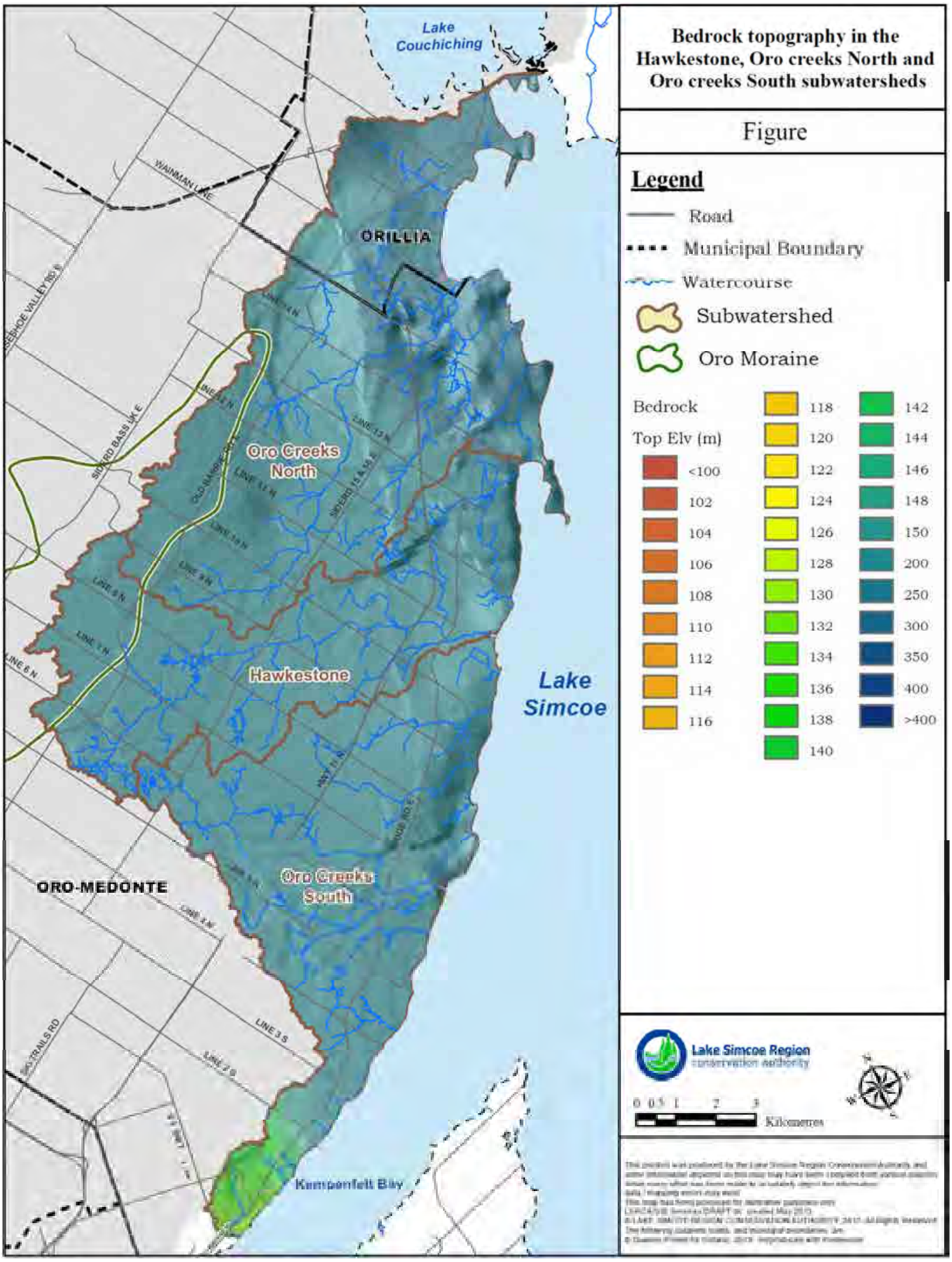


Figure 2-13: Bedrock topography in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

2.4.1.3 Quaternary Geology

Glacial History

Like all of southern Ontario, the study area was repeatedly glaciated during the Pleistocene Epoch, although locally there is only clear evidence for glacial activity during the Wisconsinan, the final major glacial episode. Regionally, sediments of Quaternary age form a complex blanket of sediment deposits, up to 250 m thick, on the bedrock surface. Most of these sediments were deposited either directly from glacier ice, in meltwater streams, or in ice-marginal or ice-dammed lakes. 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. It is possible that glacier ice was continuously present within the study area until at least the end of the Port Bruce phase.

The bedrock within the Oro North and Oro South and Hawkestone Creeks subwatersheds 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 subwatershed, 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 2-14. The lowlands within the project area are dominated by lacustrine sediments deposited in high level ice-marginal lakes and Glacial Lake Algonquin and its successor lakes following the last major period of glaciation (Barnett, 1988 and OGS, 2010). These sediments are mainly sands and extend from the northeastern portion of the Oro North subwatershed down along the Lake Simcoe shoreline and pinch out south of Shanty Bay (Earthfx, 2013a).

The surficial geology of the upland areas is more complex. Barnett (1986) observed that there are three subglacial till units in the uplands. However, the major surficial till sheet within the subwatersheds has been described as the Newmarket Till (OGS, 2010 and Barnett, 1992). The Newmarket Till is composed mainly of silt to sandy silt and sand to silt material.

Glaciofluvial sediments and glaciolacustrine sediments are superimposed on the till in the uplands. Generally, these units are fairly thin and limited in areal extent but as seen in Figure 2-15, the Oro Moraine is a thick, extensive body of sand and gravel. Numerous gravel pit operations are located in the study area, particularly along the crest of the Oro Moraine (Earthfx, 2013a).

The broad, U-shaped valleys that dissect the till uplands and form most of the Simcoe Lowlands are probably products of at least one major subglacial drainage event with an initial stage of vigourous erosion by a very large volume of water (Barnett, 1986, 1990a, 1990b; and Sharpe *et al*. 1999). Down-cutting of these deeply incised 'tunnel valleys' was followed by sedimentation as conditions such as flow changed (Earthfx, 2013a).

Throughout the glacial history of the area, regional-scale glacial lakes or even local pondings were probably present in the area whenever it became at least partly ice free and there was no free drainage of glacial meltwater. There are abandoned beaches and spits, as well as erosional shore bluffs and terraces, present on the flanks of the till upland areas (Barnett, 1989 and 1997). Recent sediments include alluvial deposits along modern stream course and organic deposits in poorly-drained areas (Earthfx, 2013a).

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 2-15 shows the overburden within the study area ranges from 0 to 250 m. In the lowland areas, it usually ranges from about 50 to 100 m, but there are small areas in the northern part of the study area where the sediment is thin (<15 m thick). In the upland areas, the overburden thickness is typically about 60 to 175 m, while the sediment thickness is greatest at the high point of the Oro Moraine (250 m). The thicker Quaternary sediments are associated with the Oro Moraine, while the areas with the thinnest Quaternary deposits occur along the Lake Simcoe shoreline.

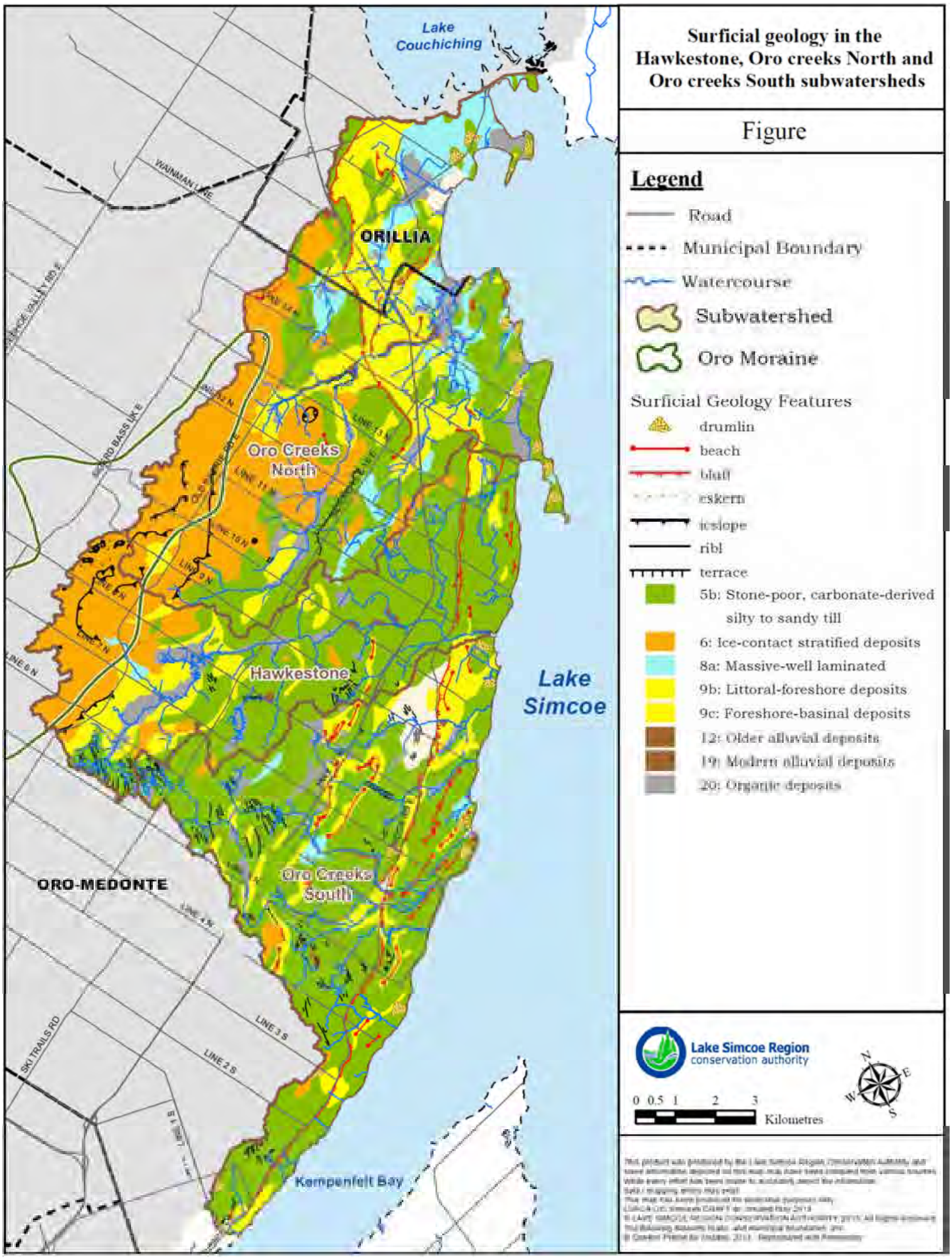


Figure 2-14: Surficial geology in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

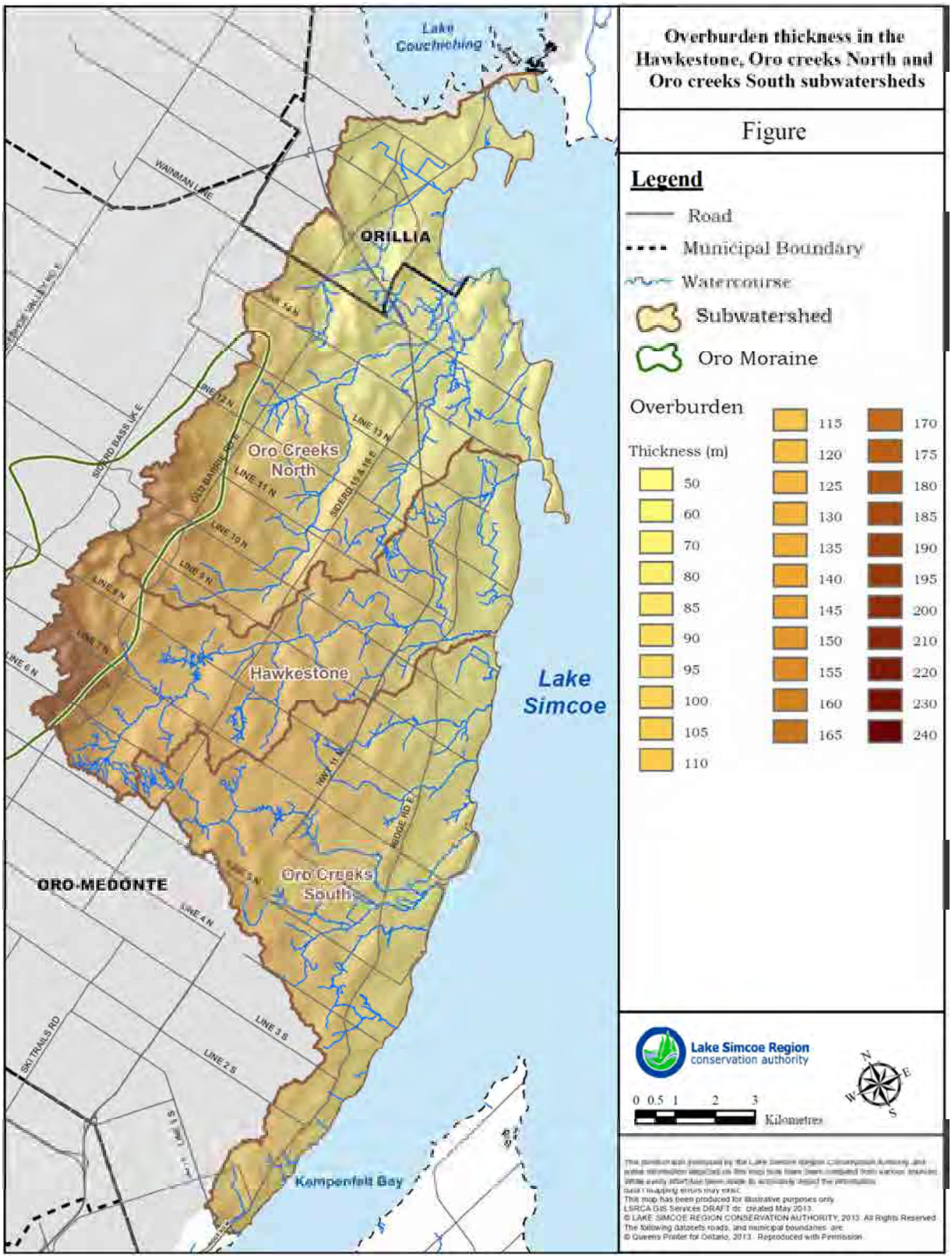


Figure 2-15: Overburden thickness (in metres) (Earthfx, 2013a).

2.4.1.4 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. There have been a number of studies that aimed to provide an understanding of the local hydrostratigraphic framework of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. The following subsections provide a brief overview of relevant and previously completed stratigraphic studies.

The stratigraphic framework of Quaternary glacial and non-glacial sediments, as shown in Figure 2-16, was completed by by the Ontario Geological Survey (Burt and Dodge, 2011) for the Oro Moraine and further refined by Earthfx (2013a) for the Tier 2 Water Budget model for the the Oro North and South and Hawkestone Creeks subwatersheds. The conceptual framework developed by Burt and Dodge (2011) consists of 23 hydrostratigraphic units – two bedrock layers and 21 Quaternary (overburden) layers. Because it is a hydrostratigraphic model, it has alternating aquifer and aquitard layers. Many of these layers may contain parts of more than one lithostratigraphic unit that have been grouped together because of their hydrogeological properties and spatial relationships. 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 associated with glacial sediments are typically composed of coarse-grained materials such as sands and gravels. An aquitard unit commonly contains till and fine-grained water laid sediments but may also have thin beds or lenses of sand (Earthfx, 2013a). A description of the interpreted hydrostratigraphic framework is provided below.

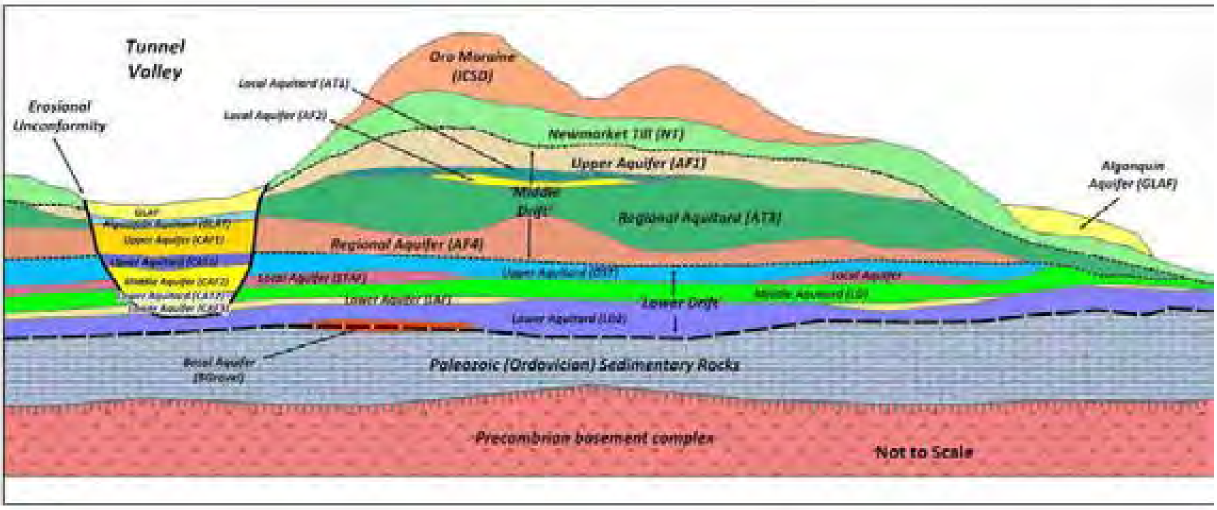


Figure 2-16 Generalized conceptual hydrostratigraphy of upland complexes, lowland tunnel channel complexes, and the Oro Moraine (Burt and Dodge, 2011).

The nine conceptual model layers (from youngest to oldest) are:

1. Upper Algonquin Aquifer (GLAF)
2. Algonquin Aquitard (GLAT)
3. Tunnel Valley Fill: series of Aquifers (AF) and Aquitards (AT) in the Upper (CAF1, CAT1), Middle (CAF2, CAT2) and Lower (CAF3) units
4. Oro Moraine Aquifer (ICSD)
5. Confining Layer Newmarket Till (NT)
6. Middle Drift Units: series of Aquifers (AF) and Aquitards (AT): (AF1), (AT1), (AF2), (AT3), and (AF4)
7. Lower Drift Units: series of Aquifers and Aquitards: (OST), (STAF), (LD), (LAF), and (LD2)
8. Basal Aquifer (BGravel)
9. Bedrock (Paleozoic and Precambrian)

<u>Algonquin Aquifer (GLAF)</u>

The Agonquin aquifer is composed of sand and silty sand material.

<u>Algonquin Aquitard (GLAT)</u>

The Algonquin Aquitard is associated with silt, silty clay, and clay material. Although it is found as scattered patches on the till uplands, it is mainly in the tunnel valley systems. An aquitard is a confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

Tunnel Valley Fill Series of Aquifers and Aquitards (CAF1, CAT1), (CAF2, CAT2), (CAF3)

The Tunnel Valley Fill Series was described as upper, middle, and lower units. The CAF1 layer has been cored as the upper aquifer in the tunnel-valley fill and is described as sand and silty sand. This aquifer is capped by the Algonquin aquitard (GLAT). The CAT1 layer is classed as the upper aquitard and is described as silt, silty clay, and clay. The CAF2 unit is the middle aquifer and is composed of sand and silty sand. CAT2 is the lower aquitard unit and is described as fine-textured silt, silty clay, and clay. The final unit in this series is the CAF3 aquifer unit which is described as coarse-textured sand and silty sand deposits.

Oro Moraine Aquifer (ICSD)

The Oro Moraine Aquifer (also referred to as the ICSD [for ice contact stratified drift]) is comprised of mainly sand and gravel and covers an area of 165 km^2 (Earthfx, 2013a). The thickness of this permeable aquifer unit contributes to high recharge conditions and provides headwater flow to numerous streams that drain to Lake Simcoe, Minesing Swamp, and Georgian Bay.

Confining Layer Newmarket Till (NT)

The Newmarket Till is mainly composed of a stony sand till (Burt and Dodge, 2011). This unit has been described as a major surficial till unit in the area (OGS, 2010 and Barnett, 1992).

Middle Drift Units (AF1), (AT1), (AF2), (AT3), and (AF4)

The middle drift was divided into the regional aquifer (AF4), plus regional aquitard (AT3) and what Burt and Dodge (2011) call the 'upper aquifer complex' which contains the local aquifer (AF2), local aquitard (AT1) and the regionally significant upper aquifer (AF1). The three aquifer units were described as predominantly gravel, sand, and silty sand units, while the two aquitards are associated with silt, silty clay, and clay material (Burt and Dodge, 2011) .

Lower Drift Units (OST), (STAF), (LD), (LAF) and (LD2)

The lower drift units are comprised of five units which consist of aquifer and aquitard units. The two aquifer units consist of coarse-textured stratified drift material, while the three aquitards within the lower drift unit consists of till and fine-textured stratified deposits (Burt and Dodge, 2011).

Basal Aquifer (BGravel)

The Basal Aquifer is a compound unit that combines the zone of weathered carbonate bedrock with younger lag gravel deposits (Burt and Dodge, 2011).

Bedrock (Paleozoic and Precambrian)

These 'basement' formations were described in the previous section (Shadow Lake, Gull River, Bobcaygeon and Verulam).

Figure 2-17: Cross-section locations (Earthfx, 2013a)

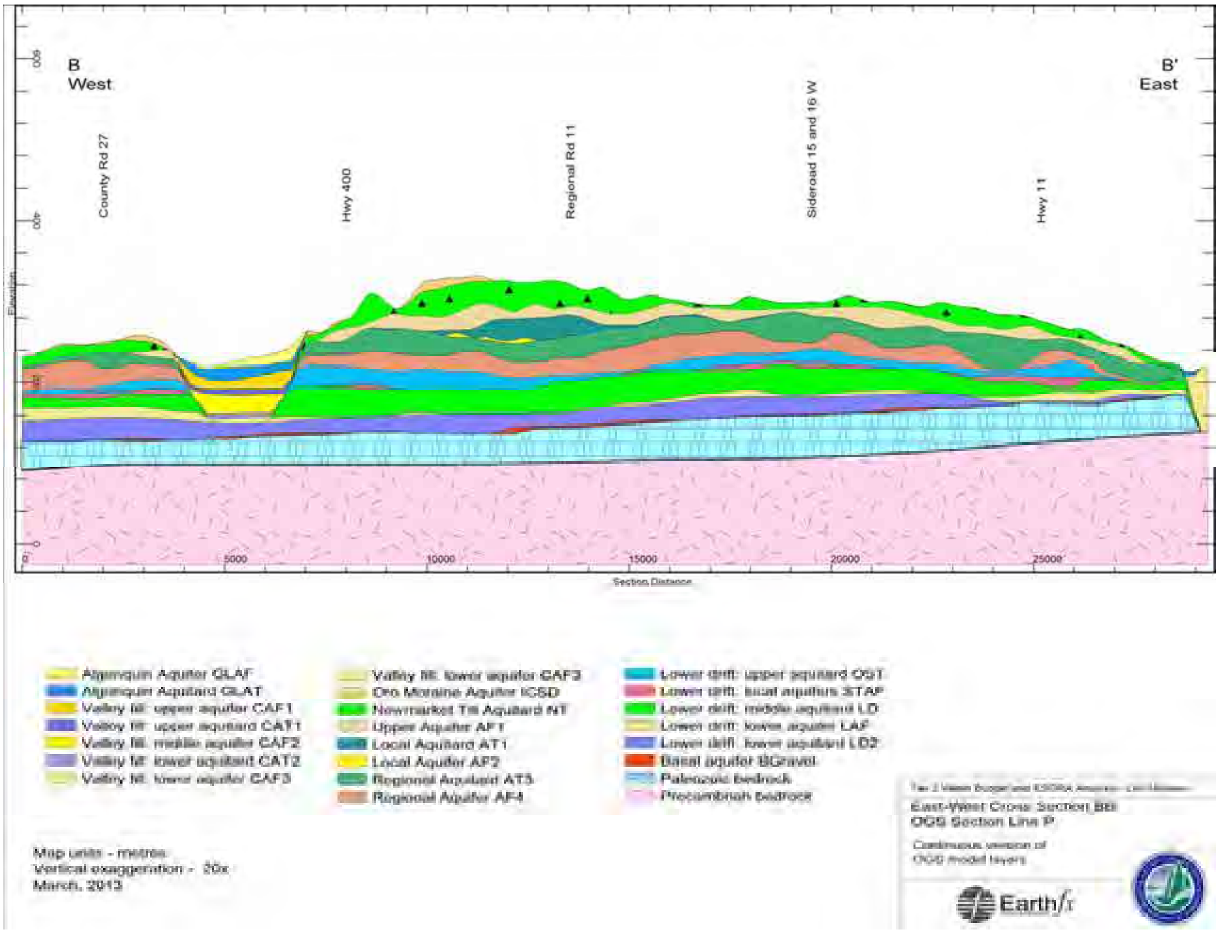


Figure 2-18: East-west cross-section through the Township of Oro-Medonte depicting the key features of the geologic and hydrogeologic system (Earthfx, 2013a).

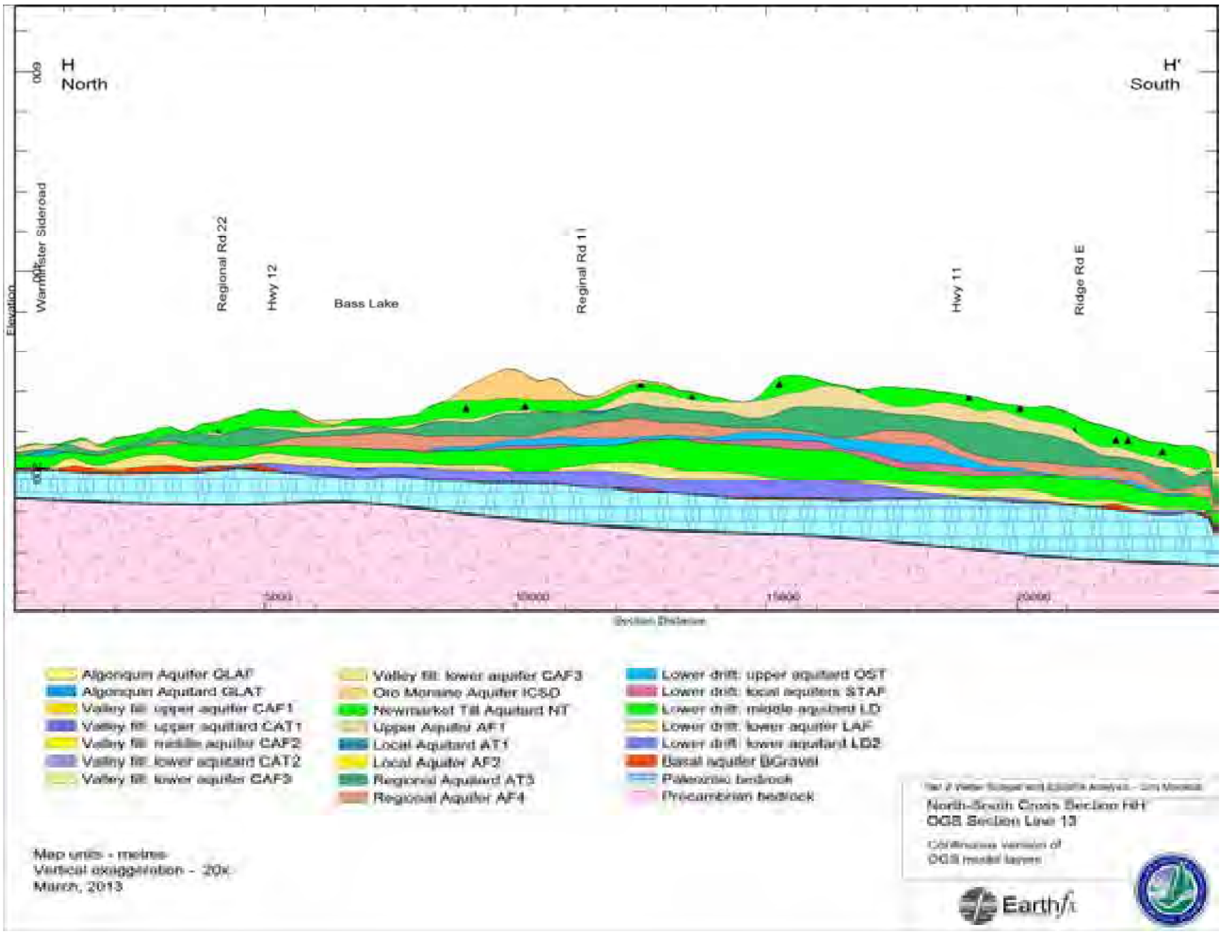


Figure 2-19: North-south cross-section through the Oro-Medonte area depicting the key features of the geologic and hydrogeologic system (Earthfx, 2013a).

2.4.2 Physiography, Topography and Soils

2.4.2.1 <u>Physiography</u>

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 Oro North, Oro South, and Hawkestone Creek 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), two physiographic regions are found within the subwatersheds: the Simcoe Uplands and the Simcoe Lowlands (Figure 2-20).

Simcoe Uplands

The Simcoe Uplands is the physiographic region centrally located within all three subwatersheds and is defined as distinct upland areas of rolling till plains that are broken up by broad, U-shaped erosional valleys (Chapman and Putnam 1984). Although Chapman and Putnam (1984) classify these till plains as drumlinized till plains, there are only a few drumlins mapped on the uplands in the study area. The Oro Moraine is a prominent feature on this large till plain that dominates the study area. Barnett (1989) states that the moraine appears to have been formed in three stages of lake deposits. The moraine is mainly comprised of sand and gravel and runs east northeast-west southwest. Numerous wetlands are found within the area on the flanks of the Oro Moraine and in the low-lying valleys (Earthfx, 2013a).

Simcoe Lowlands

The Simcoe Lowlands is the physiographic region defined as sand plains that comprises a stretch of land extending along the eastern portions of the subwatersheds and continues northerly up around Bass Lake and Silver Creek. The region is described as having lower elevations, with flat-floored valley features that generally correspond to current river systems (Sharpe *et al*., 1999). The lowlands were flooded by glacial Lake Algonquin and are dominated by lake-deposited sediments, predominantly sand including silt and clay (Chapman and Putnan, 1984). There are also a number of abandoned beaches which developed along the shorelines of post-glacial lakes, in the low lying areas and on the flanks of the till uplands (Earthfx, 2013a).

2.4.2.2 Topography

The topography of the subwatersheds closely corresponds to their physiographic regions (Figure 2-21). The topographic features of the Oro North, Oro South, and Hawkestone subwatersheds are related to the present-day stream network, as well as their geological history, including significant glacial events. Higher elevations occur along an east-west ridge of land formed by the Oro Moraine in the centre of the study area. The watershed divide for the Oro North, Oro South, and Hawkestone Creek subwatersheds occurs along the Oro Moraine. The ground surface topography within the subwatersheds ranges from a high of approximately 405 metres above mean sea level (mASL) along the Oro Moraine. Local relief ranges from 20 m to more than 150 m on the north side of the moraine. Areas of hummocky topography occur on top of the Oro Moraine and act to prevent surface runoff and focus infiltration. The watershed divide for the Oro North, Oro South, and Hawkestone Creeks subwatersheds occurs along the Oro Moraine. Lowest elevations in the subwatersheds occur along the Lake Simcoe shoreline (about 219 masl) (Earthfx, 2013a).

2.4.2.3 Soils

The soils present within the subwatersheds influence the type and productivity of the vegetation communities commonly growing within the subwatersheds. 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. OGS (2003) surficial geology maps were used to assign soil types found in the study area. Figure 2-22 depicts the spatial distribution of the soil types present throughout the subwatersheds.

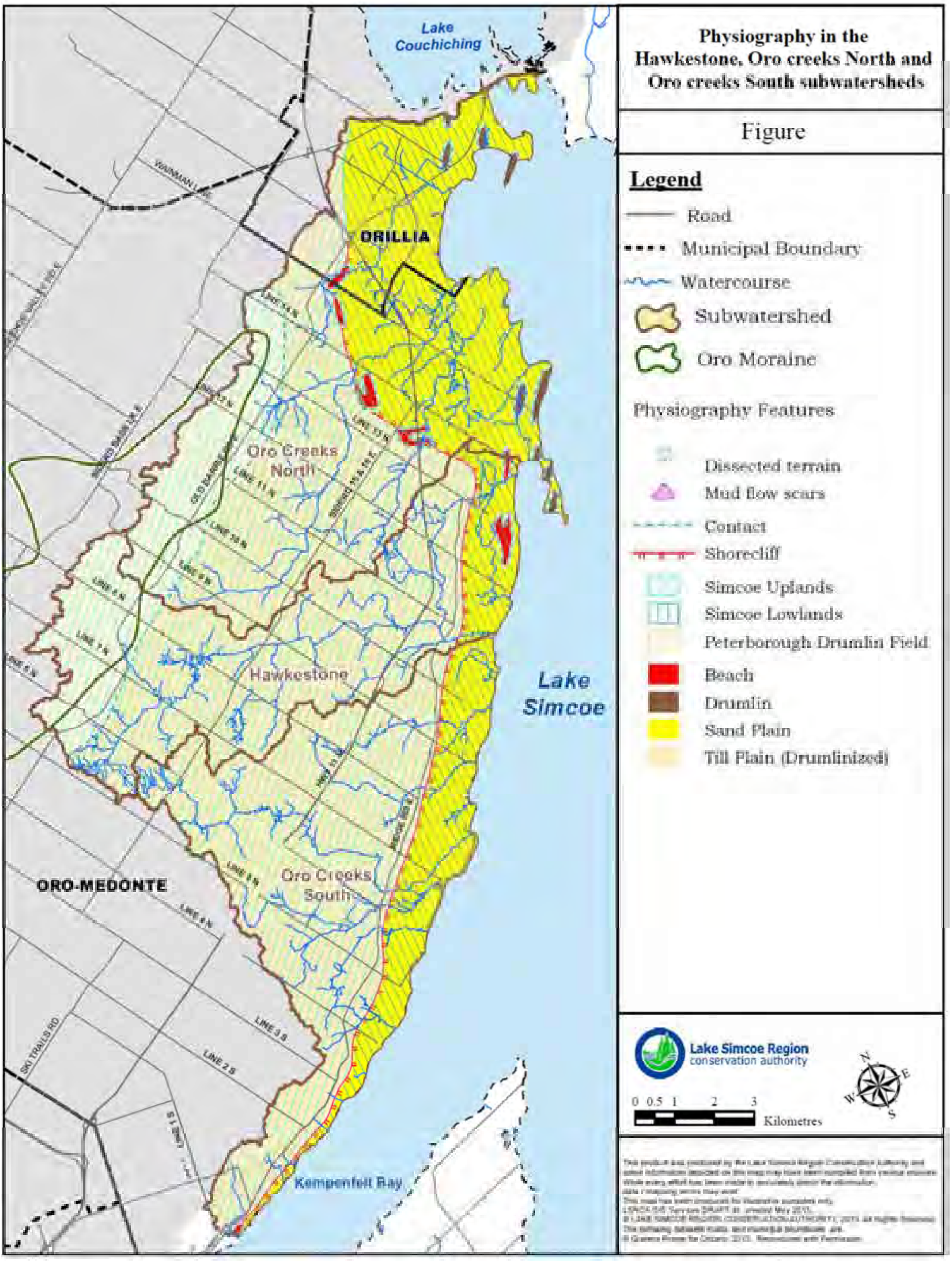


Figure 2-20: Physiography (from Chapman and Putnam, 1984).

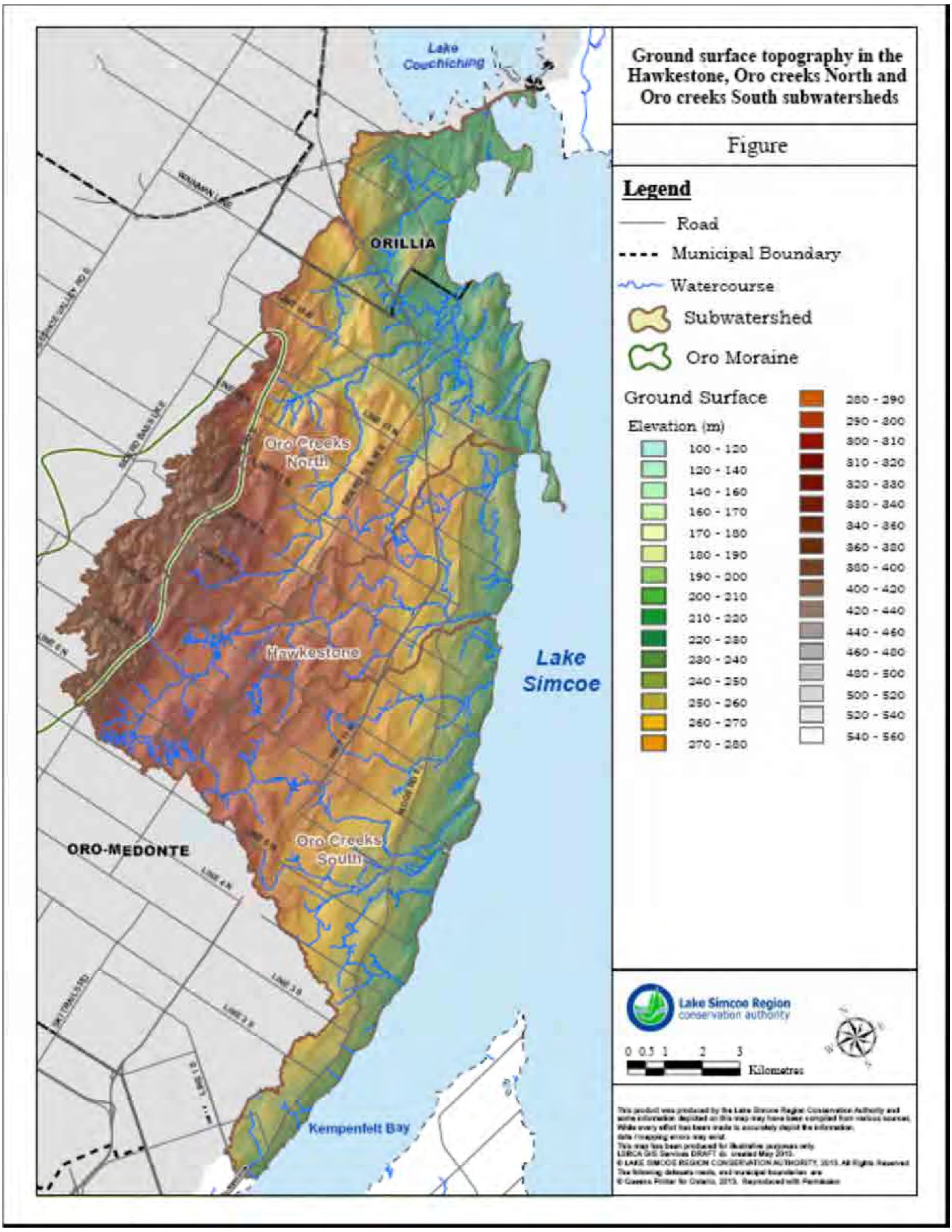


Figure 2-21: Ground surface topography (from 5-m Digital Elevation Model)

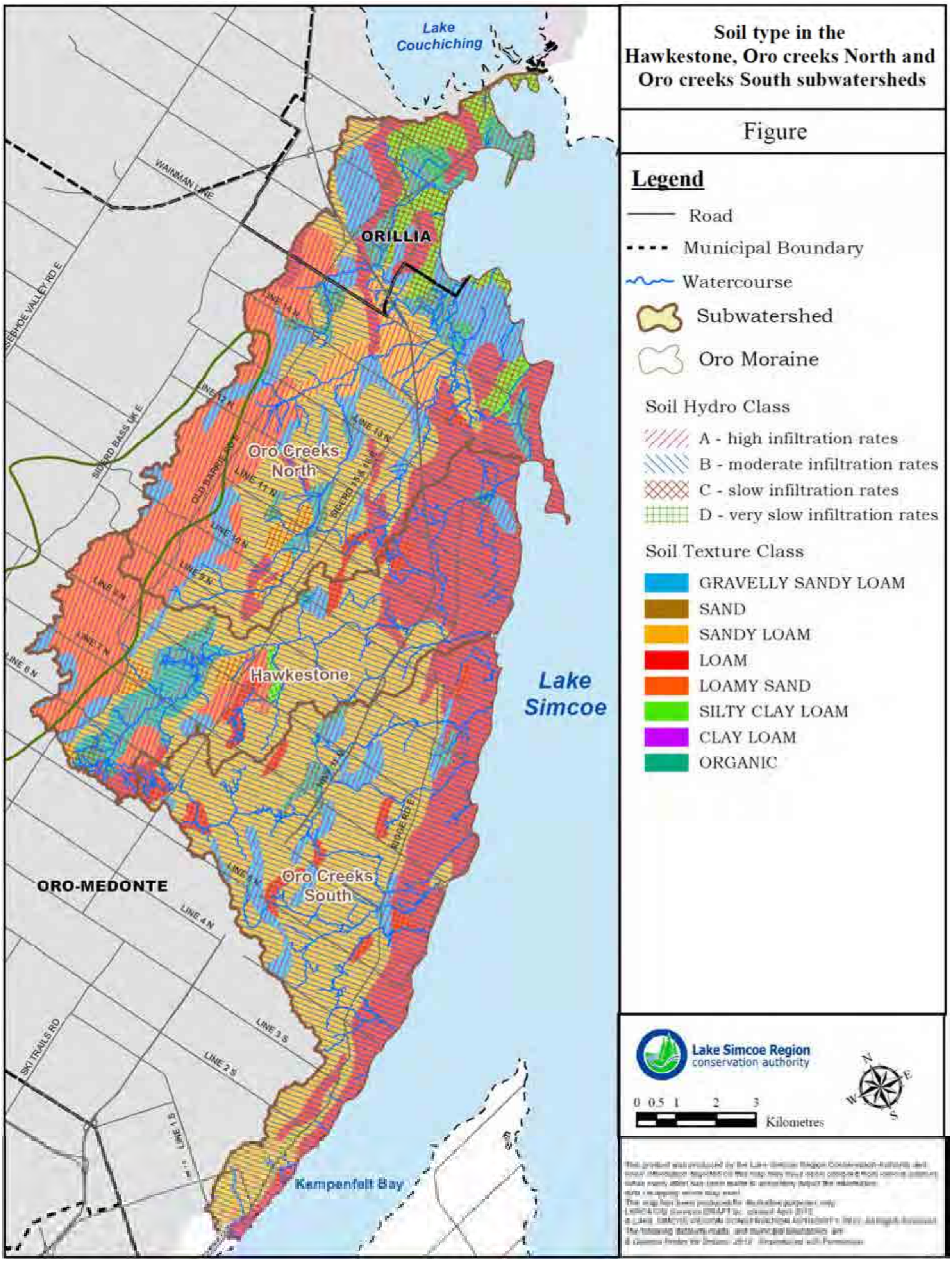


Figure 2-22: Soil types in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

2.5 Fluvial Geomorphology

2.5.1 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.

2.5.2 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.

2.5.3 Current Status

Specific fluvial geomorphology studies have not been completed for these 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, Aquatic Natural Heritage**.

2.5.3.1 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 2-7 below presents the stream order and the total length of the creek within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. To allow for more detailed reporting, the subwatersheds have been divided into their smaller catchments, as detailed in the table.

Table 2-7: Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds stream order and stream length.

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Oro Creeks North			
Bluffs Creek	1st	33,102	43
	2nd	18,384	24
	3rd	19,328	25
	4th	4,968	6
	5th	1,377	2
	TOTALS	77,159	***100***

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
Mill Creek	1st	9,482	52
	2nd	7,974	44
	3rd	685	4
	TOTALS	***18,141***	***100***
Carthew Creek	1st	1,305	39
	2nd	2,016	61
	TOTALS	***3,320***	***100***
Cedarmount Creek	1st	655	23
	2nd	2,163	77
	TOTALS	***2,818***	***100***
Oro Creeks North	1st	2598	87
	2nd	372	13
	TOTALS	***2,970***	***100***
Pointview Creek	1st	1,424	79
	2nd	388	21
	TOTALS	***1,812***	***100***
Hawkestone Creek			
Hawkestone Creek	1st	33,234	45
	2nd	18,187	24
	3rd	9,130	12
	4th	13,945	19
	TOTALS	***74,496***	***100***
Maplewood Creek	1st	4,500	59
	2nd	391	5
	3rd	2,762	36
	TOTALS	***7,653***	***100***
Wriglew Creek	1st	3,634	57
	2nd	2,734	43
	TOTALS	***6,369***	***100***
Oro Creeks South			
Allingham Creek	1st	4,948	44
	2nd	5,355	47
	3rd	1,067	9
	TOTALS	***11,370***	***100***
Barillia Creek	1st	***2566***	100
	TOTALS	***11,370***	***100***
Bradens Creek	1st	1,007	51
	2nd	953	49
	TOTALS	***1,961***	***100***
Burls Creek	1st	5,720	61
	2nd	3,581	39
	TOTALS	***9,301***	***100***
Lakeview Creek	1st	1,754	31
	2nd	3,829	69
	TOTALS	***5,583***	***100***
Oro Creeks South	1st	1,583	94
	2nd	94	6

Creek	Stream Order	Length of Creek per Order (m)	% of Creek per Order
	TOTALS	***1,676***	***100***
Orolea Creek	1st	4,073	49
	2nd	1,481	18
	3rd	2,777	33
	TOTALS	***8,331***	***100***
Pemberton Creek	1st	1,558	65
	2nd	846	35
	TOTALS	***2,403***	***100***
Shanty Bay	1st	2,399	100
	TOTALS	***2,399***	***100***
Shelswells Creek	1st	22,142	46
	2nd	5,529	12
	3rd	7,739	16
	4th	11,724	25
	5th	620	1
	TOTALS	***47,753***	***100***
Simcoe Side Creek	1st	2,734	88
	2nd	362	12
	TOTALS	***3,096***	***100***

2.5.3.2 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 Hawkestone Creeks subwatershed is 27% greater than the average Lake Simcoe watershed drainage density (Table 2-8). This indicates greater relief and increased erosion compared to other subwatersheds of Lake Simcoe. The high drainage densities of the study area agrees well with the slope of the three major subwatersheds (Hawkestone, Shelswells and Bluffs Creeks). The high drainage density for the Hawkestone Creek subwatershed is primarily due to the numerous small reaches that converge in a large headwater wetland. Figure 2-22 illustrates the rapid change in topography in the Hawkestone Creek subwatershed just downstream of the aforementioned wetland complex. The direction of drainage changes from primarily north east along the top of the Oro Moraine to almost due east down the Moraine to Lake Simcoe. The drainage density of the Oro Creeks South subwatershed is 14% greater than the Lake Simcoe watershed average. Oro Creeks South is comprised of numerous small first and second order streams that primarily run due east down the moraine. The Oro Creeks North subwatershed is similar to the Lake Simcoe average drainage density despite having a similar average slope as the other Oro Creeks. This is likely the result of the altered drainage in the lower reaches of the Oro Creeks North subwatershed where the artificial elevation of Lake Simcoe may disturb the natural drainage during parts of the year.

Table 2-8: Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds' stream length, subwatershed area, and drainage density.

Creek	Stream Length (km)	Watershed Area (km^2)	Drainage Density (km/km^2)
Oro Creeks North	106	75.3	1.41
Hawkestone Creek	89	47.8	1.86
Oro Creeks South	96	57.4	1.67
*Lake Simcoe watershed average	3672.254	2515.891	1.46

**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.*

2.5.3.3 Elevation along watercourse

When there is a change in elevation, such as when water flows down from headwaters to receiving waters, energy is produced. Where there is greater fall (steeper slope) energy is gained and waters flow faster, picking up more sediment and having more force to erode banks. These can also be areas of unique fishery habitats where water is flowing quickly over shallow bedrock (riffles and rapids) that are used by some fish species such as brook trout (*Salvelinus fontinalis*), walleye (*Sander vitreus*), and longnose dace (*Rhinichthys cataractae*), as spawning grounds. Depending on the fall, it can also create a barrier to some aquatic species that are unable to swim against the force of the flow. Where the elevation levels out, the energy dissipates, releasing sediment and creating a slower flowing stream. These different processes help to alter the stream system over time. Stream profiles are shown below in relation to underlying surficial geology and features (discussed in Section 2.4.2) and only represent the main branch.

Figure 2-23 illustrates the stream profile of three of the major catchments in the study area (Shelswells Creek, Hawkestone Creek, and Bluffs Creek), from headwater elevation (length = 0) down to their outlets (elevation = 220). Average gradients for these systems are all very similar ranging from 0.62% to 0.60%.

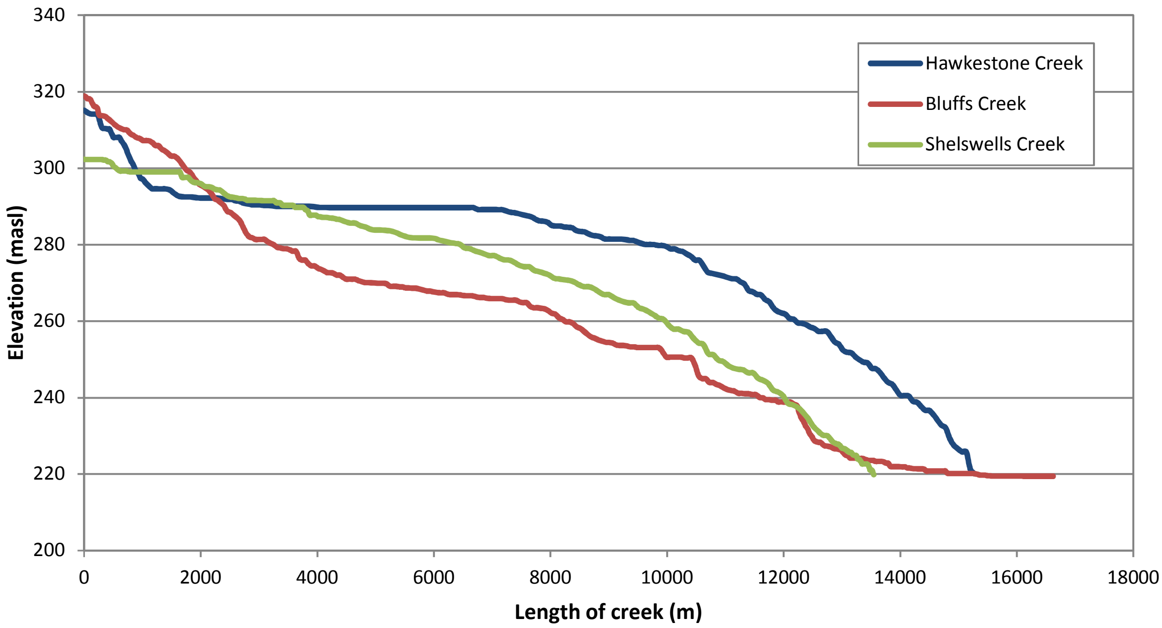


Figure 2-23 Stream profiles for Hawkestone Creek, Bluffs Creek, and Shelswells Creek

2.6 Climate and Climate Change

2.6.1 Current climate conditions and trends

The Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds lie within the Simcoe and Kawartha Lakes climatic region as defined by Brown *et al*. (1980). The climate within the City of Barrie and surrounding area is characterized by moderate winters, warm summers, and long growing seasons with usually reliable precipitation patterns. Variations in topography, prevailing winds, and proximity to Georgian Bay and Lake Simcoe lead to local differences in climate across the study area.

The Barrie Water Pollution Control Centre (WPCC) climate station is located just south of the study area. Climate data with varied periods of record from nine inactive stations also provided historic information. Table 2-9 displays a summary of the climate normals from 1971 to 2001 for the climate stations located within the City of Barrie and the surrounding municipalities (Figure 2-24). Based on the data collected at the Barrie WPCC station, the average mean annual temperature is 6.7°C, while the total mean annual precipitation is 938.5 mm/yr. It should be noted that precipitation patterns have become less predictable in recent years, perhaps due to climate change.

Long-term climate data was obtained from Environment Canada stations shown on Figure 2-24 including daily maximum and minimum temperature, daily rainfall and snowfall, and hourly rainfall for the period of 1950-2008. The data gaps were infilled using methods carried out according to the methodology outlined in “Filling gaps in meteorological data sets used for long-term watershed modelling” (H.O Schroeter, D.K. Boyd, and H.R. Whitely) by Schroeter & Associates in 2000. The record period for the Barrie WPCC (6110218) after the data infilling exercise was from 1950-2008.

Table 2-9: Climate normals (1971-2000) for stations in the study area (Earthfx, 2013a).

Station ID	Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
		Temperature (°C)												Average
6110557	Barrie WPCC	-8.1	-7.1	-2.2	5.3	12.3	17.7	20.5	19.5	14.9	8.5	2.4	-4.0	6.7
6111769	Coldwater-Warminster	-8.8	-7.8	-2.1	5.5	12.6	17.3	20.1	19.1	14.7	8.4	1.6	-4.5	6.3
6115099	Midhurst	-8.1	-7.6	-2.1	5.2	12.1	17.0	20.0	19.0	14.4	8.2	2.0	-4.5	6.3
6115820	Orillia TS	-8.4	-7.7	-2.1	5.7	12.9	17.1	20.6	19.4	14.8	8.2	2.2	-4.8	6.5
6117684	Shanty Bay	-8.2	-7.2	-1.9	5.5	12.2	17.1	19.9	19.1	14.6	8.5	2.3	-4.3	6.5
		Rainfall (mm/month)												mm/yr
6110557	Barrie WPCC	15.3	13.3	28.9	57.8	77.2	86.6	73.4	92.6	97.6	74.3	62.1	21.3	700.2
6111769	Coldwater-Warminster	21.8	14.8	32.2	55.5	75.7	85.2	84.2	93.2	96.1	81.3	62.1	25.2	727.2
6115099	Midhurst	9.5	14.7	31.2	55.0	66.8	73.9	78.6	88.9	97.8	78.1	61.2	24.3	679.9
6115820	Orillia TS	13.9	15.4	38.4	60.9	77.3	76.4	77.4	102.4	95.3	86.5	77.1	29.6	750.6
6117684	Shanty Bay	18.0	16.5	32.1	53.5	72.4	87.4	73.8	92.4	95.8	72.0	60.9	22.1	696.8
		Snowfall (cm/month)												cm/yr
6110557	Barrie WPCC	80.2	39.5	28.1	5.0	0.1	0	0	0	0	2.5	20.6	62.4	238.4
6111769	Coldwater-Warminster	93.4	54.7	34.7	13.5	1.2	0	0	0	0	6.0	40.2	75.1	318.8
6115099	Midhurst	66.6	37.4	25.3	7.2	0.7	0	0	0	0	4.0	26.3	60.6	228.0
6115820	Orillia TS	89.2	52.6	32.9	11.3	0.4	0	0	0	0	3.2	25.4	77.7	292.6
6117684	Shanty Bay	75.5	41.7	33	11.8	1.2	0	0	0	0	4.4	36.1	63.6	267.3
		Total precipitation (mm/month)												mm/yr
6110557	Barrie WPCC	95.4	52.8	57	62.9	77.3	86.6	73.4	92.6	97.6	76.8	82.6	83.7	938.5

Station ID	Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
6111769	Coldwater-Warminster	115.1	69.5	66.8	69.0	76.9	85.2	84.2	93.2	96.1	87.3	102.3	100.3	1046.0
6115099	Midhurst	76.1	52.1	56.5	62.2	67.5	73.9	78.6	88.9	97.8	82.1	87.4	84.9	907.9
6115820	Orillia TS	103.1	68.1	71.3	72.2	77.6	76.4	77.4	102.4	95.3	89.7	102.5	107.3	1043.0
6117684	Shanty Bay	93.5	58.3	65.1	65.2	73.6	87.4	73.8	92.4	95.8	76.4	97.0	85.7	964.1

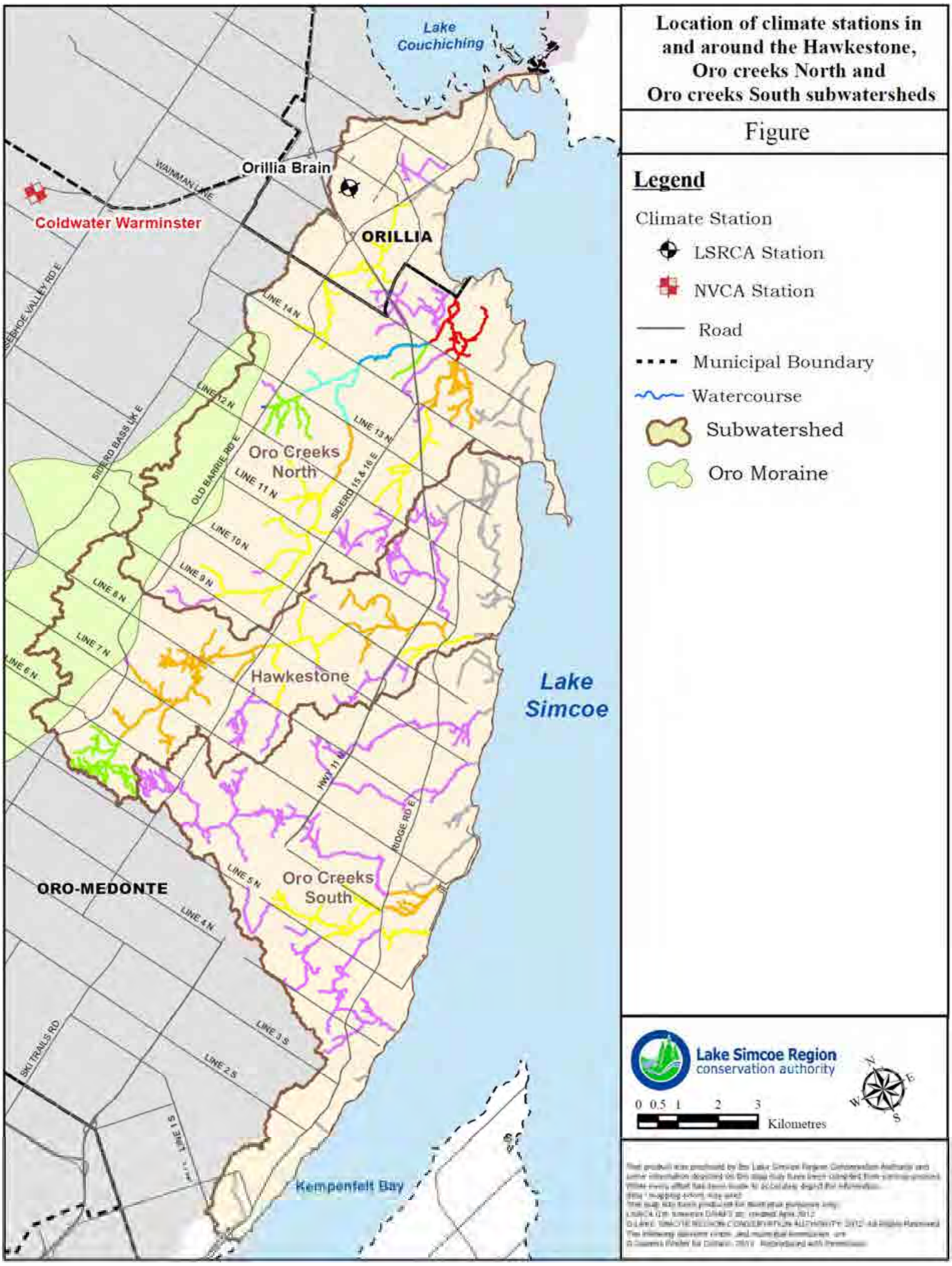


Figure 2-24: Location of climate stations in and around the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds (Earthfx, 2013a).

2.6.2 Temperature

To examine temperature trends for the past 60 years, the daily average air temperature was averaged for each year to produce Figure 2-25 to compare the average annual, average maximum annual, and average minimum annual air temperature. Figure 2-25 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.

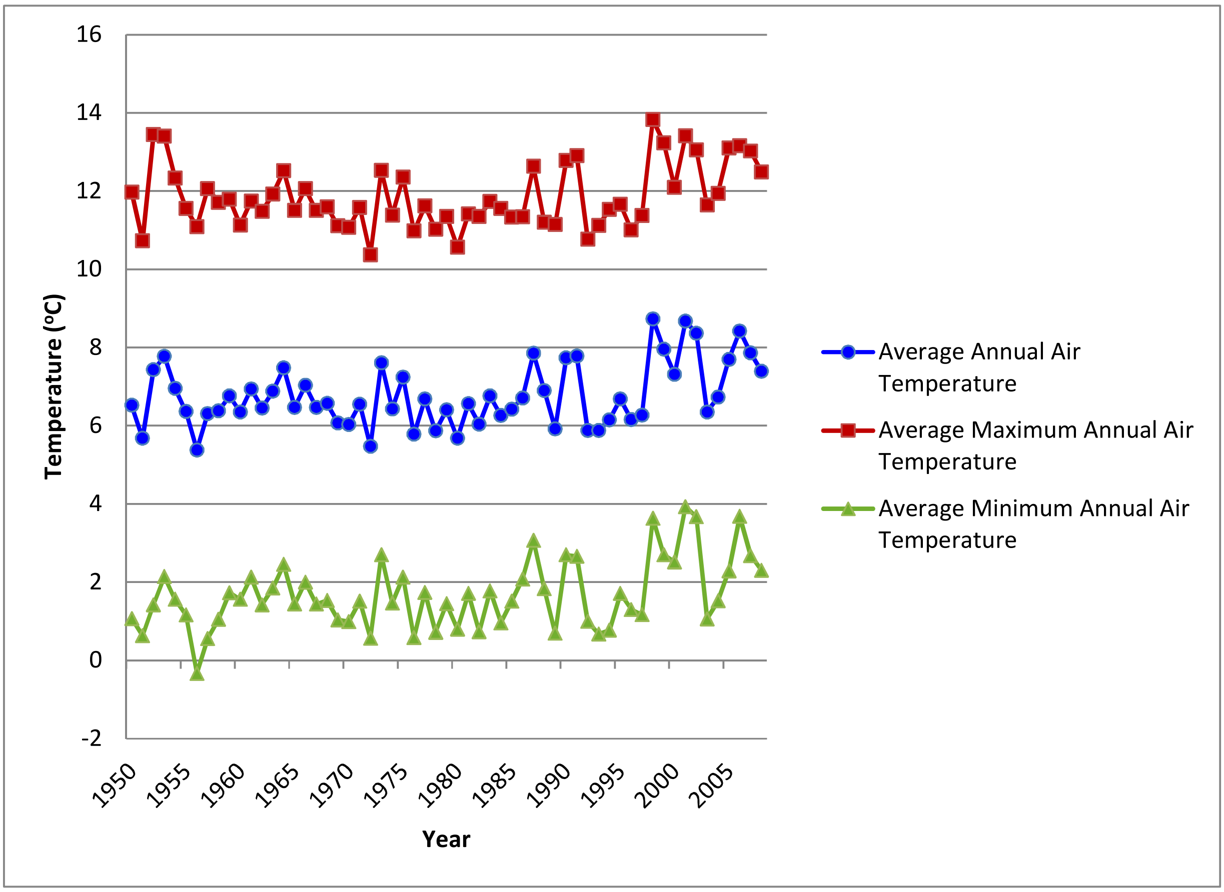


Figure 2-25: Comparison of the average annual, maximum and minimum temperatures at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

Figure 2-26 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.

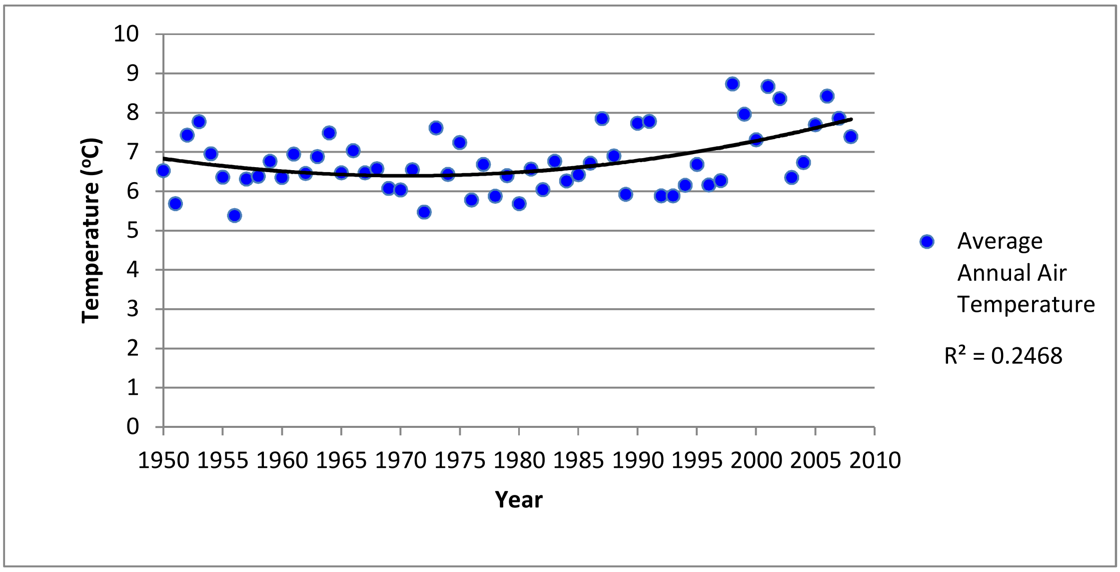


Figure 2-26: Average annual temperature at the Barrie WPCC Meteorological Monitoring Station (1950-2008). Source: SGBLS, 2012.

2.6.2.1 Precipitation

Precipitation is the driving force of the hydrological cycle, influencing aquatic and wetland habitats, as well as urban stormwater management needs.

The mean monthly rainfall, snowmelt, and precipitation measured at Barrie WPCC and other stations near the study from 1971-2000 are shown in Figure 2-27 to Figure 2-29 and shows the amount that fell as rain and the amount that fell as snow in each month. Fluctuations in the amount of precipitation, particularly winter precipitation, are somewhat expected at the Barrie WPCC meteorological station due to its close proximity to Lake Simcoe, causing lake effect precipitation events. Overall, there is no significant change in annual precipitation over the past 60 years, but a possible tendency to increasing precipitation since the 1980s. However, these data also show that annual average precipitation is fairly uniform across the three subwatersheds.

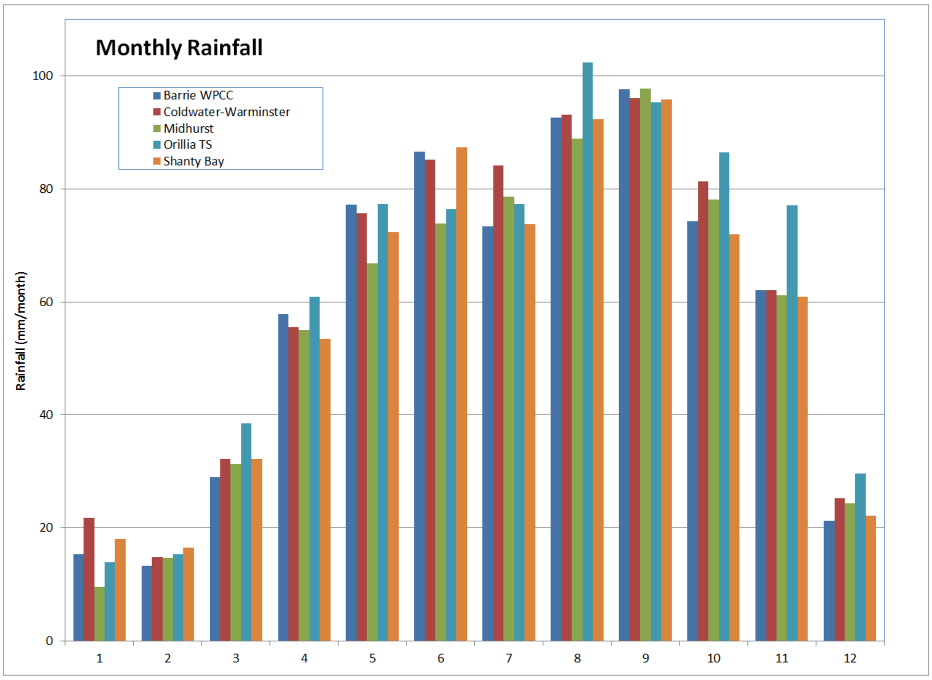


Figure 2-27: Monthly rainfall for stations in the study area (climate normals from Environment Canada [1971-2000]) (Earthfx, 2013a). *Note: Numbers 1-12 correspond to months of the year.*

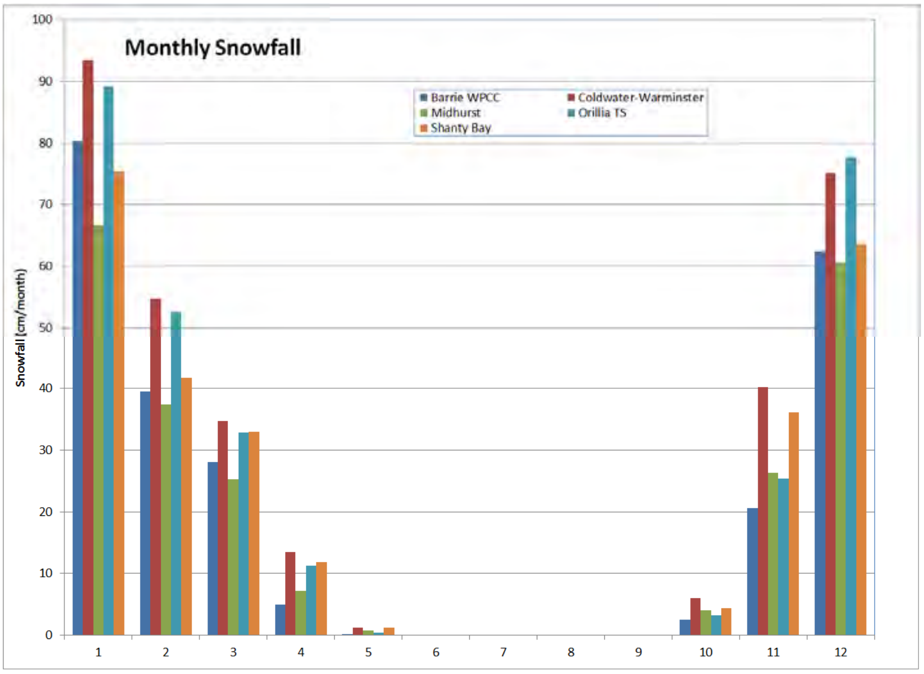


Figure 2-28: Monthly snowfall for stations in the study area (climate normals from Environment Canada [1971-2000]) (Earthfx, 2013a). *Note: Numbers 1-12 correspond to months of the year.*

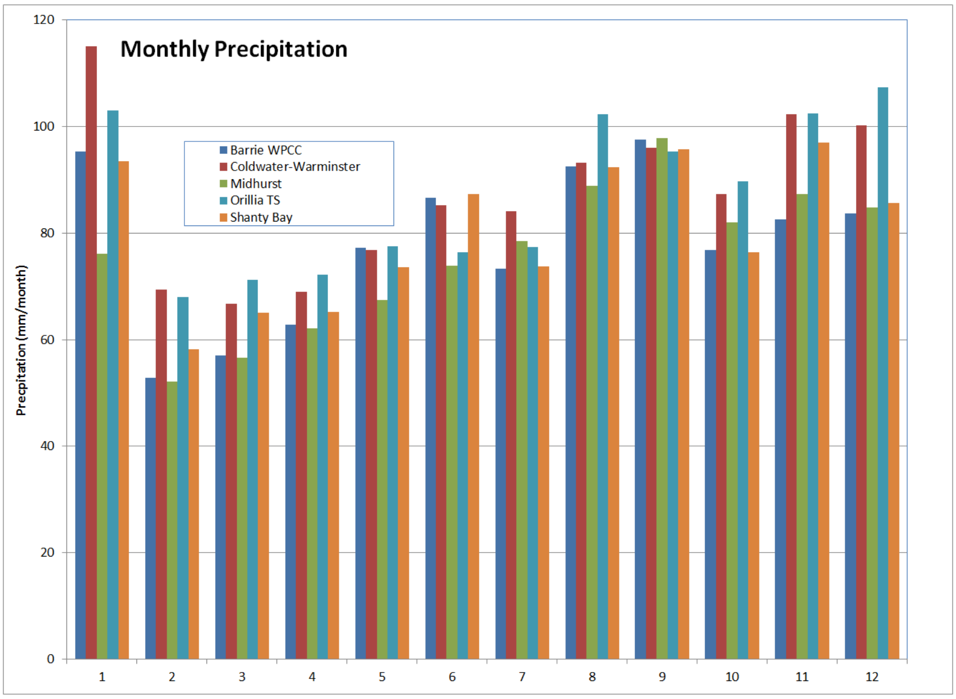


Figure 2-29: Monthly precipitation for stations in the study area (climate normals from Environment Canada [1971-2000]). *Note: Numbers 1-12 correspond to months of the year.*

2.6.2.2 Thermal Stability of Lake Simcoe

The thermal stability of the lake is important as it can have significant impacts on the biological communities within the lake, 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).

The first parameter studied was the temperature of Kempenfelt Bay during the ice-free period of the year. Figure 2-30 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

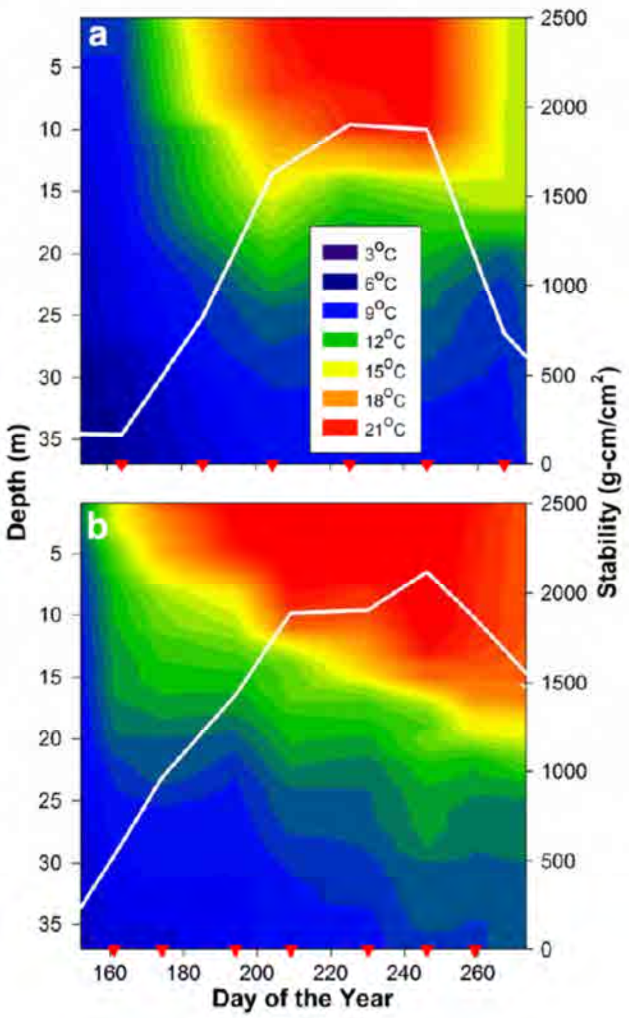


Figure 2-30: Seasonal water column temperature contour in degrees Celsius) and stability (white line) in Kempenfelt Bay in 1980 (a) and 2002 (b). Red triangles show the sampling dates along the x-axis. Source: Stainsby *et al.*, 2011.

(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 2-31 illustrates the timing of the onset of stratification in Kempenfelt Bay (Figure 2-31a) and the main basin (Figure 2-31b). 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 2-31a) than it was in 1980. In the main basin, stratification is occurring approximately 13 days earlier (Figure 2-31b).

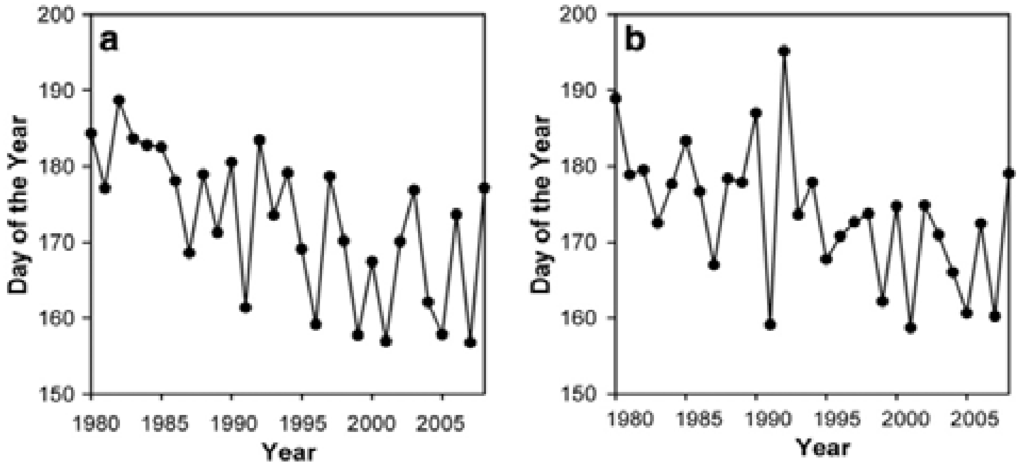


Figure 2-31: The timing of the onset of stratification in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

When looking at the fall turnover, Figure 2-32 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 (Figure 2-32a) and approximately 18 days later in the main basin (Figure 2-32b).

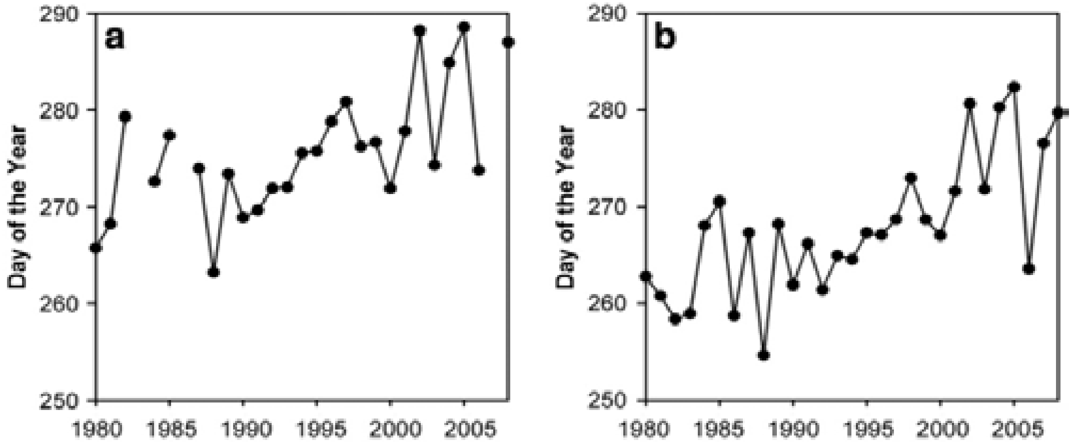


Figure 2-32: The timing of fall turnover in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

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, decrease in the fisheries, 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 2-33a and b).

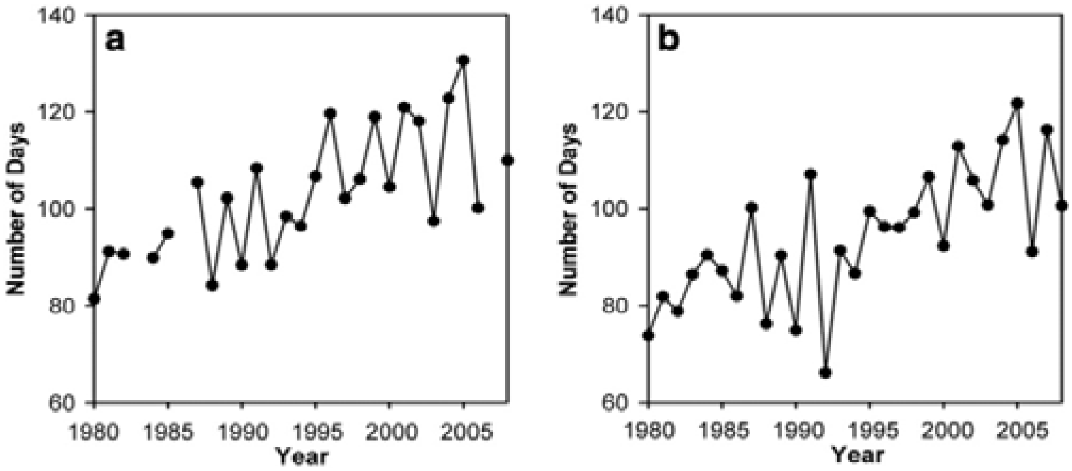


Figure 2-33: The length of the stratified period in (a) Kempenfelt Bay and (b) the main basin. Source: Stainsby *et al.*, 2011.

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, improvement of construction practices, as well as agricultural practices. Additionally, municipalities are encouraged to include climate change adaptation policies in the Official Plans, to plan for the future and implement pre-emptive measures.

2.6.3 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 (CCCSN, 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 2-10 lists the projected change in average annual and seasonal temperatures, comparing 1961-1990 to the 2050s. From it we can see under high GHG emissions there is a projected increase in temperature of 3° for the area. All seasons are expected to see at least a 2.2° temperature increase; however the most significant increase is seen during the winter, where there is a projected increase of 2.5-3.4° based on Low to High GHG emissions.

Table 2-10: Summary of projected change in average annual temperature (°C) in the 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in air temperature (°C)		
	GHG emmision 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 2-11 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 2-11: Summary of projected change in precipitation (%) in 2050s compared with 1961-1990 (CCCSN, 2009).

	Projected change in precipitation (%)		
	GHG emmision 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.

3 Water Quality– Surface and Groundwater

3.1 Introduction and background

The chemical, physical and microbiological characteristics of natural water make up an integrated index we define as “water quality”. Water quality is a function of both natural processes and anthropogenic impacts. For example, natural processes such as weathering of minerals and various kinds of erosion are two actions that can affect the quality of groundwater and surface water. There are also several types of anthropogenic influences, including point source and non-point sources of pollution. Point sources of pollution are direct inputs of contaminants to the surface water or groundwater system and include municipal and industrial wastewater discharges, ruptured underground storage tanks, and landfills. Non-point sources include, but are not exclusive to, agricultural drainage, urban runoff, land clearing, construction activity and land application of waste that typically travel to waterways through surface runoff and infiltration. 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 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 on 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.

3.2 Current Status

3.2.1 Measuring Groundwater Quality

Groundwater quality sampling was conducted by LSRCA in 2004, and then annually since 2007 at all 14 Provincial Groundwater Monitoring Network (PGMN) wells located throughout the Lake Simcoe watershed. Each sample is analyzed for 41 chemical parameters including metals, nutrients, and general chemistry. There are two PGMN wells in the study area, screened at different depths but at the same location, within the Hawkestone Creek subwatershed (Figure 3-1). The intermediate depth well is screened at a depth of 18.4 m, while the deep well is screened at a depth of 26.8 m.

Much work around the protection of drinking water sources, from both surface and groundwater sources, has been done through the *Clean Water Act, 2006* Source Protection Program. As a requirement of the *Clean Water Act, 2006*, Source Water Protection Authorities are required to determine the vulnerability of aquifers to water quality stressors and identify potential threats to drinking water supply. Results of this vulnerability and threats assessment are presented in the Lake Simcoe and Couchiching-Black River Source Protection Area, Part 1: Lake Simcoe Assessment Report (SGBLS, 2011). This report discusses the three types of vulnerable areas associated with aquifers, these being: (1) Well Head Protection Areas (WHPA); (2) Significant Ground Water Recharge Areas (SGRA); and (3) Highly Vulnerable Aquifers (HVA).

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 municipal supply well. The locations of the WHPAs within the Oro Creeks and Hawkestone Creek subwatersheds can be found in **Chapter 2, Study Area and Physical Setting**.

3.2.2 Measuring Surface Water Quality and Water Quality Standards

Water quality is currently sampled at one station on Hawkestone Creek under the the Provincial Water Quality Monitoring Network (PWQMN) and the Lake Simcoe Protection Plan (LSPP); sampling at this station was initiated in 1993 under the LSEMS program, now referred to as the LSPP, and sampling under the PWQMN started in 2002. A second station has been sampled since 2008 under the Lake Simcoe Protection Plan (LSPP) on Bluff's Creek in the Oro Creeks North subwatershed (Figure 3-1). Samples under the PWQMN program are collected eight times a year on a monthly basis during the ice-free period and analyzed for 32 chemical parameters. Samples collected under the LSPP are analyzed for 12 parameters and are collected year round, every three weeks in the winter months (December to March) and every two weeks from April to November. Samples from both these programs are analyzed in the Laboratory Services Branch of the Ministry of Environment, and are assessed against the Provincial Water Quality Objectives (PWQO) (Ministry of Environment, 1994). As stated by the Ministry of Environment, the goal of the PWQO is to protect and preserve aquatic life and to protect the recreational potential of surface waters within the province of Ontario. 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 (Environment Canada, 2003). The CWQG were developed by the Environmental Quality Branch of Environment Canada to protect aquatic species by establishing acceptable levels for substances that affect water quality and are based on toxicity data for the most sensitive species found in streams and lakes of Canada. Characteristics for some of the water quality variables of greatest concern for the Oro Creeks and Hawkestone Creek subwatersheds are summarized in Table 3-1.

3.2.2.1 Spot check samples

LSRCA also took a series of ‘spot check’ samples at seven locations throughout the study area in order to provide a snapshot of the water quality of tributaries in the area (this was in addition to regularly completed sampling). At each site a sample was collected on a day after a dry period of little to no rain. Another sample was collected at each site after a wet period of several rain events. The sites were at separate tributaries flowing into Lake Simcoe, or were on separate branches of a larger tributary. These samples were analyzed at Maxxam Analytics, and evaluated against the same objectives as the PWQMN and LSPP samples.

3.2.2.2 Kitchener Street Waste Diversion site sampling

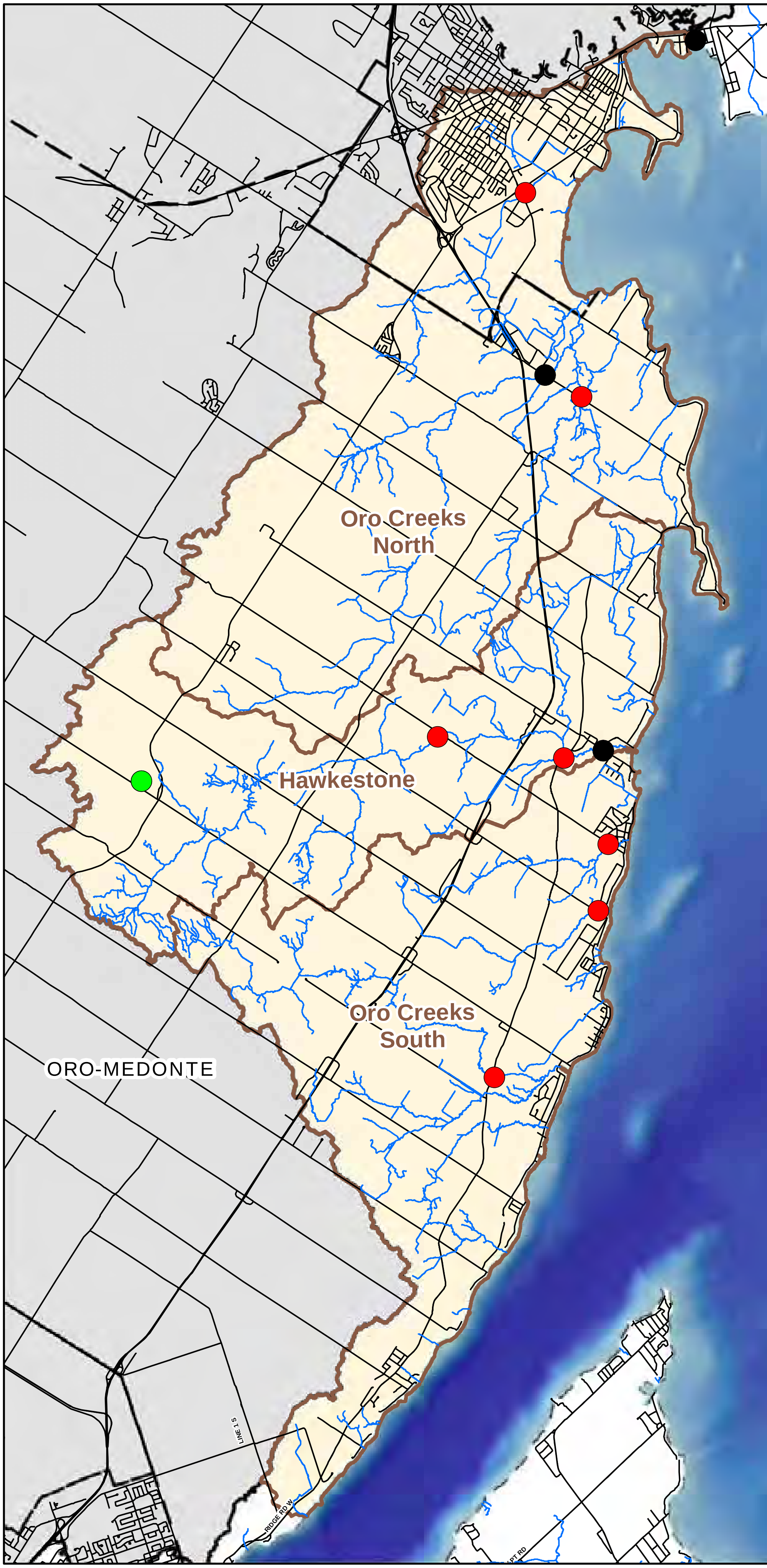
Because areas within the City of Orillia fall outside of the jurisdiction of the LSRCA, there is little monitoring data available for the watercourses within the City, aside from the spot-check samples discussed above. There are, however, data available for a number of parameters for some of the watercourses located in the vicinity of the Kitchener Street Waste Diversion Site (which is owned and operated by the City), through monitoring undertaken by Golder and Associates as part of the permit for the waste diversion site. This site is bounded by Highway 12 to the north, the CN Rail Trail to the west (this trail lies just east of Memorial Avenue), the Waste Water Treatment Plant to the east, and Lake Simcoe’s Shingle Bay to the south. The City of Orillia has provided Golder and Associates’ 2011 Annual Monitoring Report as supplemental information for this subwatershed plan. While this monitoring is undertaken primarily to assess any impacts of the waste diversion facility, it does provide some insight into background concentrations that are found in some of the watercourses that lie upstream of the site, as well as what is being discharged into the lake from the watercourses that are sampled. Surface water sampling was completed at 19 locations, including two on Mill Creek, seven on Ben’s ditch and one at the mouth of Ben’s ditch, two at culverts crossing beneath a former CN rail bed, and six on Lake Simcoe.

Table 3-1: A summary of surface water quality variables and their potential effects and sources

Variable	Effects	Sources	Objective/Guideline
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 lawn and garden fertilizers, animal wastes, eroded soil particles and sanitary sewage.	Interim PWQO: 0.03 mg/L to prevent excessive plant growth in rivers and streams.
Total Suspended Solids (TSS)	Elevated concentrations reduce water clarity which 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, coarse rock and gravel spawning and nursery areas become coated with fine particles, limiting the ecological function of these important areas. Many pollutants are readily adsorbed and transported 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 (approx 5 mg/L) for short term (<25 hr) exposures. EPA (1973) and European Inland Fisheries Advisory Commission (1965): no harmful effects on fisheries below 25 mg/L
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 (draft June 2010): CWQG for protection of freshwater aquatic life is 120 mg/L for chronic (long-term) exposure and the benchmark concentration is 640 mg/L for acute (short-term) exposure.
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, wind-blown dusts, roof runoff and road surface materials	PWQOs: Copper: 5 µg/L Zinc: 20 µg/L Lead: 5 µg/L Iron: 300 µg/L

Water quality monitoring sites in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 3-1



Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Monitoring Stations

Ground Water (PGMN)

Water Quality Stations (PWQMN)

Water Quality Stations (LSPP)

Oro Ramara Spot Checks

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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 created December 2013.

3.2.2.3 Temperature Collection

The MNR/DFO protocol ("*A Simple Method to Determine the Thermal Stability of Southern Ontario Trout Streams*" (Stoneman, C.L. and M.L. Jones, 1996), Figure 5-1 in Chapter 5, Aquatic Habitat) 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 from the various stream locations, the data is downloaded and 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 5: Aquatic Habitat**, for a 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.

Temperature monitoring has been undertaken at several locations throughout the study area. Oro Creeks North has two temperature monitoring sites: Mill Creek was monitored in 2005 and 2006, and Bluff's Creek has been monitored annually since 2005. There have been a number of sites in the Hawkestone Creek subwatershed since 2004. In Oro Creeks South, temperature monitoring was conducted on the Allingham Creek tributary in 2004. While this has been sufficient for increasing our understanding of where coldwater systems are found in the subwatershed, it is difficult at this point to see any trends or patterns in the data for most sites. 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.

3.2.2.4 Beach Monitoring

Public beaches in the City of Orillia and Township of Oro-Medonte are monitored every year, from June until the end of August, to ensure that the water is safe for swimmers (in terms of bacteria). Typically, a there is a minimum of five sampling sites at each beach that are spread out to be representative of the whole beach area. Samples are normally taken once a week, but additional samples will be taken under certain conditions. Samples are sent to the Provincial Laboratory and analyzed for *E. coli* bacteria (a key indicator of fecal pollution). Other parameters are not tested for unless deemed necessary. Additional data that is recorded at the time of sampling include weather conditions, whether there was rain in the previous two days, wind direction, degree of wave action, number of bathers, number of waterfowl and/or animals in the area, and clarity of the water (Simcoe Muskoka District Health Unit, 2011).

3.2.3 Groundwater Quality Status

Samples at the two PGMN wells located within the Hawkestone Creek subwatershed have not shown any issues at this location. Concentrations of two common parameters of concern, chloride and nitrite + nitrate (the combination of two commonly found forms of nitrogen) are both well below guideline values at both depths. While chloride can naturally be found in groundwater, elevated concentrations are typically an indication of winter salt use; while elevated concentrations of nitrate+nitrate generally indicate an influence from agricultural land uses or septic systems. Drinking water guidelines are commonly applied in looking at groundwater samples; a comparison of the average concentrations found in these wells with the applicable guidelines is shown in Table 3-2:

Table 3-2: Comparison of measured concentrations of chloride and nitrite + nitrate with their respective guidelines at the Provincial Groundwater Quality Monitoring Network stations located in Oro

Parameter	Canadian Drinking Water Guideline (mg/L)	Oro-intermediate well (average concentration, mg/L)	Oro-deep well (average concentration, mg/L)
Chloride	250	2	5
Nitrite + Nitrate	10	0.66	0.77

Through the Source Water Protection initiative, Well Head Protection Areas (WHPAs) and Intake Protection Zones (IPZs) have been delineated for all of the municipal drinking water supplies (surface and ground water) in the South Georgian Bay-Lake Simcoe Source Protection Region. A number of municipal wells are found within the Township of Oro-Medonte, several of which are located within the Lake Simcoe watershed. These include the Canterbury Subdivision, Cedar Brook Subdivision, Harbourwood Estates, Maplewood Estates, and Shanty Bay Well Supplies. While a part of the City of Orillia also falls within the study area, its surface water intake and municipal wells fall outside of the Lake Simcoe watershed, and are thus not included in this subwatershed plan.

WHPAs have been delineated for all of the municipal groundwater supplies within the Township of Oro-Medonte. An assessment of potential Significant Drinking Water Threats, Issues and Conditions was undertaken within each WHPA. A number of potential significant threats were identified within each of the WHPAs, these mainly related to the residential use of private individual septic systems, the storage of fuel for home heating purposes, the application of agricultural source material, non-agricultural source material, and pesticide to land, and the use of land as livestock grazing, pasturing, or outdoor confinement and farm animal yards (SGBLS, 2011). No drinking water issue(s) or conditions were identified within the Township of Oro-Medonte (SGBLS, 2011).

For more in-depth information on the drinking water systems in these subwatersheds, see the Lakes Simcoe and Couchiching – Black River Source Protection Area, Part 1: Lake Simcoe Watershed Assessment Report (SGBLS, 2011). Individual studies completed by consultants on the water quality of the drinking water sources are available in the Assessment Report's Appendix OM.

3.2.4 Surface Water Quality Status

While its period of record is not as long as that of some Lake Simcoe stations, data for the Hawkestone Creek sampling site do allow for current conditions and trends to be compared to historical data to examine changes in water quality over time. Key parameters for the station over the period of record show historic water quality to be extremely good, with the vast majority of samples meeting the relevant water quality guidelines (Table 3-3). The data only supported analysis of the long term trends for two parameters: chloride, which was found to be increasing, and phosphorus, which was not showing a significant trend.

Current conditions (2007-2011), as shown in Table 3-4, show that the majority of samples at Hawkestone continue to meet the relevant guidelines, with slightly lower percentages of samples meeting guidelines for phosphorus, TSS, iron, and copper during this period than for the entire period of record. In addition, there is sufficient data to calculate trends for a more current period of record (2002-2011 for TSS; 2000-2011 for chloride and phosphorus). None of these parameters is showing a significant trend in the current data set.

Due to the fact that a large proportion of the metals data set falls below the laboratory analytical detection limit, trend analysis could not be performed on any metals data set. The majority of metals concentrations are below the relevant guideline indicating that, at this time, metals concentrations in the Lake Simcoe tributaries are not impacting the aquatic system.

Table 3-3: Historic surface water quality conditions for Hawkestone Creek compared to other tributaries within the Lake Simcoe watershed.

Monitoring Station	Historic Conditions (Entire Station Record) Percentage of samples that meet objectives: Orange = median Concentration ≥objective Green = median Concentration <objective							Historical Trends[1] Analysis (entire station record)[+] Orange = Increasing Grey = no significant trend Green = Decreasing		
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	TSS
West Holland River (1965 – 2011)	97	3	93	82	53	97	85			
Tannery Creek (1965 – 2011)	61	9	85	52	36	77	73			N/D
Mt. Albert Creek (1971 – 2011)	100	9	100	89	61	99	89			N/D
Beaver River (1972-2011)	100	63	99	94	91	98	86			
Pefferlaw Brook[++] (1973-2011)	100	50	100	97	89	98	85			
Lovers Creek (1974-2011)	87	76	100	90	83	96	83			
Schomberg River (1977-2011)	100	7	97	67	38	97	76			
Maskinonge River (1985-2011)	93	14	100	93	33	93	91			
East Holland River (1993-2011)	38	1	100	45	7	90	81			N/D
Black River (1993-2011)	99	39	100	100	69	99	99			N/D
Hawkestone Creek (1993-2011)	100	89	100	96	91	100	99			N/D
Kettleby Creek (1993-2011)	100	54	100	80	N/D					N/D
North Schomberg River (1993-2011)	32	25	51	79	N/D					N/D
Talbot River (1993-2011)	100	84	100	98	N/D			N/D		N/D
Whites Creek (1994-2011)	100	69	98	97	N/D					N/D
Uxbridge Brook (2002-2011)	100	29	99	93	76	99	99	N/D	N/D	N/D
Objective	120 mg/L	0.03mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L			

Note: Monitoring of zinc and copper generally started in the early 1980s. There were no data for metals where stations were monitored under the LSSP program but not PWQMN (Kettleby, North Schomberg, Talbot and Whites).

[1]Trends for nitrate required further analysis, and will be included in an update to this section

[+]Where trends were not listed for TSS or iron for stations with early monitoring (60s or 70s), either monitoring for those parameters started after 2000 or there were large gaps in the data (>10 years). For stations monitored starting 1993, nitrate, TSS and metals were not monitored until after 2000.

[++]Chloride started in 1993 for Pefferlaw.

Table 3-4: Current water quality conditions for Hawkestone Creek compared to other tributaries within the Lake Simcoe watershed

Monitoring Station	Current Conditions (2007 – 2011) Percentage of samples that meet objectives Orange = median Concentration ≥objective Green = median Concentration < objective							Current Condition Trend Analysis (2002-2011)[1] Orange = Increasing Grey = no significant trend Green = Decreasing		
	Chloride	Phosphorus	Nitrate	TSS	Iron	Zinc	Copper	Chloride	Phosphorus	TSS
West Holland River*	92	6	98	91	75	100	92			
Tannery Creek	50	8	100	63	26	95	87			
Mt. Albert Creek	100	16	100	79	49	100	95			
Beaver River*	100	71	98	94	87	97	100			
Pefferlaw River*	100	50	100	96	84	100	97			
Lovers Creek*	61	62	100	86	66	100	97			
Schomberg River	99	19	99	78	32	100	95			
Maskinonge River**	91	5	100	94	9	97	82			
East Holland River*	22	3	100	45	3	89	74			
Black River*	99	34	100	99	66	100	100			
Hawkestone Creek*	100	84	100	96	87	100	97			
Kettleby Creek[+]	100	66	100	80	N/D					N/D
North Schomberg River[+]	34	36	56	79	N/D					N/D
Talbot River***[+]	100	90	100	98	N/D					N/D
Whites Creek[+]	99	71	98	97	N/D					N/D
Uxbridge Brook	100	24	100	89	68	97	97			
Objective	120 mg/L	0.03mg/L	2.9 mg/L	30 mg/L	300 µg/L	20 µg/L	5 µg/L			

[1] Trends for nitrate required further analysis, and will be included in an update to this section
* Chloride and phosphorus trends for this station are 2000 to 2011
** All trends for this station are 2003-2011
*** All trends for this station are 2006-2011
[+] TSS for this station is 2008-2011

An additional station was recently initiated (2008) in Bluff's Creek, in the Oro Creeks North subwatershed. While the period of record for this station is short, it has thus far shown healthy water quality conditions for key parameters (Table 3-5), with only 12 percent of samples not meeting the provincial water quality objective for phosphorus and only six percent not meeting the objective for TSS. All of the samples for chloride and nitrate met the relevant objectives. As can be seen from the table, this station does very well in comparison with other stations that were initiated at the same time.

Table 3-5: Current water quality conditions for Bluff's and Hawkestone Creek compared to other tributaries where monitoring has more recently started within the Lake Simcoe watershed (2008-2011)

Monitoring Station	Current Conditions (2008-2011). Percentage of samples that meet objectives Orange = median concentration ≥ objective Green = median concentration < objective			
	Chloride	Phosphorus	Nitrate	TSS
Bluffs Creek	100	88	100	94
Hawkestone Creek	100	84	100	96
Hewitts Creek	87	53	80	86
Hotchkiss Creek	9	56	98	84
Leonards Creek	98	56	100	92
Ramara Drain*	100	37	100	90
Objective	120 mg/L	0.03 mg/L	2.9 mg/L	30 mg/L

*Data for Ramara started 2009

3.2.4.1 Phosphorus

Reading & Interpreting Box Plots

A box plot presents a data set in graphical form. The shaded portion of the box represents the middle 50% of the data set showing where the majority of the values fall and the spread of the data. The line in the box is the median (50th percentile) of the data set. The whiskers show the lower and upper quartiles of the data set. The points above and below the whiskers represent outliers in the data set at the 5th and 95th percentile. A red line has also been included to highlight the applicable guideline for the parameter.

While the period of record for water quality sampling is not overly long, it is possible to discern some trends. As can be seen in Figure 3-2, after generally displaying a slightly decreasing trend for the period from 1993 to 2005, phosphorus concentrations are now showing an increasing trend. While the median concentration remains below the PWQO, the upper quartile of the data is now showing levels above the PWQO, whereas in the previous ten-year period the majority of the data fell below the objective. It will be important to undertake work to ensure that concentrations do not rise to a point that they are affecting aquatic life. It is, however, important to note that phosphorus loads from the Hawkestone Creek subwatershed account for less than 1% of the total load to the lake (this is discussed further in the Stressors section of this chapter). Again, the causes of this increasing trend are not well understood at this point, but further investigation could help to identify sources and possible measures for preventing and/or reversing these increases.

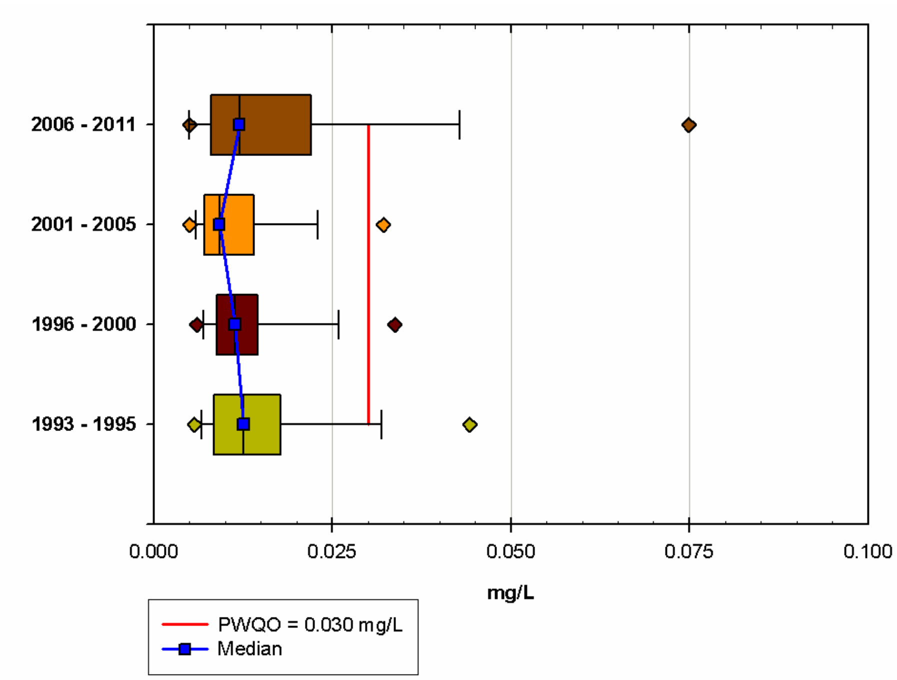


Figure 3-2: Hawkestone Creek phosphorus concentrations 1993-2011 (mg/L).

There is not yet a long enough period of record for the Bluff's Creek water quality site to compare periods of data in a box plot and determine trends; however, the data collected for the period from 2008-2011 was plotted along with the same period for the Hawkestone Creek station for comparison. As demonstrated in Figure 3-3, the Bluff's Creek station displays even lower concentrations of phosphorus than the Hawkestone Creek station, with the median concentration at less than half of the objective. The upper quartile of the data does show some concentrations in exceedance of the guideline. Protecting existing natual areas and undertaking BMPs will help to ensure that the majority of samples continue to meet the objective in this catchment.

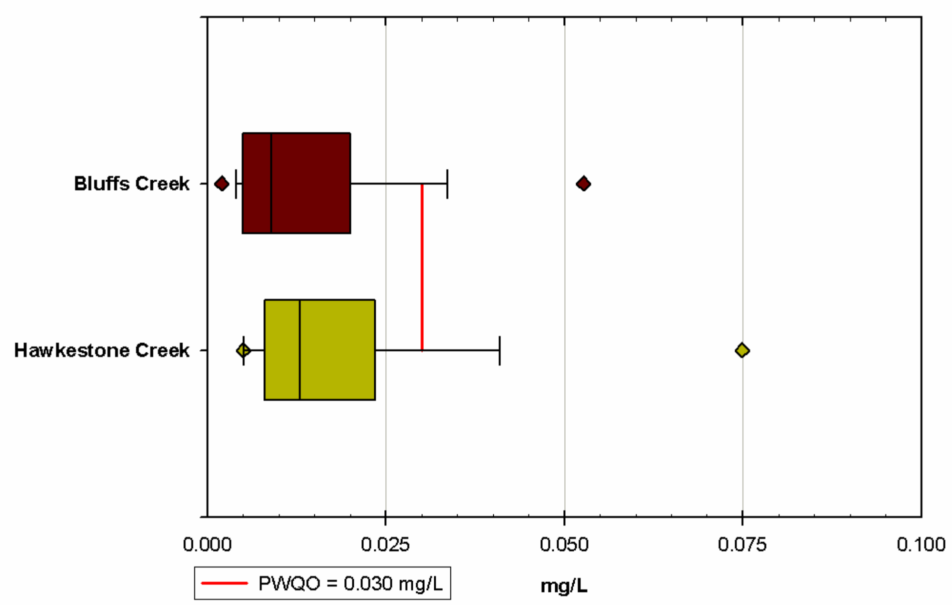


Figure 3-3: Hawkestone and Bluff's Creek phosphorus concentrations 2008-2011 (mg/L).

3.2.4.2 Chloride

The *Canadian Environmental Protection Act* has defined winter salt containing chloride as toxic (2001). This was based on research that found that the large amount of winter salt being used can negatively impact ground and surface water, vegetation, and wildlife. While elevated chloride levels are primarily found around urban centres, 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 (MOE, 2011) as well as in Lake Simcoe (Eimers and Winter, 2005).

Chloride concentrations at the Hawkestone Creek sampling site meet the Canadian Water Quality Guidelines 100% of the time, with even the highest outlier sample at less than half of the guideline concentration (Figure 3-4). The long term data (1993-2011) show an increasing trend for chloride concentrations at this station (Table 3-3); while the shorter term data (2000-2011 (Table 3-4) display no trend, as the median concentration for the 2006-2011 period showed a decrease. These data, however, may not be representative of the highest concentrations seen at the Hawkestone Station, as sampling under the Provincial Water Quality Monitoring Network has not been undertaken during the winter months. Given that the urban area is anticipated to increase by 4%, 1.2%, and 7.9% in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds (Louis Berger Group, Inc., 2010), respectively, in the coming years, and through looking at recent trends in nearby subwatersheds, it is likely that chloride concentrations will continue to rise in the study area. It will be important to undertake efforts to manage the use and storage of road salt in order to prevent impacts to the aquatic community in these subwatersheds, as well as in Lake Simcoe itself.

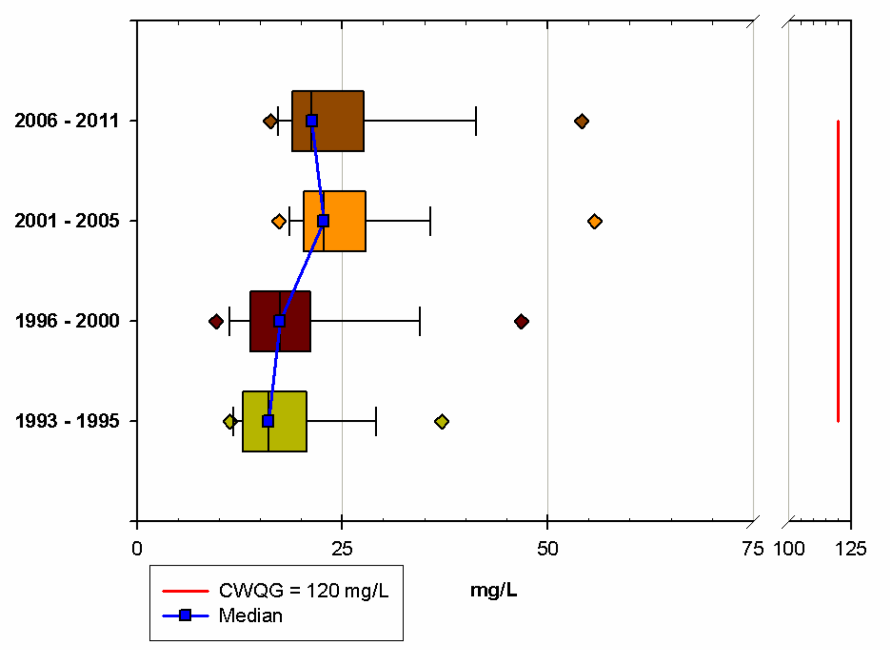


Figure 3-4: Hawkestone Creek chloride concentrations 1993-2011 (mg/L)

Figure 3-5 shows that the chloride concentrations for the period of record at the Bluff's Creek station are even lower than those at the Hawkestone Creek station. While this station is found near the community of Forest Home in Oro-Medonte, the land use around the station has very high levels of natural cover, which may protect the watercourse from water quality impacts, including increased concentrations of chloride.

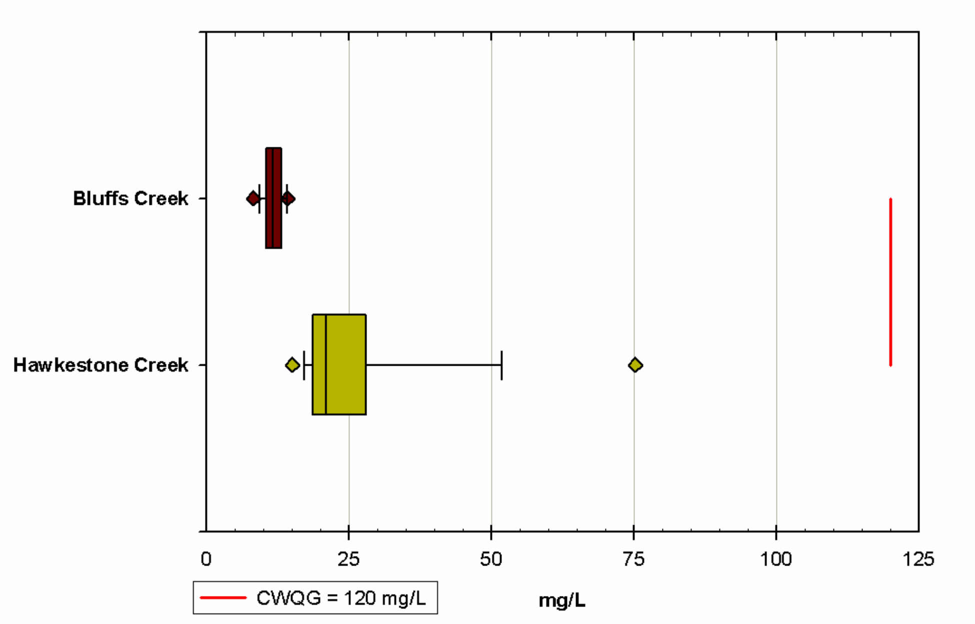


Figure 3-5: Hawkestone and Bluff's Creek chloride concentrations 2008-2011 (mg/L).

3.2.4.3 Total Suspended Solids

Total suspended solids (TSS) is a measure of the material in suspension in the water column. This is an important measure because, as outlined in Table 3-1, 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 will also have negative impacts on fish and benthic organisms.

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. Water quality sampling conducted during predominantly dry weather conditions will usually indicate a lower occurrence of TSS exceedances.

The Canadian Council of Ministers of the Environment (CCME) has set an interim guideline for TSS of 30 mg/L (CCME, 2001). Figure 3-6 illustrates that TSS is not an issue at the Hawkestone Creek station, with the median concentration falling well below the CWQG throughout the period of record. While the 2009 – 2011 period shows a greater spread in the data than in the previous period, this has not been enough to influence the trend, which has remained stable.

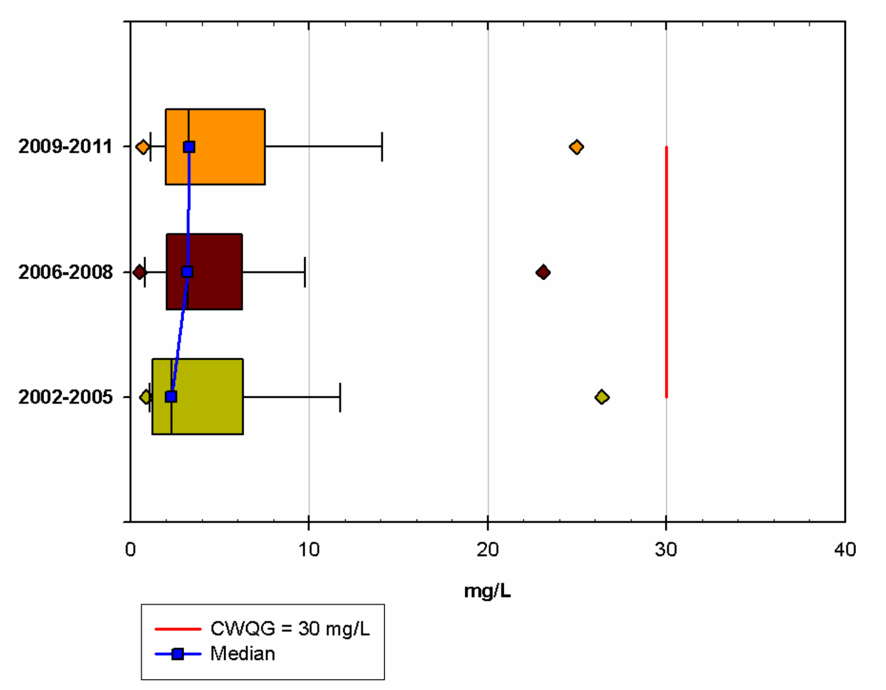


Figure 3-6: Hawkestone Creek total suspended solids concentrations 1993-2011 (mg/L).

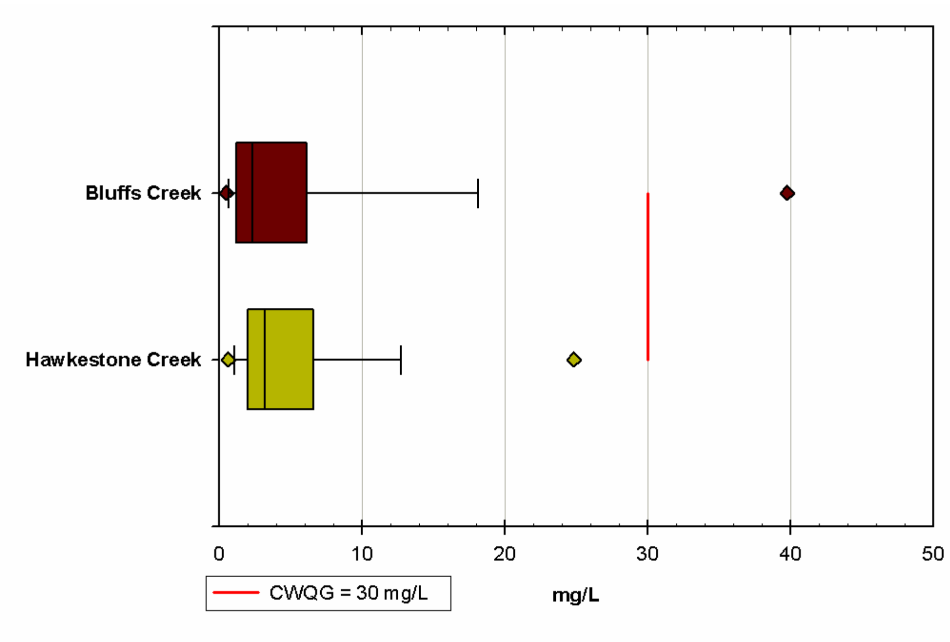


Figure 3-7: Hawkestone and Bluff's Creek total suspended solids concentrations 2008-2011 (mg/L).

Total suspended solids data from 2008 to 2011 for Hawkestone Creek and the more recently initiated Bluff's Creek station show that the sample with the highest concentration of TSS during this time period was Bluff's Creek, but also shows that the mean TSS concentration for the Bluff's Creek station is lower than that of the Hawkestone Creek station, with the mean concentration for both stations being well below the CWQG of 30 mg/L (Figure 3-7). The Bluff's

Creek station shows a wider spread to the data, perhaps indicating that while background levels are lower, that sediment is more likely to be mobilized by a precipitation or snow melt event, with these events sometimes being captured by monitoring crews. More information will be needed before any definitive conclusions regarding the sources of sediment in this system can be made; however, it is clear that TSS is generally not an issue at these stations.

3.2.4.4 Spot Check Data

Out of the 14 samples taken in the spring and early summer of 2012, four had total phosphorus concentrations that exceeded the PWQO (0.030 mg/L). These elevated concentrations were between 0.087 and 0.10 mg/L. These occurred on the “dry condition” sample day at four different stations. One of these stations was in the Oro Creeks South subwatershed, one in Hawkestone Creek, and two were in Oro Creeks North.

One of the Oro North stations was in Orillia and road construction was noted near the sampling site, producing soil disturbance and excess dust (especially during this very dry period). These factors likely contributed to high phosphorus levels there. It is not presently known why the other three stations had high concentrations on the low flow day. Possible explanations are construction, wind blown deposition, or a point source upstream.

The phosphorus concentrations at all sites were below the PWQO for the “wet condition” samples. At the beginning of a rain event phosphorus concentrations typically increase as built-up dust and debris is carried over non-porous areas such as roads and as sediment is eroded from stream banks. But once the water levels are receding, much of the available phosphorus has already moved through the system. The samples were likely collected once the flow was already receding. This would explain why the concentrations were low for the “wet condition” samples. Another possible reason is that high concentrations contributed from a point source in low flow conditions may become diluted during high flow conditions.

Samples were also analyzed for chloride, nitrogen, metals, and dissolved organic carbon. The measurement of physical parameters including dissolved oxygen, pH and water temperature showed normal summer levels. Iron was the only other chemical parameter that was above the PWQO, and this occurred only at the Orillia site. The source of this iron is not currently known.

These spot samplings provide a snapshot of the tributaries, but more samples would be required to better understand the status of the water quality of these tributaries.

3.2.4.5 Kitchener Street Waste Diversion site sampling

In their 2011 Annual Report, Golder breaks down the monitoring results by geographic area around the waste diversion site. More detailed discussion and a breakdown of the monitoring results discussed below can be found in Golder’s report (Golder and Associates, 2012).

Ben’s Ditch North of Highway 12

Sampling in Ben’s ditch, north of Highway 12, depicts conditions upstream of the waste diversion site, and thus shows impacts from land uses off the site and upstream of the influence of the highway. These four sites showed exceedances of phosphorus, with the average concentration at all sites over the PWQO; chloride, with some samples (taken in summer, so likely not an indication of the highest levels that would be seen in winter) doubling and even tripling the CWQG chronic effects level; copper, which showed exceedances at two of the sites; and iron and zinc, which had samples exceeding the PWQO at three of the sites.

Ben's Ditch and the Waste Water Treatment Centre outfall

Three stations are monitored in this area, one at the Waste Water Treatment Centre (WWTC) outfall, one just downstream of the outfall, and one upstream of the WWTC which monitors runoff from the Snow Disposal Area located nearby. All three sites showed elevated sodium and chloride concentrations, and there were also elevated nutrient concentrations, particularly at and downstream of the WWTC outfall (although the average concentration even at the station upstream of the WWTC still exceeds the PWQO).

Downstream of these sites, Ben's Ditch flows to the east before discharging to Lake Simcoe. There are two monitoring stations located here, one in Ben's ditch and one at the outflow. Both stations show exceedances of phosphorus, with the average concentration at 0.05 mg/L and 0.06 mg/L at the station in Ben's Ditch and the discharge to the lake, respectively. Chloride concentrations are also elevated at these sites.

Mill Creek Diversion

There are two monitoring stations on the Mill Creek Diversion, located to the north of the waste diversion site. There were some exceedances of phosphorus at these two sites; with the average concentration being equal to the PWQO at one site and just below the PWQO at the other. Iron concentrations also exceeded the PWQO at both sites, with the average concentrations being well above the objective. It was noted in the report that these concentrations of iron and phosphorus are typical of discharge from peat and wetlands, which may be contributing to elevated concentrations observed at these sites.

There were some exceedances of chloride at these sites, with many samples approaching the CWQG guideline for chronic exposure, again keeping in mind that sampling generally occurred during the ice-free period when chloride levels would be expected to be lower.

CNR Railbed Drain

There are two stations located within the CNR Railbed Drain that assess surface water west of the waste diversion site, one of which looks at flows from the Huronia Regional Centre compound, a recently closed institution the disabled, and the other looks at flows from an industrial subdivision. Chloride concentrations were elevated at the station draining the industrial subdivision, with the average concentration being more than twice the CWQG chronic exposure guideline. Phosphorus concentrations reached the PWQO at this site, although the average was below it; with higher concentrations seen at the other site, with the average being equal to the PWQO.

3.2.4.6 Beach Postings

The Simcoe Muskoka District Health Unit (SMDHU) collects samples at beaches throughout Simcoe County, including those in Oro-Medonte and Orillia, to test for *E.coli* levels. Table 3-6 lists each of the beaches in the municipalities and indicate which years had an advisory or closure posted, and for how many days. Only Oro-Medonte beaches saw advisory postings in the study area during this period.

An advisory indicates that bacteria levels in the water are at a concentration that could potentially cause minor skin, eye, ear, nose, and throat infections and stomach disorders. Warning signs are posted at the beach and those who still choose to swim are advised to not put their head under water or swallow the water.

A closure, which rarely occurs, happens when there is a catastrophic event or an immediate risk to health present. Issues that could cause a beach closure include sewage spills or toxic chemical release.

There were no beach closures in the City of Orillia or the Township of Oro-Medonte in the five year period of 2008-2012. In addition, there were no beach advisories in the City of Orillia's Lake Simcoe beaches in this period. There were three advisory postings in Oro-Medonte in this period, at Oro Memorial Park in 2010 and 2011, and at Bayview Memorial Park in 2012 (Table 3-6).

Table 3-6: Beach postings in the Township of Oro-Medonte, 2008-2012 (SMDHU, 2013).

Beach	Year	Posting	# of days
Oro Memorial Park	2010	Advisory	2
	2011	Advisory	2
Bayview Memorial Park	2012	Advisory	2

Key points – Current Water Quality Status:

- An assessment of potential Significant Threats, Drinking Water Issues, and Drinking Water Conditions was undertaken within each WHPA. A number of potential significant threats were identified within each WHPA; these mainly related to the residential use of septic systems; the potential for subsurface storage of fuel for home heating purposes; the application of agricultural source material, non-agricultural source material, and/or pesticide to land; and the use of land as livestock grazing or pasturing land
- The Hawkestone Creek surface water quality station is the only long-term station in the study area. The majority of samples meet relevant guidelines for phosphorus, chloride, total suspended sediment, iron, and copper. In general, the percentage of samples that meet the objectives at this site are slightly lower for the current period of record (from 2007-2011) than they are for the entire period of record.
- At the Hawkestone station, concentrations of phosphorus, iron, zinc, and copper show increasing trends in in the short-term data set (2002-2011). With respect to trends in the long-term data, there is only sufficient data to calculate trends for concentrations of phosphorus and chloride. These data show no trend for phosphorus, and an increasing trend for chloride.
- Based on the available 2008-2010 data, the Bluffs Creek station showed:
    - Some samples for phosphorus exceeded the PWQO, but the median concentration and the vast majority of the samples fall well below the PWQO
    - The samples for chloride fall well below the Canadian Water quality guideline
    - Lower mean TSS concentrations than Hawkestone Creek, but a wider spread to the data, indicating that, while background concentrations may be lower, perhaps sediment is more easily mobilized in a rain or snow melt event. The concentration of most samples falls well below the CWQG.
- No issues have been found in the two Provincial Groundwater Monitoring Network wells located in the Hawkestone Creek subwatershed
- There have been no beach closures in the study area in the past five years (2008-2012). There were advisory postings at Oro Memorial Park in 2010 and 2011, each lasting two days, and one at Bayview Memorial Park in 2012, also lasting two days.

3.3 Factors impacting status - stressors

There are numerous substances, processes, and activities that can have an effect on the water quality of the ground and surface water within these subwatersheds. These include:

- Phosphorus,
- Chloride,
- Sediment,
- Thermal degradation,
- Pesticides,
- Emerging contaminants,
- Uncontrolled stormwater and impervious surfaces,
- Recreation, and
- Climate change.

These factors are discussed further in the following sections.

3.3.1 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; and, over time, degradation. 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 winter salt use. 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 winter salt 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, and winter salt 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. As mentioned in Section 3.2.3, there are currently no issues around the well supplies in these subwatersheds; however possible Significant Threats were identified related to a variety of land uses including septic systems, underground storage of fuel, and agricultural practices such as the application of agricultural source material and non-agricultural source material and use of land as livestock grazing or pasturing land.

3.3.2 Surface Water

3.3.2.1 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).

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 (MOE, 2010; LSRCA and MOE, 2013). Rural and agricultural land uses make up 37% of the Oro Creeks North and Hawkestone Creek subwatersheds, and 43% of the Oro Creeks South subwatershed. Runoff from both pasture and crop land, as well topsoil being eroded by wind, contribute to the phosphorus loading in these subwatersheds. Urban land use comprises 15%, 3% and 10% of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively, and is a significant contributor to the phosphorus loading in the City of Orillia through stormwater runoff.

As discussed above, phosphorus loads have been calculated for the Lake Simcoe watershed by the LSRCA in partnership with the Ministry of the Environment. 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 tributary (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 3-8 below. The Oro Creeks North subwatershed had the highest load in the study area, at 2.6 tonnes, Oro Creeks South contributed 0.8 tonnes, and Hawkestone Creek contributed 0.7 tonnes.

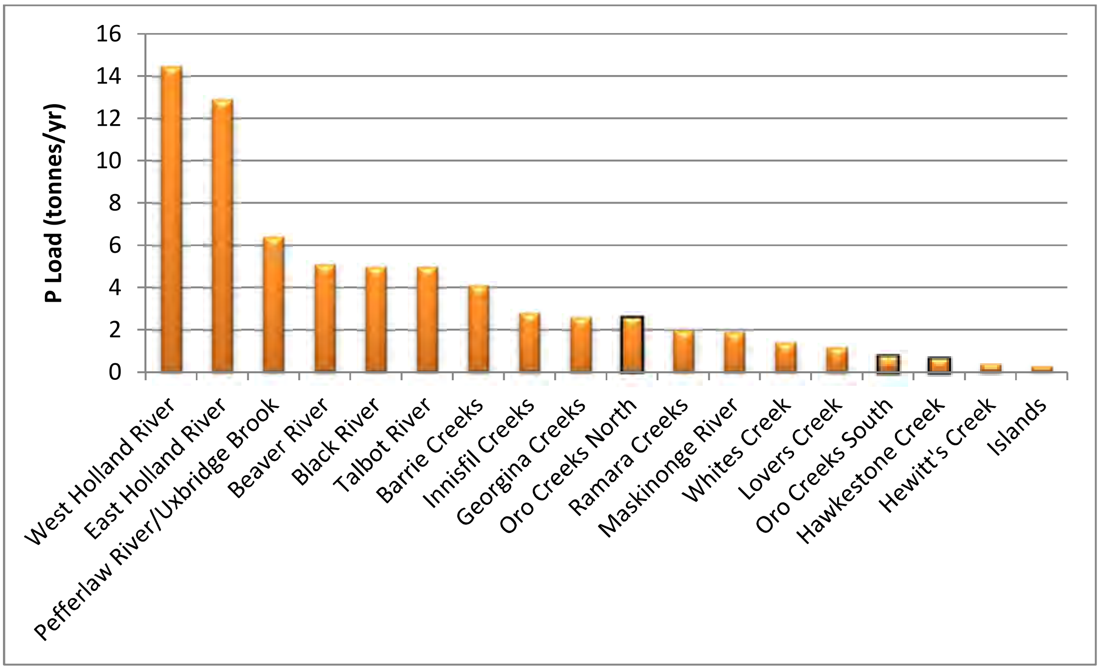


Figure 3-8: Phosphorus loads (tonnes/year) contributed by each Lake Simcoe watershed (data: LSRCA/MOE, 2013)

Similar work was undertaken using loading estimate models for the *Assimilative Capacity Studies (ACS), 2006*, but have since been updated by the original authors, the Louis Berger Group, in a report completed in September, 2010, entitled '*Estimation of the Phosphorus Loadings to Lake Simcoe*'. 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 loads in each subwatershed is influenced by land use, and how the loads will change as land use changes. The following tables (Table 3-7 to Table 3-9) present the average yearly phosphorus loads (as modeled through the 2010 Louis Berger Group report) derived from each source in the subwatersheds under current conditions, the approved growth scenario, and the approved growth scenario with implementation of agricultural 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 Plan will consider the amount of phosphorus that can be reduced through urban BMPs, which are particularly important in the highly urbanized subwatersheds, such as the portion of Oro Creeks North that is occupied by the City of Orillia. However, in Section 3.3.2.9 (Uncontrolled stormwater and impervious surfaces), BMPs related to retrofit opportunities for stormwater ponds and the resulting phosphorus reduction is presented for each subwatershed.

According to the model, the primary source of phosphorus in the Oro Creeks North subwatershed under existing conditions is derived from high intensity development (28%) and hay/pasture (19%). Loads from the Orillia Water Pollution Control Plant, a point source, have also been allocated to this subwatershed, and constitute 20% of the annual phosphorus load. Under the approved growth scenario, there is a projected increase in total phosphorus loads of 15% without the implementation of agricultural BMPs (does not consider urban BMPs). There is potential for a 3.4% reduction in phosphorus loads through the implementation of agricultural

BMPs (Table 3-7). According to the modelling, under existing conditions, the Oro Creeks North subwatershed is the fourth highest contributor of total phosphorus to Lake Simcoe (Table 3-7), and is expected to remain as such under the committed growth scenario, behind the East Holland River, West Holland River, and Barrie Creeks subwatersheds. (Louis Berger Group Inc., 2010).

Table 3-7: Phosphorus loads by source for the Oro Creeks North subwatershed associated with agriculture BMP scenarios (Louis Berger Group Inc., 2010a).

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Change (Existing Condition to Committed Growth)	Agricultural Committed Growth (with BMPs) (kg/year)	Change (Committed Growth scenario with BMP implementation)	% Change (with BMP implementation)
Hay/Pasture	1,097	1,083	-14	1,067	-16	-1.5
Crop Land	646	539	-107	334	-205	-38.3
Turf-Sod	0	0	0	0	0	0
Tile Drainage	10	9	-1	9	0	0
Low intensity development	9	9	0	9	0	0
High intensity development	1,584	2,729	1,145	2,729	0	0
Septics	612	612	0	612	0	0
Polder	0	0	0	0	0	0
Quarry	198	198	0	198	0	0
Unpaved road	23	23	0	23	0	0
Transition	72	65	-7	65	0	0
Forest	22	20	-2	20	0	0
Wetland	1	1	0	1	0	0
Stream bank	7	7	0	6	-1	-14.3
Groundwater (shallow subsurface flow)	235	216	19	216	0	0
Point sources	1,114	996	-118	996	0	0
TOTAL	**5,629**	**6,507**	**878**	**6,285**	**-17**	**-3.4%**

- 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.

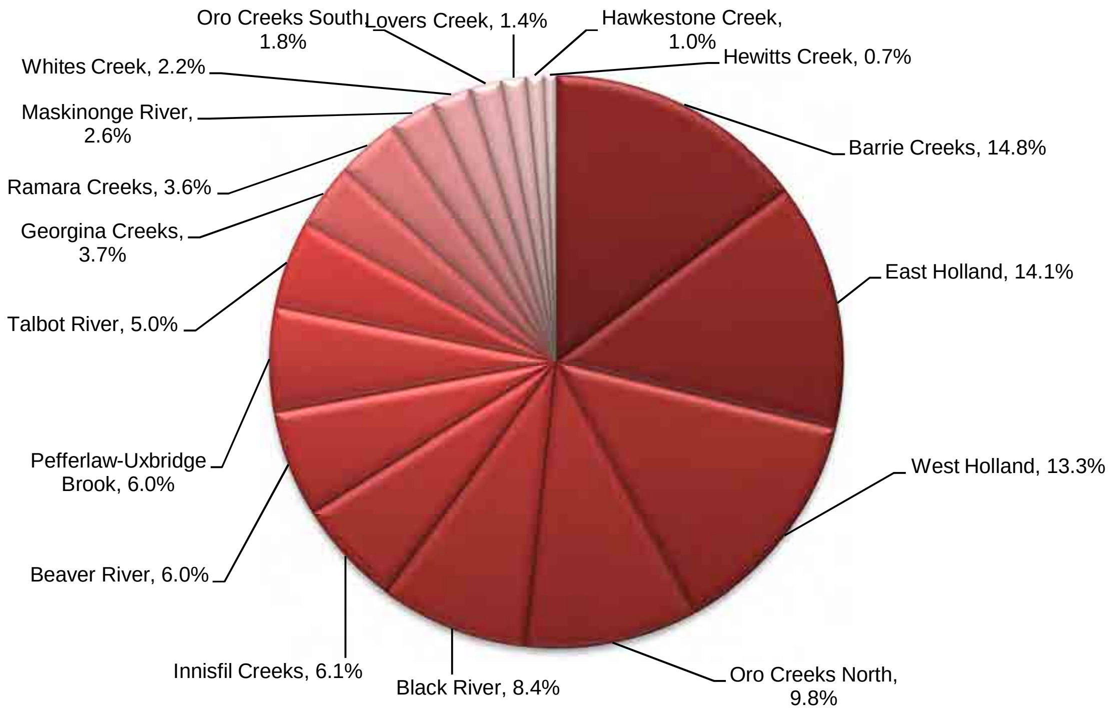


Figure 3-9: Percent phosphorus loads (modelled) to Lake Simcoe per subwatershed under current conditions (data: Louis Berger Group Inc., 2010).

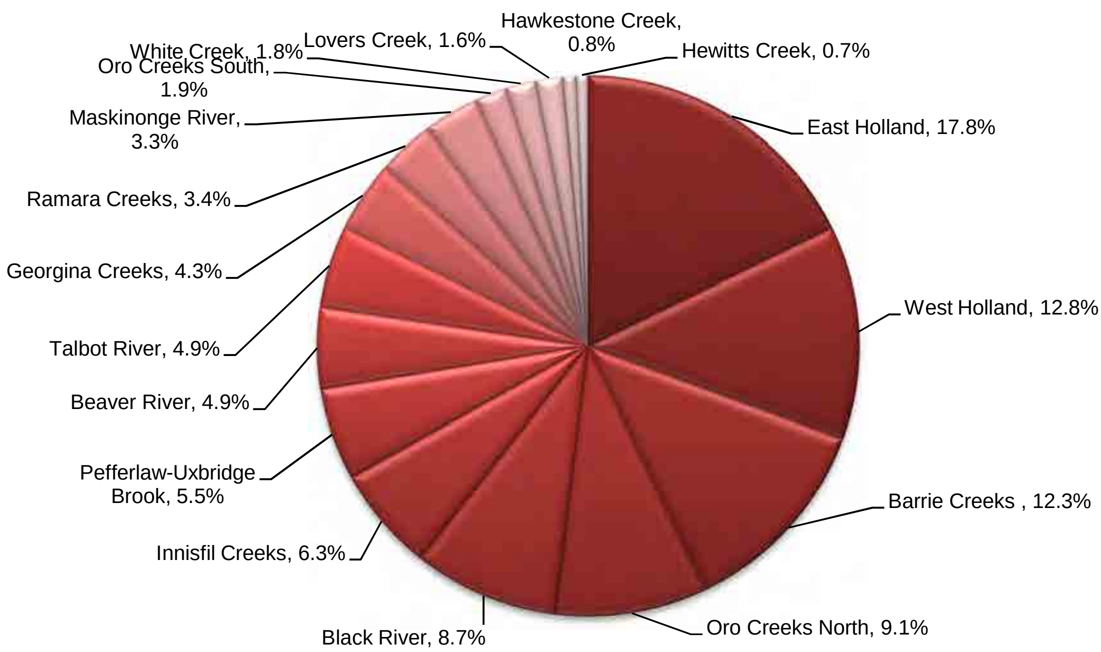


Figure 3-10: Percent phosphorus loads (modelled) to Lake Simcoe per subwatershed under committed growth scenario (data: Louis Berger Group Inc., 2010).

The model identified that the primary source of phosphorus in the Hawkestone Creek subwatershed, under existing conditions, is derived from septic systems within 100 metres of the shoreline (34.5%), hay/pasture and cropland contribute 28%, and 16% is from non-point sources that seep into the ground and reach the watercourses via groundwater (Table 3-8). Under the approved growth scenario, there is a projected increase in total phosphorus loads of only 3% without the implementation of agricultural BMPs (does not consider urban BMPs). With the implementation of agricultural BMPs, the phosphorus load will actually decrease below the current levels, a reduction of 5.7% below the future modeled loads. Under existing conditions, the Hawkestone Creek subwatershed is the second lowest contributor of total phosphorus to Lake Simcoe (Figure 3-9). Under the committed growth scenario, while still seeing a small increase in total phosphorus, it is expected to still be the second lowest contributor of total phosphorus (Figure 3-10) (Louis Berger Group Inc., 2010).

Table 3-8: Phosphorus loads by source for the Hawkestone Creek subwatershed associated with agriculture BMP scenarios (Louis Berger Group Inc., 2010).

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Change (Existing Condition to Committed Growth)	Committed Growth (with BMPs) (kg/year)	Change (Committed Growth scenario with BMP implementation)	% Change (with BMP implementation)
Hay/Pasture	86	85	-1	83	-2	-2.6
Crop Land	74	74	0	45	-29	-39.1
Turf-Sod	4	4	0	4	0	0
Tile drainage	16	16	0	16	0	0
Low intensity development	9	7	-2	7	0	0
High intensity development	34	52	18	52	0	0
Septics	192	192	0	192	0	0
Polder	0	0	0	0	0	0
Quarry	3	3	0	3	0	0
Unpaved road	19	21	2	21	0	0
Transition	3	3	0	3	0	0
Forest	7	6	-1	6	0	0
Wetland	0	0	0	0	0	0
Stream bank	21	23	2	22	-1	-5.2
Groundwater (shallow subsurface flow)	87	86	-1	86	0	0
Point sources	0	0	0	0	0	
TOTAL	**555**	**572**	**17**	**540**	**-32**	**-5.7**

- 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.

Lastly, as can be seen in Table 3-9, the primary source of phosphorus (modelled) in the Oro Creeks South subwatershed, under existing conditions, is derived from septic systems within 100 metres of a watercourse (62%). Crops, streambank erosion, and high intensity development contribute the majority of the remainder of the load, at 10.5%, 9.5%, and 9%, respectively. Under the approved growth scenario, there is a projected increase in total phosphorus loads of 25% without the implementation of agricultural BMPs (does not consider urban BMPs), although due to the small load contributed by this subwatershed, this only amounts to 267 kg of phosphorus. However, the projected phosphorus load under the approved growth scenario can be reduced by approximately 3.6% through the implementation of agricultural BMPs (Figure 3-9). Taken together, this suggests that with agricultural BMP implementation, under the committed growth scenario, phosphorus loading will still increase by 20.8% compared to the current estimated load if all committed growth plans are implemented. Under existing conditions, the Oro Creeks South subwatershed is the fourth lowest contributor of total phosphorus to Lake Simcoe (Figure 3-9). Under the committed growth scenario, while still seeing an increase in total phosphorus, it is expected to still be fourth lowest contributor of total phosphorus (Figure 3-10) (Louis Berger Group Inc., 2010).

Table 3-9: Phosphorus loads by source for the Oro Creeks South subwatershed associated with agriculture BMP scenarios (Louis Berger Group Inc., 2010).

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Change (Existing Condition to Committed Growth)	Committed Growth (with BMPs) (kg/year)	Change (Committed Growth scenario with BMP implementation)	% Change (with BMP implementation)
Hay/Pasture	40	36	-4	35	-1	-3.5
Crop Land	111	104	-7	67	-37	-35.3
Turf-Sod	0	0	0	0	0	0
Tile drainage	31	29	-2	29	0	0
Low intensity development	0	0	0	0	0	0
High intensity development	95	369	274	369	0	0
Septics	660	660	0	660	0	0
Polder	0	0	0	0	0	0
Quarry	0	0	0	0	0	0
Unpaved road	3	3	0	3	0	0
Transition	3	2	-1	2	0	0
Forest	1	1	0	1	0	0
Wetland	0	0	0	0	0	0
Stream bank	100	109	9	100	-9	-8.4
Groundwater (shallow subsurface flow)	13	11	-2	11	0	0

Source	Existing (kg/year)	Committed Growth Scenario (kg/year)	Change (Existing Condition to Committed Growth)	Committed Growth (with BMPs) (kg/year)	Change (Committed Growth scenario with BMP implementation)	% Change (with BMP implementation)
Point sources	0	0	0	0	0	0
TOTAL	**1,058**	**1,325**	**267**	**1,278**	**-47**	**-3.6%**

- 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.

Another way to look at the phosphorus loading of each subwatershed is the amount per year per hectare, or export rate. Figure 3-11 illustrates this, using the loads calculated by LSRCA and MOE, 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 3-8), it contributes the fifth highest amount of phosphorus per hectare in the entire Lake Simcoe watershed. Hawkestone Creek has the third lowest phosphorus load of Lake Simcoe's subwatersheds, but is the 7th lowest in terms of export rate.

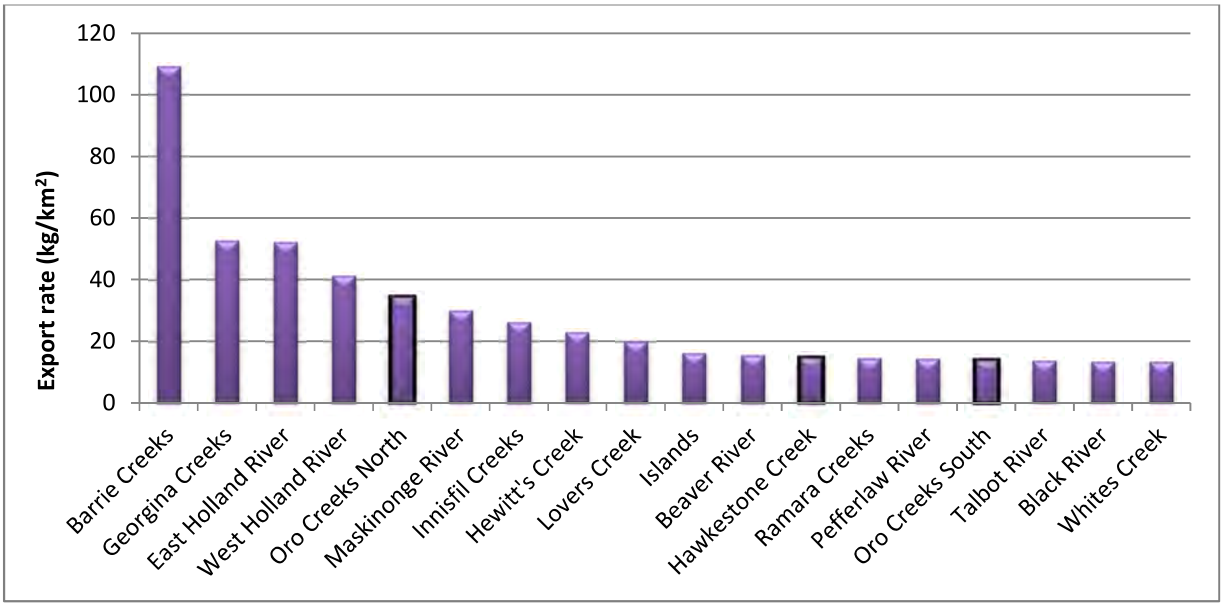


Figure 3-11: Phosphorus loading (kg/yr) per hectare under current conditions for each Lake Simcoe subwatershed (data: LSRCA/MOE, 2013).

Catchment Level Best Management Practices Analysis

An additional part of the analysis in the 2010 report by the Louis Berger Group was to the split the subwatersheds up further into catchments, each named by the tributaries they contain. The Oro Creeks North subwatershed has nine catchments, with areas ranging from 139.0 ha (Oro Creeks North 2) to 1,702.1 ha (Bluffs Creek 1). Oro Creeks South contains five catchments, the largest being Allingham/Burls Creek (2,025.7 ha) and the smallest being Orolea/Lakeview Creek, at 790 ha. There are two catchments in the Hawkestone Creek subwatershed, Hawkestone Creek, at 3,971 ha, and Maplewood/Twelfth Line Creek, at 817 ha.

As already mentioned, an overall potential reduction of 3.4%, 5.7% and 3.6% can be achieved through the implementation of agricultural BMPs for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively. 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 3-12, Figure 3-14 and Figure 3-16 illustrate the total phosphorus loads per catchment, based on the agricultural BMP scenario, while Figure 3-13, Figure 3-15 and Figure 3-17 illustrate the target total phosphorus loads for each catchment. The difference between the two figures for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds is a further 67.8%, 73.7% and 69.2% reduction, respectively, from the agricultural BMP scenario to the required (modelled) target loads.

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. Berger (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 3-10 lists each of the 14 catchments based on this ranking system.

Table 3-10: Classification of catchments in prioritization tiers (Berger, 2010).

Subwatershed	Catchments*			
	Tier 1 (highest priority)	Tier 2	Tier 3	Tier 4 (lowest priority)
Oro Creeks North	Bluffs Creek 1	Carthew/Cedarmount/ Pointview Creek	Bluffs Creek 4	
	Bluffs Creek 2 Bluffs Creek3	Mill Creek	Bluffs Creek 5 Oro Creeks North 1	
			Oro Creeks North 2	
Oro Creeks South			Allingham/Burls Creek	
			Orelea/Lakeview Creek	
			Shanty	

			Bay/Pemberton Creek	
			Shelswells Creek 1	
			Shelswells Creek 2	
Hawkestone Creek		Hawkestone Creek	Maplewood/Twelfth Line Creek	

** Catchments are illustrated in following figures*

Figure 3-12: Oro Creeks North subwatershed agricultural BMP scenario total phosphorus loads (Louis Berger Group Inc., 2010).

Figure 3-13: Oro Creeks North subwatershed target total phosphorus loads (Louis Berger Group Inc., 2010).

Figure 3-14: Oro Creeks South subwatershed agricultural BMP scenario total phosphorus loads (Louis Berger Group Inc., 2010).

Figure 3-15: Oro Creeks South subwatershed target total phosphorus loads (Louis Berger Group Inc., 2010).

Figure 3-16: Hawkestone Creek subwatershed agricultural BMP scenario total phosphorus loads (Louis Berger Group Inc., 2010).

Figure 3-17: Hawkestone Creek subwatershed target total phosphorus loads (Louis Berger Group Inc., 2010).

3.3.2.2 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, parking lots, sidewalks, and driveways, 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 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).

As can be seen in Table 3-3 and Figure 3-4, there is an increasing trend for chloride concentrations over the long term at the Hawkestone Creek station. The trend is not as steep as in other subwatersheds, and actually levelled off through the period from 2006-2011, but this is likely due to the lower levels of developed area in the subwatershed. Given the growth that is slated to occur in the study areas in the future, it is reasonable to assume that concentrations will increase further over time unless practices are instituted to prevent chloride from reaching area watercourses.

3.3.2.3 Sediment

While a certain amount of sediment input is normal in a natural system, in larger amounts it begins to cause a number of problems. Many contaminants, including phosphorus, bind themselves to soil particles, and eroding soil acts as a vector for introducing these contaminants to an aquatic system. There are also impacts to aquatic biota, which are discussed in greater detail in **Chapter 5, Aquatic Natural Heritage**.

There are a number of sources of sediment in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds:

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, such as the creation of riparian buffers, will help to reduce soil loss and its associated impacts on watercourses. For more information on the extent of agriculture and riparian buffers in these subwatersheds, see **Chapter 2: Study Area** and **Chapter 6: Terrestrial Natural Heritage**, respectively.

Development sites: Although developments are often built in phases, entire sites (on which several phases of development are to be built) are often stripped of vegetation to save costs, rather than stripping vegetation on a phase-by-phase basis, leaving surface soils exposed for long periods of time. These bare soils are then subject to erosion by both wind and water. The proper installation of erosion controls can prevent some of the soil from reaching watercourses, but need to be inspected and maintained regularly.

Urban areas: The use of sand as well as salt for maintaining safe conditions for driving and walking during the winter is commonplace. However, large quantities of sand remain on the roadsides after 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 snow melt and 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 these subwatersheds, see **Chapter 2 – Study Area and Physical Setting**.

3.3.2.4 Thermal degradation

Increased temperatures in water can have an impact on the quality of water and to the aquatic communities living in it. Increasing temperatures in water decrease its ability to carry dissolved oxygen, minimum levels of which are critical to supporting fish and other aquatic organisms. The warming of surface water can generally be attributed to flow over impervious surfaces and/or the detention of water in a pond. 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. 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. While practices such as the planting of vegetation around a pond and along its outflow and the installation of structures such as bottom-draws to ensure that the coolest water is being discharged can help to reduce the heating effect, ponds will still have an impact on the thermal regime of a watercourse. This issue will likely worsen as the amount of impervious area in the study area increases in the coming years. **Chapter 5 – Aquatic Natural Heritage** discusses the impact of thermal degradation on survival of cold water fish such as brook trout and which watercourses are experiencing a degree of thermal degradation.

3.3.2.5 Pesticides

Given the large proportion of agricultural and urban land uses in these subwatersheds, pesticide use is a concern. While pesticide use for cosmetic purposes has been banned by the Province of Ontario since 2009, a very positive step, there are a number of exceptions to this law that allow 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; the use of pesticides for structural exterminations (e.g. in and around homes to control insects); and the use 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; and
- Loss of predator avoidance (Ongley, E., 1996, Helfrich *et al*., 2009).

The use of best management practices for the storage and use of pesticides 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 undertook sampling for pesticides, hydrocarbons, and heavy metals in the Hawkestone Creek and Oro Creeks North subwatersheds in 2004 with the Toxic Pollutant Screening Program. Only water samples were taken at the Oro Creeks North site, while both water and sediment samples were taken at the Hawkestone Creek site. Pesticides referred to as PAHs were detected in the rain event (e.g. high flow) sample at the Oro Creeks North site, while phenols were detected in the low flow samples, although only trace amounts that fell well short of applicable guidelines. No pesticides were found in either the water or sediment samples at the Hawkestone Creek site, and although the sediment samples contained measurable amounts of chromium and copper, they did not exceed any guidelines.

3.3.2.6 Metals

Metals are found almost everywhere and are persistent within the environment. While some are naturally occurring, elevated amounts in settled areas are typically associated with agricultural waste, industrial wastes (e.g. metal finishing, tanneries, plastic fabrication), residential sewage and urban runoff (Adriano, 2001). These elevated levels of metals in the environment can have significant impacts on wildlife communities, as metals can bioaccumulate within organisms, cause chronic toxicity, and adversely affect organisms' behaviour, growth, metabolism, and reproduction (Wright and Welbourne, 2002).

In 2008, Landre, *et al.* took sediment samples from Lake Simcoe, at the same 22 locations of an earlier study (Johnson and Nicolls, 1988). Sampling sites were located in the main basin, at the outlet to Lake Couchiching, and in Kempenfelt Bay and Cook's Bay. Each of the samples was tested for 17 metals: aluminum, arsenic, barium, cadmium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, rubidium, antimony, strontium, vanadium, and zinc. This study found high concentrations of cadmium, chromium, copper, mercury, nickel, lead, and zinc near the shore in Kempenfelt, with concentrations decreasing farther away from shore and into the main basin, and declining further still toward the outlet basin (offshore of the Oro Creeks North subwatershed). A similar pattern was seen in Cook's Bay, with sites closest to the shore having the highest metal concentrations (Landre *et al.,* 2011).

Higher concentrations close to shorelines are not unexpected as these are the areas of the subwatersheds experiencing urban growth, both in the residential and commercial sectors, and is where streams running through agricultural and urban lands discharge loads into the lake. In addition, metal pollution historically was not regulated from metal finishing facilities and tanneries that were operating in and around areas such as Kempenfelt Bay, in the southern portion of the study area, in the past.

When comparing current results to the results of the earlier study (Johnson and Nicolls, 1988), metal concentrations had remained the same or decreased, with the exception of copper and zinc in Kempenfelt Bay. The concentrations of these two metals were on par with the peak levels seen in the 1950s, 60s, and 70s (both decreased slightly in 1980s). Additionally, cadmium, mercury, lead and antimony were found at concentrations that were three to seven times higher than pre-1900s conditions (Landre *et al.,* 2011). Of all the metals studied, chromium was the greatest concern, as it exceeded the Ontario Sediment Quality Guidelines severe effect level at three sample sites. This makes it one of the metals of most concern to ecological systems. Depending on the chemical form of chromium, the type of organism and the life stage of the organism, contamination over the guideline can impact the growth, activities, reproduction and survival, as well as causing changes to chromosomes and physical formation, due to its carcinogenic, mutagenic, and teratogenic properties (U.S Environmental Protection Agency, 2011).

Overall though, because of a decrease in industrial activity, better wastewater treatment and an increase in urban area, there has been a shift in the source of metals from industrial discharge to urban runoff (Landre *et al.,* 2011). Hence, to manage the concentration of metal contaminants in Lake Simcoe, it is important to install and maintain sufficient stormwater treatment facilities and to decrease metal inputs into stormwater.

3.3.2.7 Bacteria

The presence of bacteria in surface waters has become a significant concern in recent years. Municipal health units monitor the health of local beaches at regular intervals throughout the summer to ensure that they are safe for human contact. The Provincial Water Quality Objective (PWQO) for body-contact recreation has been defined by the Ministry of the Environment by using the relative numbers of *Escherichia coli* (*E. coli*) bacteria as an indicator to assess the risk to human health. When the *E. coli* population exceeds the PWQO, the beach is designated unsafe for bathing activities. *E. coli* is a fecal bacteria found in the intestines of mammals that can cause serious illness and even death.

The presence of high levels of *E. coli* in the lake's waters is an indication of contamination by human sewage or animal wastes. While there are other reasons for beach postings, including water turbidity, the presence of blue-green algae, or poor aesthetics, closures in Lake Simcoe are generally due to high levels of *E. coli*. The number of beach closures due to high concentrations of *E. coli* varies from year to year, as they are heavily influenced by precipitation levels. Storm water carries with it animal waste (e.g. from farms with livestock, as well as from pet and waterfowl waste), which can contaminate beaches when it reaches them either through direct runoff from adjacent areas, or being carried to tributaries and discharged when it reaches the lake.

From 2008 to 2012, no beaches were closed in the Township of Oro-Medonte or the City of Orillia. There were advisories at Oro Memorial Park in the Township of Oro-Medonte in 2010 and 2011, and an advisory at Bayview Memorial Park, also in Oro-Medonte, in 2012.

3.3.2.8 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 whose levels exceed 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; hormones, including 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 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. While the effects of pharmaceuticals on humans during the course of treatment are very well studied; the impacts of their by-products after use 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 been 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 defined as 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.

3.3.2.9 Uncontrolled stormwater and impervious surfaces

In the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, urban land use makes up 14%, 3% and 10% of total land use, respectively. 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 feces. Generally, concentrations of pollutants such as bacteria (e.g. *Escherichia coli*, fecal coliform, *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 (OMOE, 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 now 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 (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 Oro Creeks North and Oro Creeks South subwatersheds are above the 10% guideline, but are below the upper limit threshold with approximately 20% and 14% impervious surface, respectively. As these subwatersheds haven't reached the 30% threshold, there is still room through mitigative action and careful development to reduce or at least maintain this number to assist in maintaining the water quality. The Hawkestone Creek subwatershed remains below the 10% threshold, with 8% impervious surfaces. Careful planning will be needed to ensure that impervious surface in this subwatershed remains below 10%, preventing further stress to its aquatic communities.

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, such as the implementation of Low Impact Development practices.

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. A further input of sediment and nutrients from urban areas is the wind erosion of soils stripped bare for development. These areas can be without vegetation for prolonged periods of time, and can be a significant source of windborne pollution.

Based on the Stormwater Practices Manual (MOE, 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:

> **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.

[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 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.

The only major urban area in Oro Creeks and Hawkestone Creek subwatersheds is the City of Orillia, which lies in the northern portion of the Oro Creek North subwatershed. The City of Orillia contains 27 stormwater catchments that fall within the Lake Simcoe watershed, none of which have any level of stormwater control (Figure 3-18). Stormwater catchments have not been mapped for the subwatershed area within the Township of Oro-Medonte; however an inventory of stormwater facilities located in the small communities found within the Township that lie in the Lake Simcoe watershed was completed in 2009. This inventory found a total of nine facilities; seven of which are dry ponds, and two of which are wet ponds. All of the dry ponds are assumed to have basic control, removing 60% of TSS; this is also the level of control for one of the wet ponds. The other wet pond has enhanced controls, and is rated to remove 80% of the TSS. In total, approximately 150 ha of land is serviced by these ponds.

The *Lake Simcoe Basin Stormwater Management and Retrofit Opportunities* report (LSRCA, 2007) identified and evaluated opportunities to control phosphorus from many of the Lake Simcoe watershed's larger urban areas, including the City of Orillia (Figure 3-19). In the urban areas, stormwater runoff is most often addressed through stormwater pond retrofits. These include creating facilities in uncontrolled catchments or upgrading existing facilities or quantity only facilities to higher level of control (i.e. Level 1). The report identified a total of five retrofit opportunities in the City of Orillia. The completion of these retrofits would result in a reduction in phosphorus loads by approximately 730 kg, a 36% decrease from the current estimated load from these urban catchments. It is noted, however, that the completion of these retrofits may be difficult to achieve, given the land available and what would be required to service some of these larger areas. It may be most appropriate, in these and other locations, to place emphasis on the implementation of Low Impact Development (LID) practices. LIDs shift the focus from end-of-pipe stormwater ponds to treating and infiltrating stormwater on site through the use of practices such as rain gardens, permeable pavement, green roofs, and bioswales. Rather than running overland and being captured in storm sewers, much of the water is infiltrated into the ground, with nutrients, sediments, and other contaminants being captured in the naturally vegetated areas that are a part of these systems. This greatly reduces the need for traditional stormwater ponds and the space and maintenance that they require. These practices are being encouraged in all new developments throughout the Lake Simcoe watershed.

Table 3-11: Controlled vs. uncontrolled stormwater catchments in the City of Orillia.

Location	Total Number of Catchments	Total Urban Area (ha) Used	Uncontrolled			Quantity			Level 1			Level 2			Level 3			Level 4			Controlled (Total of Levels 1 to 4)		
			#	Area (ha)	% (area)	#	Area (ha)	% (area)	#	Area (ha)	% (area)	#	Area (ha)	% (area)	#	Area (ha)	% (area)	#	Area (ha)	% (area)	#	Area (ha)	% (area)
City of Orillia	27	1,468.13	27	1468.13	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	**27**	**1,468.13**	**27**	**1468.13**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Stormwater control in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 3-18

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 December 2013.

Stormwater control in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 3-19

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Storm Watersheds

- Controlled
- Uncontrolled, Retrofit Opportunity
- Uncontrolled, No Retrofit Opportunity

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

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 December 2013.

3.3.2.10 Recreation

Natural areas such as streams and rivers are popular locations 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.

3.3.2.11 Climate Change

While difficult to predict direct results of climate change to water quality within the Lake Simcoe watershed, it is likely that it will exacerbate 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 3-20 to Figure 3-22 show two different climate scenarios (based on different models) and how they will impact the total phosphorus loads in the coming years. The climate change scenario outputs were initially reporting the base case phosphorus load (2004-2007). However, it was felt 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 3-20 illustrates the current 'baseline' value for Oro Creeks North. Both scenarios show phosphorus load increases, with most occurring after 2041.

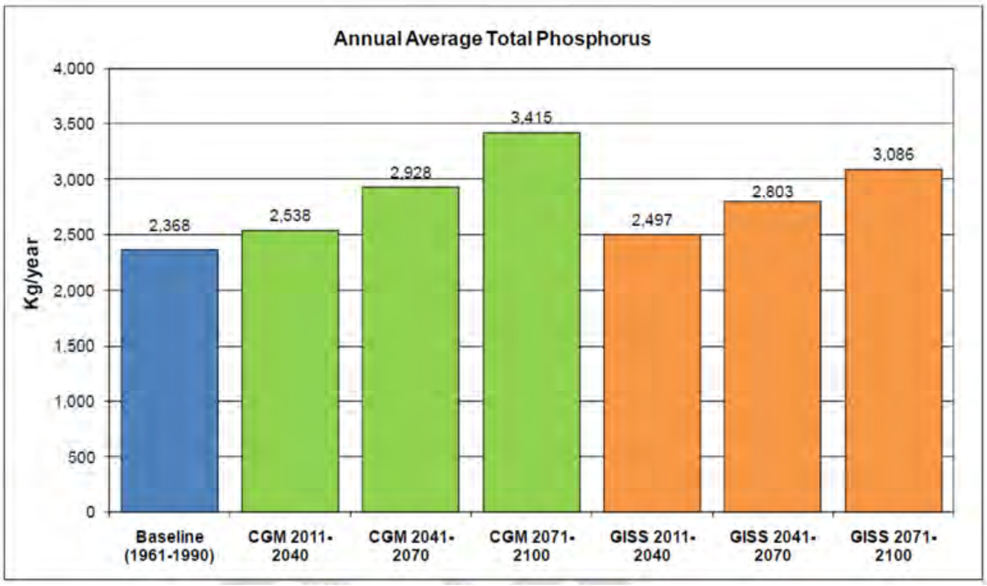


Figure 3-20: Base case land use applied to climate change scenarios for total phosphorus loads in the Oro Creeks North subwatershed (Louis Berger Group Inc., 2011).

For the Hawkestone Creek subwatershed, both models show a decrease from 'baseline' to 2070, with a increase after that time (Figure 3-21)

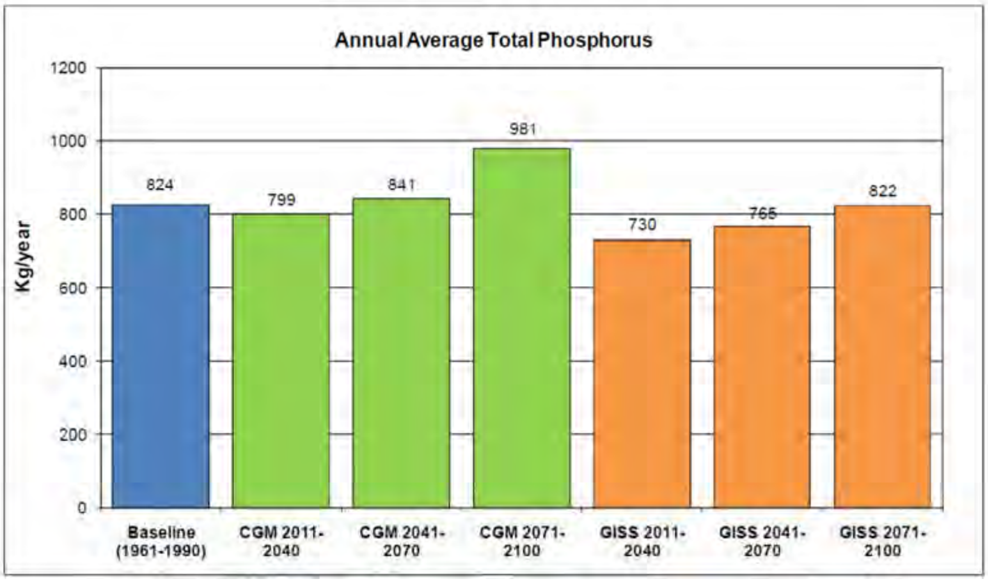


Figure 3-21: Base case land use applied to climate change scenarios for total phosphorus loads in the Hawkestone Creek subwatershed (Louis Berger Group Inc., 2011).

Lastly for the Oro Creeks South subwatershed (Figure 3-22), both show slight decreases for the periods from 2011-2070, followed by increases after 2070.

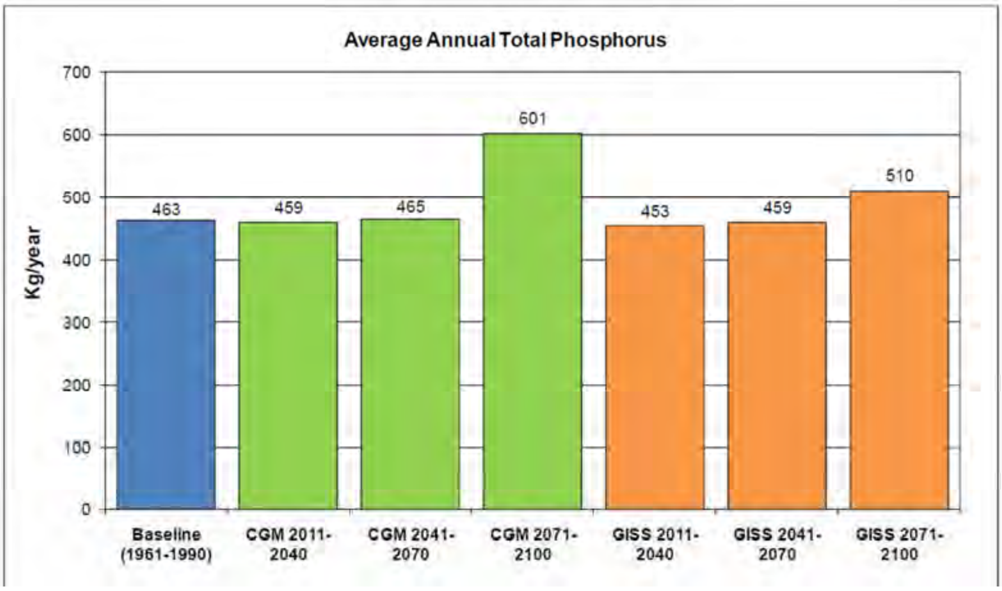


Figure 3-22: Base case land use applied to climate change scenarios for total phosphorus loads in the Hawkestone Creek subwatershed (Louis Berger Group Inc., 2011).

Further information on how climate change will affect aquatic and terrestrial natural heritage can be found in Chapters 5 and 6, respectively.

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

- There are currently no issues identified for groundwater with respect to drinking water; however some Significant Threats have been identified related to a number of land uses.
- The CANWET model identifies the primary source of phosphorus in the Oro Creeks North subwatershed to be high intensity development (28% of the load). In addition, the phosphorus load from the Orillia Water Pollution Control Plant is allocated to this subwatershed, and accounts for 20% of the subwatershed load. Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 15% if agricultural BMPs are not implemented.
- According to the CANWET model, the primary source of total phosphorus in the Hawkestone Creek subwatershed is septic systems within 100 metres of a watercourse (34.5% of the annual load). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of only 3% if agricultural BMPs were not implemented.
- The primary source of total phosphorus in the Oro Creeks North subwatershed, as predicted by the CANWET model, is also septic systems (62%). Under the approved growth scenario in the ACS modelling, there is a projected increase in total phosphorus loads of 25% if agricultural BMPs were not implemented.
- The Oro Creeks North contributes the fourth largest load of the Lake Simcoe subwatersheds; however, in terms of the unit-area load (kg/yr per hectare), it is the second highest in the watershed.
- The Hawkestone Creek subwatershed is the second smallest contributor to the annual phosphorus load, and its unit-area load is the third lowest in the watershed. The Oro Creeks South subwatershed is the fifth lowest in terms of phosphorus load, and its unit-area load is the 8th lowest in the watershed.
- Most of the chloride in the subwatersheds comes from the use of winter salt, with an increasing trend showing in the long term data for the Hawkestone Creek station. It is expected that this load will increase into the future as the urban areas continue to expand.
- Sediment sources include sites stripped for development, agricultural areas, 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. Sediment is not considered an issue in the study area at this point.
- 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.

3.4 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, as outlined below.

3.4.1 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 3-12 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 **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 3-12: 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 Oro-Medonte Official Plan (2007)	City of Orillia Official Plan (2011)
Development and site alteration	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓
Application of road salt	✗	✓	✗	✗	✓ 3	✗	✗	✗	✗	✗	✗	✓
Loss of natural heritage features	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓
Uncontrolled Stormwater	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓ 9
Impervious surface	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗ 7	✓ 10	✓ 10
Discharge of material	✗	✗	✗	✓	✓	✓	✓	✗	✓	✗	✓ 8	✓
Agricultural runoff	✓	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗
Septic systems	✓	✗	✓ 2	✗	✓ 4	✗	✗	✓ 5	✗	✗	✓ 11	✗
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] Targets for impervious cover provided for the Oak Ridges Moraine Conservation Plan areas, but not subject area

[8] Required to identify through EIS

[9] Includes stormwater policies consistent with LSPP

[10] Does not discuss impervious surfaces directly, but does discuss maintaining water balance

[11] New septics allowed in certain areas, council must be satisfied that soils are suitable.

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 LSPP 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 manage 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 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, Source Protection Authorities, Source Protection committees, municipalities, First Nations, consultants and the public. Currently (2012) the program is in Stage 3 of 4 and in the midst of preparing a Source Protection Plan that is due to be submitted to the ministry in 2012. The Source Protection Plan is a document that focuses on preventing the overuse and contamination of drinking water supplies across the SGBLS SPR. The plan will include 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).

In addition to the PPS, the LSPP, the *Clean Water Act* and the other acts and policies in Table 3-12, the municipalities, in this case the Township of Oro-Medonte and City of Orillia, municipal Official Plans are key to preserving and improving water quality within the subwatersheds.

The Township of Oro-Medonte supports the maintenance and improvement of water quality through Policy B5.1.6.1, which requests that all applications for an Official Plan amendment and all applications for major development to be supported by a Water Resources Management (WRM) Report; the purpose of which is to investigate the impacts of the proposed development on water qualtiy and quantity, and to provide recommendations on issues including how to ensure that the quality of the watercourses affected by the development are maintained and, specifically in the Lake Simcoe watershed, how to ensure that there will be no negative impacts on the water quality of Lake Simcoe resulting from the development. In addition, Policy B5.1.6.2 requires all major commercial, industrial, institutional and residential development proposals to be supported by a Stormwater Management report.

In its official plan, one of the City of Orillia Principles is Ensuring the Sustainability and Integrity of the Environment, including considering the overall impact to water quality in Lake Simcoe. This is reflected in its Environment and Open Space policies, where the Official Plan lists as one of its objectives ensuring that changes in land use do not have negative impacts on the natural heritage system, with particular attention to the water quality of Lake Simcoe (3.5.2 (f)). The

City also requires stormwater management facilities for new development that will maintain or enhance water quality, as well as requiring Environmental Impact Studies for developments, which describe any potential impacts on water quality.

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 their incorporation into municipal Official Plans.

3.4.2 Restoration and Remediation

There are 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. In the period from 1999-2004, LEAP projects were categorized by municipality. Twenty-two projects aimed at improving water quality were completed in the Township of Oro-Medonte during this period; these are shown in Table 3-13 below. Since 2004, LEAP has supported 88 water quality improvement projects in these subwatersheds, outlined in Table 3-14 below for each subwatershed:

Table 3-13: LEAP projects completed in the Township of Oro-Medonte from 1999-2004

Project Type	Number
Clean water diversion	3
Fencing	2
Wellhead protection	5
Septic system upgrades	6
Streambank erosion control	1
Manure storage	1
Milkhouse washwater management	1
Total	19

Table 3-14: LEAP projects undertaken from 2004-2012 in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Project Type	Oro Creeks North	Hawkestone Creek	Oro Creeks South
Erosion streambank	1	2	2
Manure storage	1	1	1
Milkhouse waste	1	0	0
Septic system upgrade	8	3	46
Tree planting	2	0	6
Well decommissioning	2	0	7
Wellhead protection	0	0	5
Total	**15**	**6**	**67**

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, approximately 45 projects have been implemented in the Township of Oro-Medonte.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in these subwatersheds, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. This survey found over 220 sites in these three subwatersheds where runoff was entering creeks, potentially impacting water quality.

3.4.3 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 MOE 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, 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. The effectiveness of management efforts and understanding of issues, such as climate change and atmospheric deposition, will improve through research and monitoring and 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 MOE, MNR, 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).

3.5 Management Gaps and Recommendations

As described in the previous sections, many regulations and municipal requirements aimed at protecting water quality of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds already exist. Similarly these subwatersheds have been the focus of numerous restoration and remediation efforts, such as those coordinated through the Landowner Environmental Assistance Program (LEAP). 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 the existing protection and restoration of the water quality in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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

3.5.1 Groundwater (Hydrogeologic and Hydrologic)

There is a need to maintain, and in some locations, enhance groundwater flow patterns in terms of volume and temperature in the tributaries that are dependent on baseflow contributions for the ecological requirements of those systems, within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

> **Recommendation 3-1 -** That the LSRCA work with MOE to develop an action plan to address barriers to the implementation of LID technologies in the subwatershed, using the previously developed LID discussion paper

3.5.2 Surface Water

3.5.2.1 Urban - improving stormwater

Within the City Orillia it has been found that none of the urban area within the Lake Simcoe watershed has stormwater control. The lack of stormwater control within the subwatershed provides many opportunities the use of the more innovative Low Impact Design (LID) solutions, or for stormwater retrofits where LIDs are not appropriate. Significant reductions in phosphorus loads to Lake Simcoe, in addition to improvements to the tributaries, would result from improved stormwater control.

The LSPP already includes a number of polices related to 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 3-2 -** That the subwatershed municipalities, with the assistance of the LSRCA, promote the increased use of innovative solutions to address stormwater

management and retrofits, particularly in areas lacking adequate stormwater controls, and lacking conventional retrofit opportunities, such as:

- the use of soakaway pits, infiltration galleries, permeable pavement (where appropriate), and other LID solutions, where conditions permit;
- enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls;
- improving or restoring vegetation in riparian areas;
- installation of rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways; and
- the on-going inventory, installation, and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where appropriate.

Recommendation 3-3 - That the Province of Ontario, through the implementation of initiatives including the stormwater policies contained in the LSPP, Showcasing Water Innovation, and the Great Lakes Protection Act, be encouraged to support, through financial or other measures, municipalities and/or the LSRCA to design, maintain (where appropriate), and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-4 - Given the high rate of phosphorus loading per hectare in the Oro Creeks North subwatershed, that the MNR, MOE, and LSRCA make the Oro Creeks North subwatershed a priority for stewardship projects intended to reduce phosphorus loading. Further, that the City of Orillia make stormwater retrofits and the use of LID solutions in the Oro Creeks North subwatershed a priority, due to their significant potential to reduce phosphorus loading.

Recommendation 3-5 - That the subwatershed municipalities routinely monitor and maintain the design level of stormwater facilities. In addition to maintaining design level, criteria for maintenance should also include frequency and exposure to spills and other contaminant sources.

Recommendation 3-6 - That Official Plans be amended to contain policies that would help minimize impervious surface cover in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds through requirements such as using low impact development solutions, limiting impervious surface areas on new development, and/or providing stormwater rates rebates and incentives to residential and non-residential property owners demonstrating best practices for managing stormwater.

Recommendation 3-7 - That the Township of Oro-Medonte manage ditch run-off from the municipal roads that end at the Lake Simcoe shoreline 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 lake.

3.5.2.2 Urban – construction practices

Projected growth within these subwatersheds dictates that rate of construction is going to increase. 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 and tree cutting 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 3-8 -** That the LSRCA and watershed municipalities 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 3-9 -** That subwatershed municipalities 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 3-10 –** That the municipalities undertake a review of current tree cutting by-laws to ensure that they conform with 'good forestry practices' as described in the Ontario Woodlot Association's by-law template.

3.5.2.3 Urban – reducing salt (chloride)

Chloride concentrations in Hawkestone Creek have been increasing since monitoring was initiated in the 1993, although the rate of increase has slowed in the last number of years, and the samples at this station still meet the guidelines. Data from Bluff's Creek, which started in 2008, also show levels below the guidelines. However; given that increasing chloride is an issue across the watershed, and that the urban area in the study area is planned to increase, it will be important to ensure that salt is managed properly in order to maintain stream and lake health.

> **Recommendation 3-11 -** That the LSRCA, with the support of subwatershed municipalities, develop a program to determine relative contribution of chloride from road salt application (e.g. how much is coming from roads vs. parking lots, etc.), establish baseline indicators, and examine the effectiveness of current protocols on salt storage, application, and disposal, as outlined in their respective Salt Management Plans, adapting them as necessary.

> **Recommendation 3-12 -** That the LSRCA, with the support of subwatershed municipalities, identify areas within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds which are vulnerable to road salt, such as Lake Simcoe and the watercourses flowing through the study area's urban areas (as outlined by Environment Canada). 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, once identified.

Recommendation 3-13 - That the LSRCA, in collaboration with subwatershed municipalities, deliver a salt education and certification program, to increase awareness and understanding of the importance of salt management by snow removal contractors, property managers, and the general public.

Recommendation 3-14 - Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that the watershed municipalities, academia, LSRCA, MOE, MTO and MNR form a Salt Working Group, or utilize an existing group such as the Simcoe County Road Superintendents, as a mechanism to share information on best practices for salt application, methods of increasing public awareness of the environmental impacts of road salt, and the effectiveness of municipal Salt Management Plans.

3.5.3 Agriculture and rural areas

Subwatershed modelling (that excludes atmospheric) indicates that 31%, 32%, and 17% of phosphorus loads can be attributed to agriculture in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively. Recent water quality monitoring (2008 to 2010) within these two creeks has shown that phosphorus concentrations often exceed the provincial standards. Considering the relatively high proportion of phosphorus that can be attributed to agricultural sources in these subwatersheds, actions leading to reduction in agricultural phosphorus loads to these two creeks 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) provide 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 3-15 - That the subwatershed municipalities, through the LSRCA, create a roundtable made up of municipalities, LSRCA, MOE, MNR, MAF, agricultural groups, NGOs, and related landowner representatives, or through the expansion of existing frameworks such as the Lake Simcoe Stewardship Network or the Water Quality

Trading Working Group, to determine co-operative ways of implementing phosphorus reduction and improved water quality measures in Oro North, Hawkestone, and Oro South Creeks, and to develop an 'action plan' for their implementation within the agricultural and rural communities.

Recommendation 3-16 - That the spatially-explicit tool described in Recommendations 5-7 and 5-8 (**Chapter 5 – Aquatic Habitat**) and the terrestrial prioritization tool described in Recommendation 6-17, be used to prioritize allocation of 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.

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**. Recommendations 5-7 and 5-8 are most relevant to the concern.

3.5.4 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 coldwater species like brook trout and mottled sculpin due to their restrictive thermal requirements.

Recommendation 3-17 – That, as new or retrofit stormwater facilities are constructed, LSRCA work with subwatershed 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 3-18 -That the LSRCA work with its 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, and other BMP implementation in conjunction with the protection of current hydrologic functions.

Note that thermal issues associated with dams were 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.

3.5.5 Monitoring and Assessment

Currently there are only two surface water quality monitoring stations within the study area, one on Hawkestone Creek to represent that subwatershed, and one on Bluff's Creek representing the many smaller creeks within the Oro Creeks North subwatershed. Obviously there is a significant need to provide improved and expanded information on temporal and spatial change in water quality within the subwatersheds, particularly since neither of these stations would show any of the impacts of the study area's urban areas. 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 3-19 - That the LSRCA enhance the existing monitoring network, through the comprehensive monitoring strategy, to address identified limitations and gaps of the current monitoring program. Review of potential enhancements should consider:

- 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
- Establishing new monitoring stations
- Monitoring additional parameters that are key indicators of ecosystem health and restoration progress such as brook trout spawning.

Recommendation 3-20 – That the MNR, LSRCA, and MOE 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.

Recommendation 3-21 - That the LSRCA, MNR and MOE analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs regularly, and that the information be used to update the LSRCA Watershed Report Card. 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 3-22 - That the LSRCA, in collaboration with MNR, MOE, and MAF, 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.

4 Water Quantity – Surface and Groundwater

4.1 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. Fish species that depend on coldwater conditions for their survival require a very high ratio of cold, clean groundwater to total stream flow. Many ponds and wetlands are 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 many 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds have altered the hydrologic cycle (Figure 4-1), including changes to the surface flow volumes, recharge, annual flow patterns, and the risk of flooding.

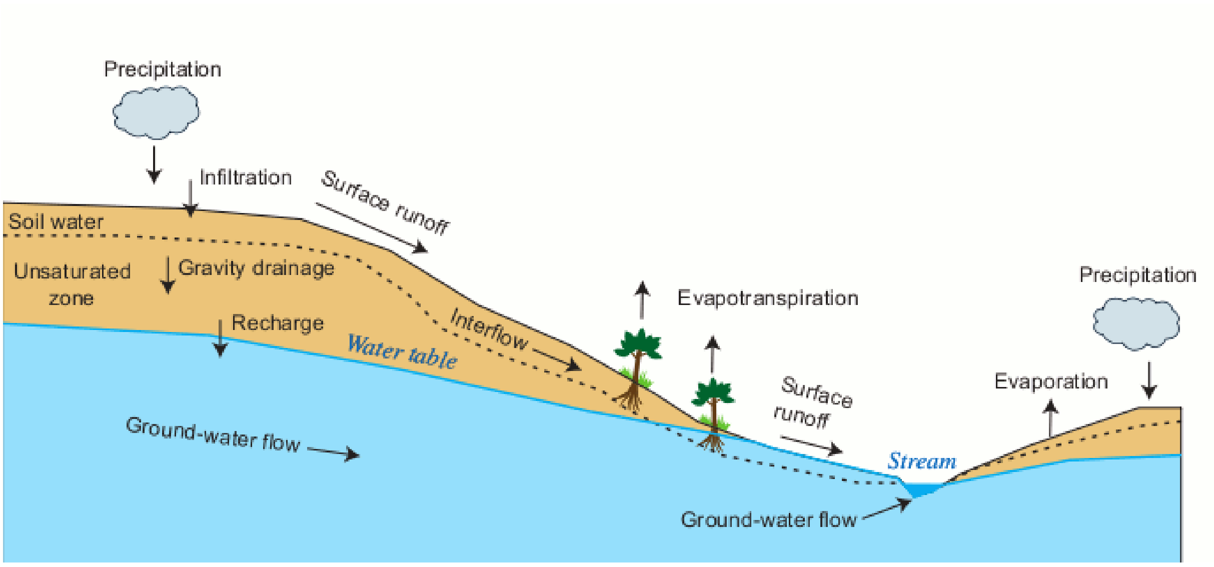


Figure 4-1: Hydrologic cycle (USGS, 2008)

4.1.1 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.

<u>Climate</u>

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 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 observed in March or April snowmelts or the onset of spring rains in April or May.

There are three climate stations established by Environment Canada that are active in the study area. The Barrie WPCC station (6110557) is located just south of the study area. In addition, there are nine inactive stations with varied periods of record that have historic information (Earthfx, 2013a). Temperature, precipitation, and snowfall records for this area span a 29 year period. Temperature data are consistent within the area, while snowfall rates were more variable. According to the Orillia TS and Coldwater-Warminster, snowfall rates were generally high, while Barrie WPCC and Midhurst were generally low. Overall, the average snowfall recorded within the study area was 269 centimetres per year (cm/yr). Total precipitation based on these data averaged 980 mm/yr. Precipitation is higher from August to January, averaging 93 mm/month, and lowest from February to April, averaging 63 mm/month (Earthfx, 2013a).

However, it should be noted that precipitation patterns have become less predictable in recent years, perhaps due to climate change.

There are other variables associated with climate that will 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 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 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.

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 subwatershed will influence how much water remains at the surface and how fast it will be flowing. The land types present in the study area include the Oro Moraine, wetlands, woodlands, and grasslands. The Oro Moraine influences surface water flows in the study area. Areas of hummocky topography occur on top of the Oro Moraine and act to prevent surface runoff and focus infiltration. The Oro Moraine is an area of high recharge and provides headwater flow to numerous streams that drain to Lake Simcoe, Minesing Swamp, and Georgian Bay. The wetlands are found in areas of topographic lows, often where the groundwater intersects the surface. The intersection of the surface with the groundwater table allows for a constant flow of surface water through these areas. Since the wetlands are in areas of topographic lows, water flow in the areas will be relatively slow compared to the slopes of the Oro Moraine.

As the population continues to grow, urbanized areas are expanding, resulting in widespread areas of 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. The Hawkestone Creek subwatershed currently has a low percentage of hardened surfaces (8%), and few development pressures. Impervious cover is higher in the Oro Creeks South (14%), and higher still in the Oro Creeks North (20%), with some fairly large areas of development pressure, particularly in Oro Creeks North.

Water Use

In the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds both surface and groundwater are used for a variety of purposes, including municipal water supply, agriculture, golf course irrigation, private water supplies, and by the native plants and animals. Many of these users 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 Source Water Protection initiatives required under the Clean Water Act, 2006 (discussed in Section 4.4.1).

4.1.2 Previous Studies

Information from several groundwater and water budget studies were used to assess the hydrogeology of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

- 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).

Although Tier 2 studies were completed for the Barrie Creeks subwatershed to the south and the Coldwater Creek watersheds to the northwest (AquaResources & Golder, 2010) they did not significantly change the model or analysis of the Oro and Hawkestone watersheds. A complete summary of the SWPP work in the study area is included in the “Approved Assessment Report: Lake Simcoe and Couchiching-Black River Source Protection Area, Part 1 Lake Simcoe Watershed” (South Georgian Bay-Lake Simcoe Source Protection Committee, 2012).

Ontario Geological Survey Groundwater Modelling of the Oro Moraine

The Ontario Geological Survey (OGS) completed a three-dimensional hydrostratigraphic model of the Oro Moraine area (Burt and Dodge, 2011) by using data from an extensive high-quality drilling program, together with water well and other data.

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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds by Earthfx (2013a). The Tier 2 was completed by incorporating the three-dimensional hydrostratigraphic model of the Oro Moraine area (Burt and Dodge, 2011) into 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 MOE’s Clean Water Act, 2006 Technical Rules (MOE, 2011).

In addition to the Tier 2 Water Budget study, the Lake Simcoe Protection Plan Policy 6.37-SA requires that ecologically significant groundwater recharge areas be identified. This study was completed by Earthfx (2013b) and is discussed further in Section 4.2.6.

Lake Simcoe Region Conservation Authority Surface 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, 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, nutrient budget estimation for Lake Simcoe, and to support the water quantity information needs of our municipal partners.

4.2 Current Status

4.2.1 Hydrogeologic Setting

The hydrogeology of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds are shaped by the stratigraphic framework discussed in **Chapter 2 – Study Area and Physical Setting**. In order to characterize the hydrogeological conditions across these subwatersheds and the Oro Moraine, the Ontario Geological Survey conducted a study to characterize the hydrogeological setting. Subequent modelling work to characterize the groundwater flow system was completed as part of the Tier 2 Water Budget study mentioned in Section 4 of the Earthfx (2013a) Report. An integrated groundwater and surface water model known as GSFLOW was developed for the study area using MODFLOW for groundwater and PRMS for surface water. The groundwater sub-model determined groundwater levels in the study area, provided estimates of the rates of groundwater discharge to streams and wetlands, and identified the exchange of water between shallow and deep aquifers and lateral groundwater inflow and outflow across catchment boundaries (Earthfx, 2013a). The model boundaries are shown in Figure 4-2.

As seen in Figure 2-14 and 2-15 (**Chapter 2 – Study Area and Physical Setting**) the elevation of the Oro Moraine along with the thickness of the associated stratified drift influence groundwater flow within the Oro North and South and Hawkestone Creeks subwatersheds.

The OGS conceptual model of stratigraphic units within the subwatershed was presented in Figure 2-16 **Chapter 2 – Study Area and Physical Setting**. The location of the main aquifer and aquitard complexes can be observed from the diagram. The interpreted location of the tunnel channels within the subwatershed are shown in Figure 2-16 (**Chapter 2 – Study Area and Physical Setting**).

As a result of the model the cross sectional profile of the study area was created, and is representative of the Oro North and South and Hawkestone subwatersheds (Figure 2-18 and Figure 2-19, **Chapter 2 – Study Area and Physical Setting**).The profile demonstrates how the thickness and depth of the aquifer complexes vary throughout the region.

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 in the overburden generally followed the geologic layering described in **Chapter 2 – Study Area and Physical Setting**.

A listing of the final seven integrated hydrostratigraphic units represented in the Tier 2 Model is described below. The layering outlined in Table 4-1 below follows the OGS hydrostratigraphic model (discussed in 2.2.4) with some simplification. Generally, silty sand till formations are associated with aquitards while the sandier units generally behave as aquifers. Seven layers represent aquifers or aquifer complexes while six layers represent aquitards. The channel silts and sands refer to the sediments infilling the tunnel channels where erosional processes have removed some of the earlier deposits. Model layers differed between the tunnel channels and the till uplands, although common layers are found at depth.

Table 4-1: MODFLOW layer structure (Earthfx, 2013a).

Layer	Oro Moraine/Till Upland	Tunnel Channels
1	Oro Moraine Aquifer (ICSD)	(GLAF)
2	Newmarket Till	(GLAF)
3	Upper Aquifer - AF1	Algonquin Aquifer - GLAF
V3a	Local Aquitard - AT1	
V3a	Local Aquifer - AF2	Algonquin Aquitard - GLAT
V3a	Regional Aquitard - AT3	
4	Regional Aquifer - AF4	Valley Fill: Upper Aquifer - CAF1
V4a	Lower Drift - Upper Aquitard OST	Valley Fill: Upper Aquitard - CAT1
5	Lower Drift - Local Aquifers - STAF	Valley Fill: Middle Aquifer - CAF2
V5a	Lower Drift - Middle Aquitard - LD	Valley Fill: Lower Aquitard - CAT2
6	Lower Drift - Lower Aquifer - LAF	Valley Fill: Lower Aquifer - CAF3
V6a	Lower Drift - Lower Aquitard LD2	Lower Drift - Lower Aquitard LD2
7	Basal Aquifer - Bgravel	Basal Aquifer - Bgravel
7	Weathered Bedrock	Weathered Bedrock

The groundwater system within the study area is complex. The uppermost model layer outside of the tunnel channels represents the Oro Moraine ICSD deposits, where present, along with patches of glaciofluvial material found on the till highlands. Layer 2 represents the Newmarket Till aquitard which consists of the upper till unit on the till uplands.The Newmarket Till effectively forms a protective barrier for the deeper aquifers. Layer 3 represents the upper regional aquifer (AF1). The Local Aquifer, AF2, is patchy over most of the study area, and for simplicity, was grouped with the Local Aquitard (AT1) and Regional Aquitard (AT3) into one aquitard unit. The MODFLOW code has an option to represent aquitards as virtual layers located between the primary aquifer layers. When this option is used, flow in the aquitards is assumed to be in the vertical direction only. This approach was adopted to represent the AT1/AF2/AT3 unit. Virtual layers only need information on the thickness and equivalent vertical hydraulic conductivity. The model does not solve for the water levels, known as heads, in the virtual layer, but flow across the unit can be determined based on the simulated heads in the adjoining aquifers and the vertical conductance (i.e., the vertical hydraulic conductivity divided by the aquitard thickness).

The regional aquifer is represented by Layer 4, AF4. Layer 5 represents local aquifers within the lower drift (STAF), and Layer 6 represents the lower regional aquifer, LAF. Virtual layers were used to represent the intervening upper aquitard (OST) and the middle aquitard (LD), and the underlying lower aquitard (LD2).

Within the tunnel channels, the uppermost unit is the Algonquin Aquifer (GLAF), composed of sandy postglacial lake deposits, gravelly beach and bar sediments, and recent alluvium. These tunnel channels were infilled with sand and silt deposits as melt water energy waned. The nature of the infill material is important for understanding the groundwater flow system as it determines the amount of transfer between the shallow and deeper aquifer systems. To keep the number of model layers the same as for the till uplands, the GLAF was subdivided and represented in Layers 1, 2, and 3. The Algonquin Aquitard was represented as a virtual layer separating the GLAF and upper valley-fill aquifer (CAF1). Layer 4 represents the upper valley-fill aquifer (CAF1), Layer 5 represents the middle valley-fill aquifer (CAF2), and Layer 6 represents the lower valley fill aquifer (CAF3). Virtual layers represent the intervening upper and lower aquitards, CAT1 and CAT2 (Earthfx, 2013a).

The lower aquitard (LD2) is assumed to be present beneath the entire study area (including the tunnel channels) and is the first of the common units. The basal gravel unit beneath LD2 is patchy and, for simplicity, was combined with the weathered bedrock in Layer 7. The base of the model is represented by the top of the unweathered bedrock.

An important consideration in translating the conceptual model layers to numerical model layers is that the MODFLOW code requires continuity of aquifer layers whereas the hydrostratigraphic model can have zero thickness. Where physical layers pinched out (i.e., had a zero thickness), the layer was assigned a minimum thickness (2.0 m for aquifers and 1.0 m for aquitards) and hydraulic properties were assigned based on those of the underlying layer (Earthfx, 2013a).

4.2.2 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). Coarse grained materials (sands and gravels) were assigned a higher hydraulic conductivity than finer grained materials (silts and clay). Figure 4-3 through Figure 4-9 display the spatial distribution of hydraulic conductivities within each aquifer and aquitard in the subwatershed. The higher hydraulic conductivities assigned in Layer 1 within the study area correlate to the Oro Moraine aquifer unit whose permeable sand and gravel materials are associated with high recharge rates (Figure 4-3). Contrary to Layer 1, the extensive Newmarket Till aquitard unit (Layer 2) overlies much of the study area and has lower hydraulic conductivity values typically associated with the silty sand unit. The hydraulic conductivity values assigned to Layers 3, 4, 5, 6, and 7 represent variable conditions within the underlying areas. Some of the variations in the layers are due to the assignment of hydraulic conductivities from underlying layers in areas where the main unit is not present (Earthfx, 2013a).

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 increases 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 (5.2.3) will discuss how these properties influence groundwater flow.

Figure 4-2: Study area (Earthfx, 2013a).

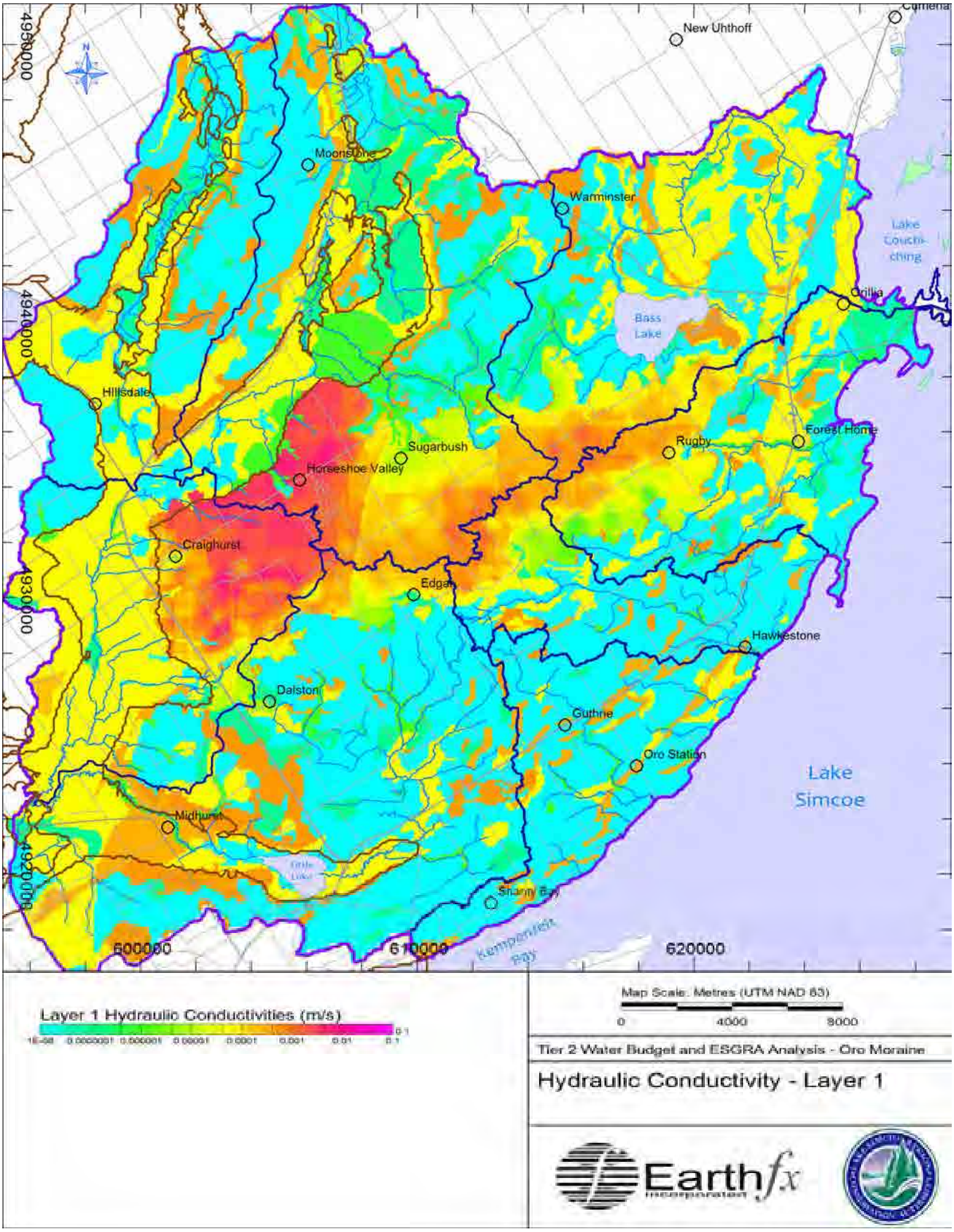


Figure 4-3: Hydraulic conductivity, in m/s, for Layer 1 (ICSD and GLAF) (Earthfx, 2013a).

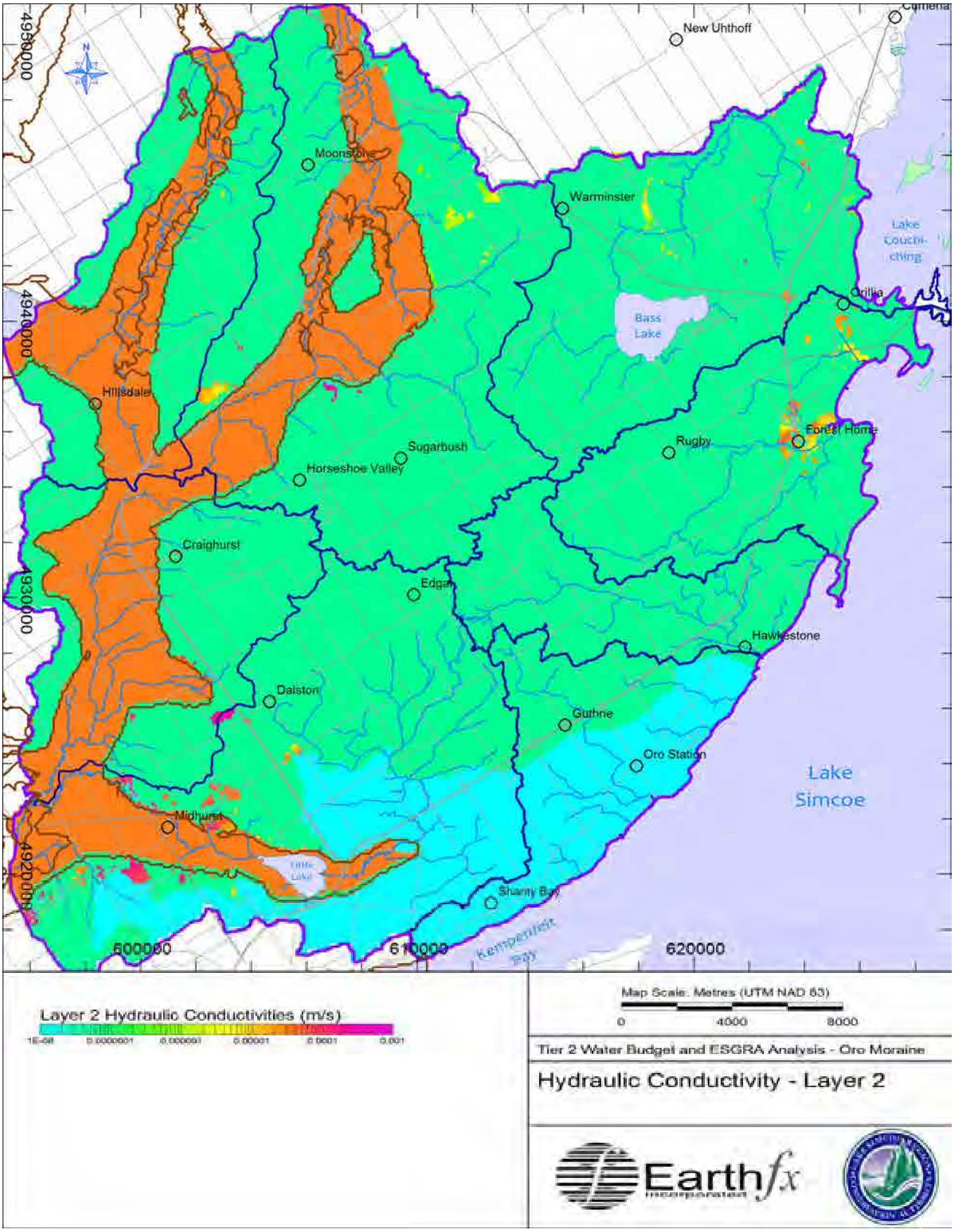


Figure 4-4: Hydraulic conductivity, in m/s, for Layer 2 (Newmarket Till/GLAF) (Earthfx, 2013a).

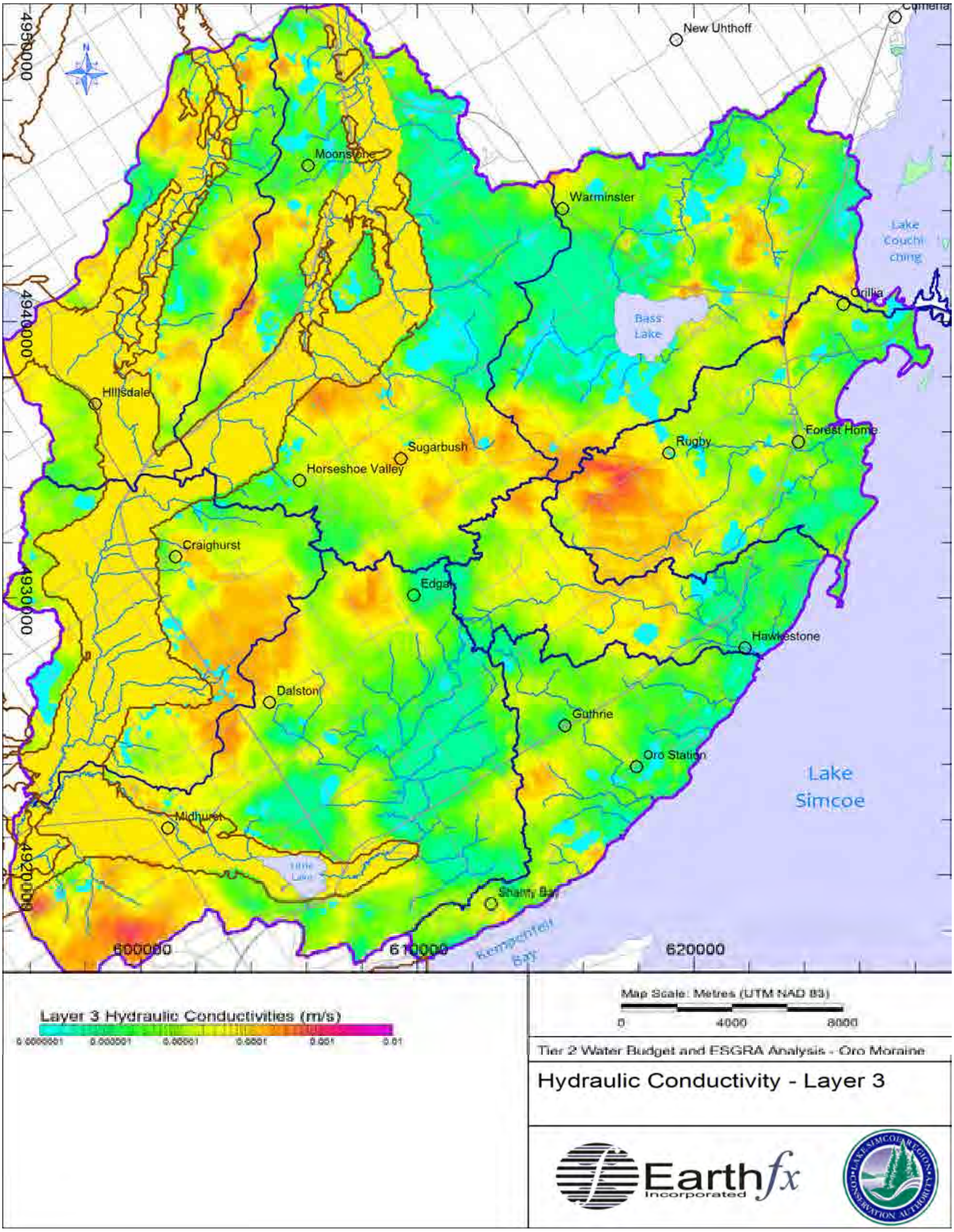


Figure 4-5: Hydraulic conductivity, in m/s, for Layer 3 (AF1I/GLAF) (Earthfx, 2013a).

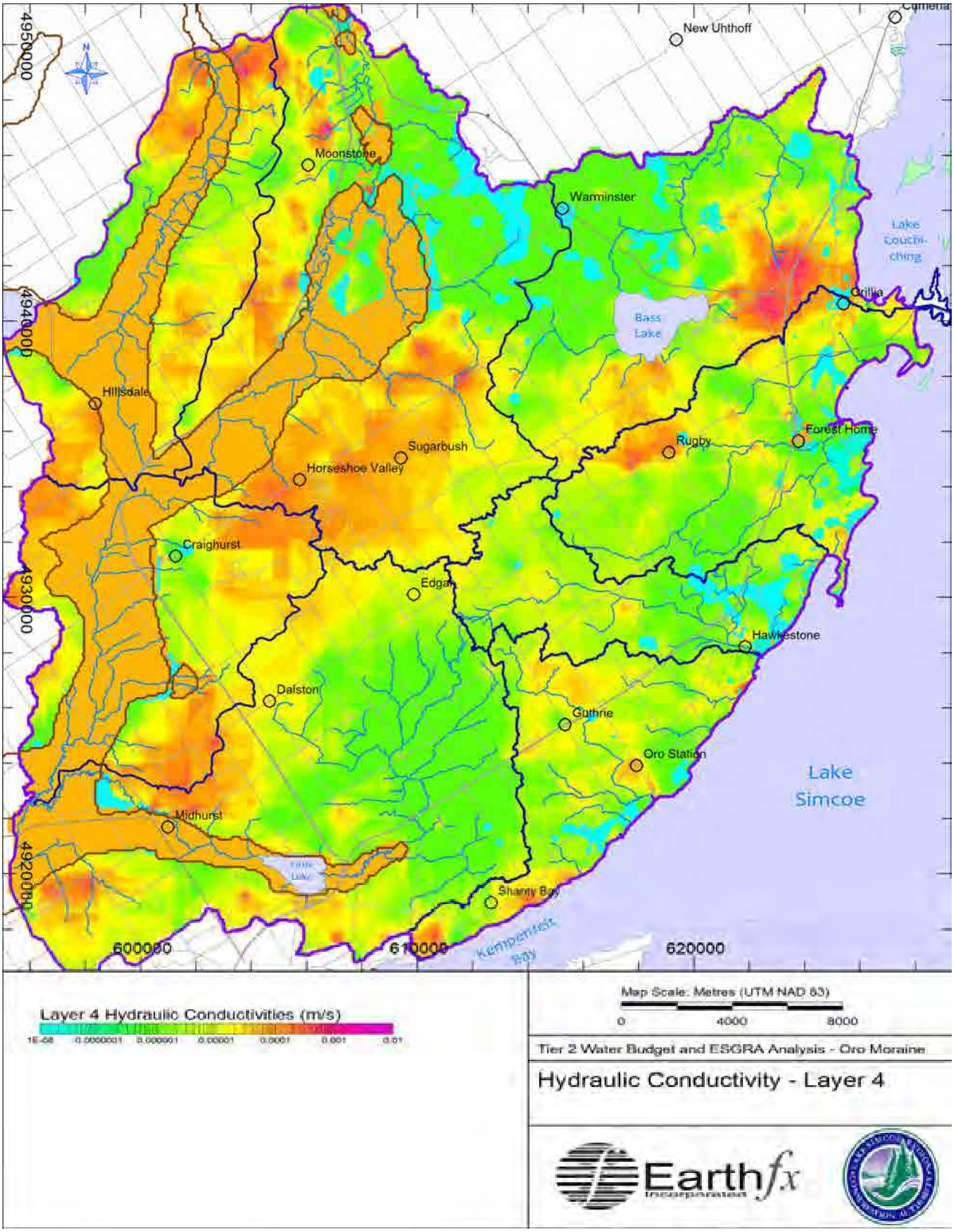


Figure 4-6: Hydraulic conductivity, in m/s, for Layer 4 (AF4/CAF1) (Earthfx, 2013a).

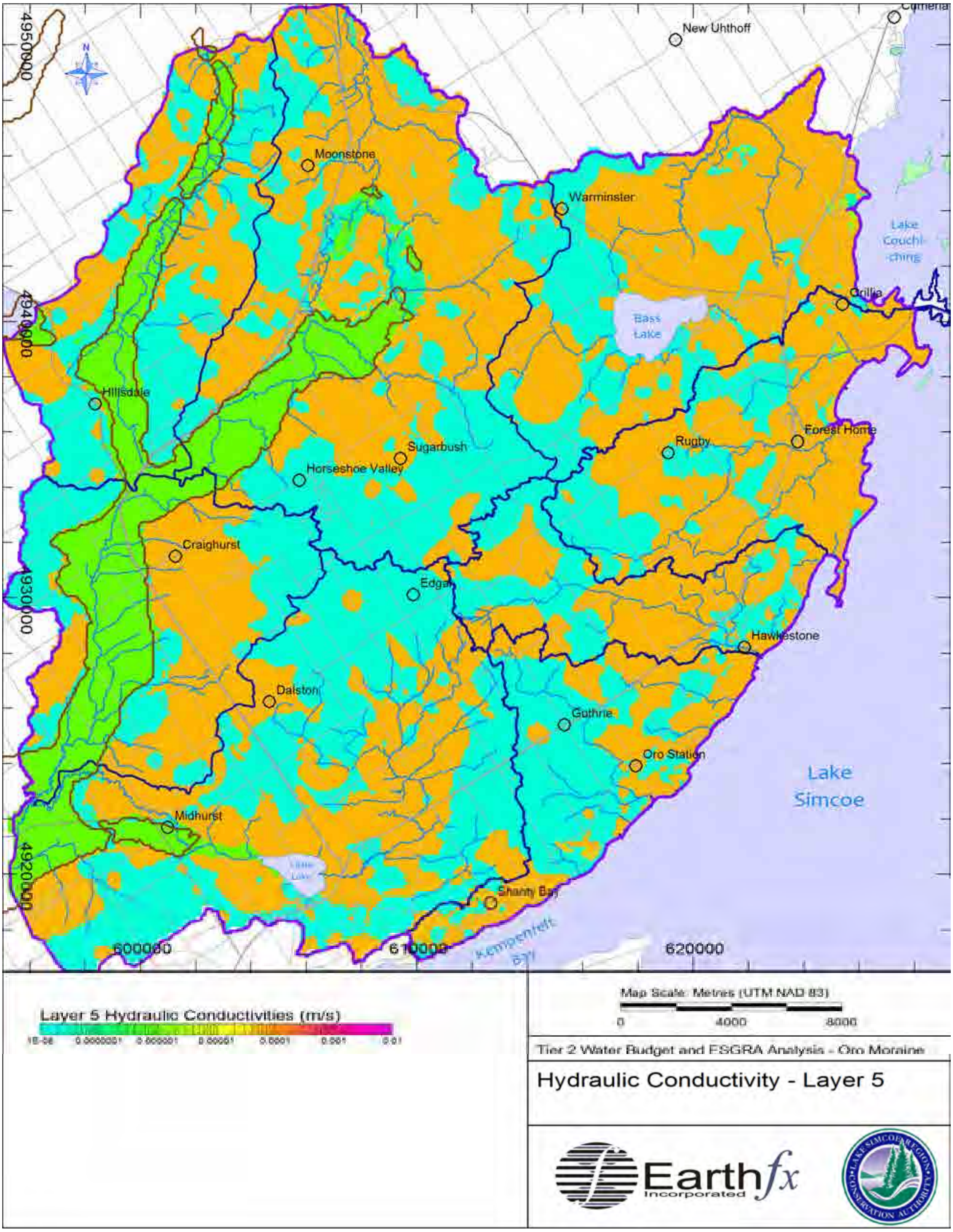


Figure 4-7: Hydraulic conductivity, in m/s, for Layer 5 (STAF/CAF2) (Earthfx, 2013a).

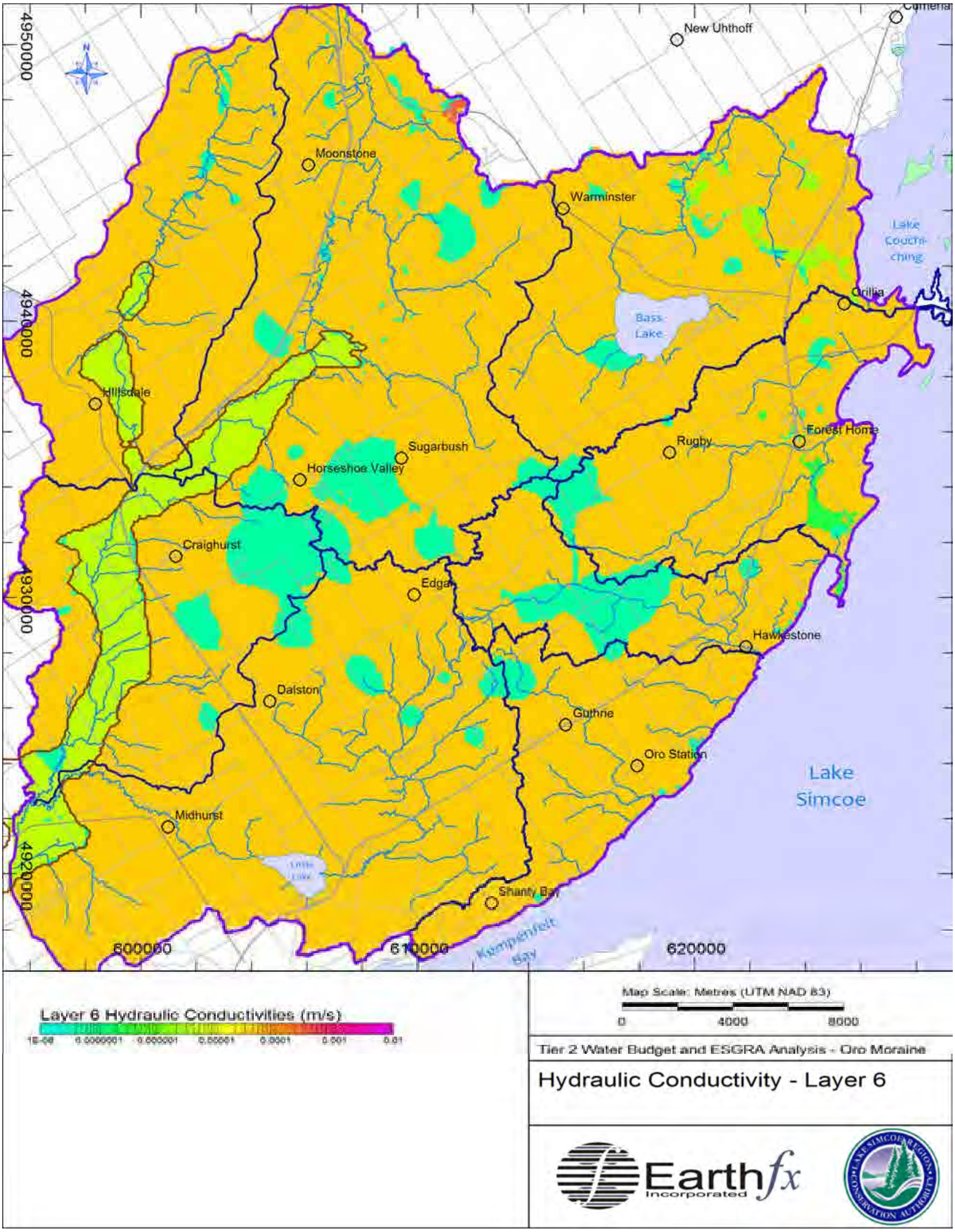


Figure 4-8: Hydraulic conductivity, in m/s, for Layer 6 (LAF/CAF3) (Earthfx, 2013a).

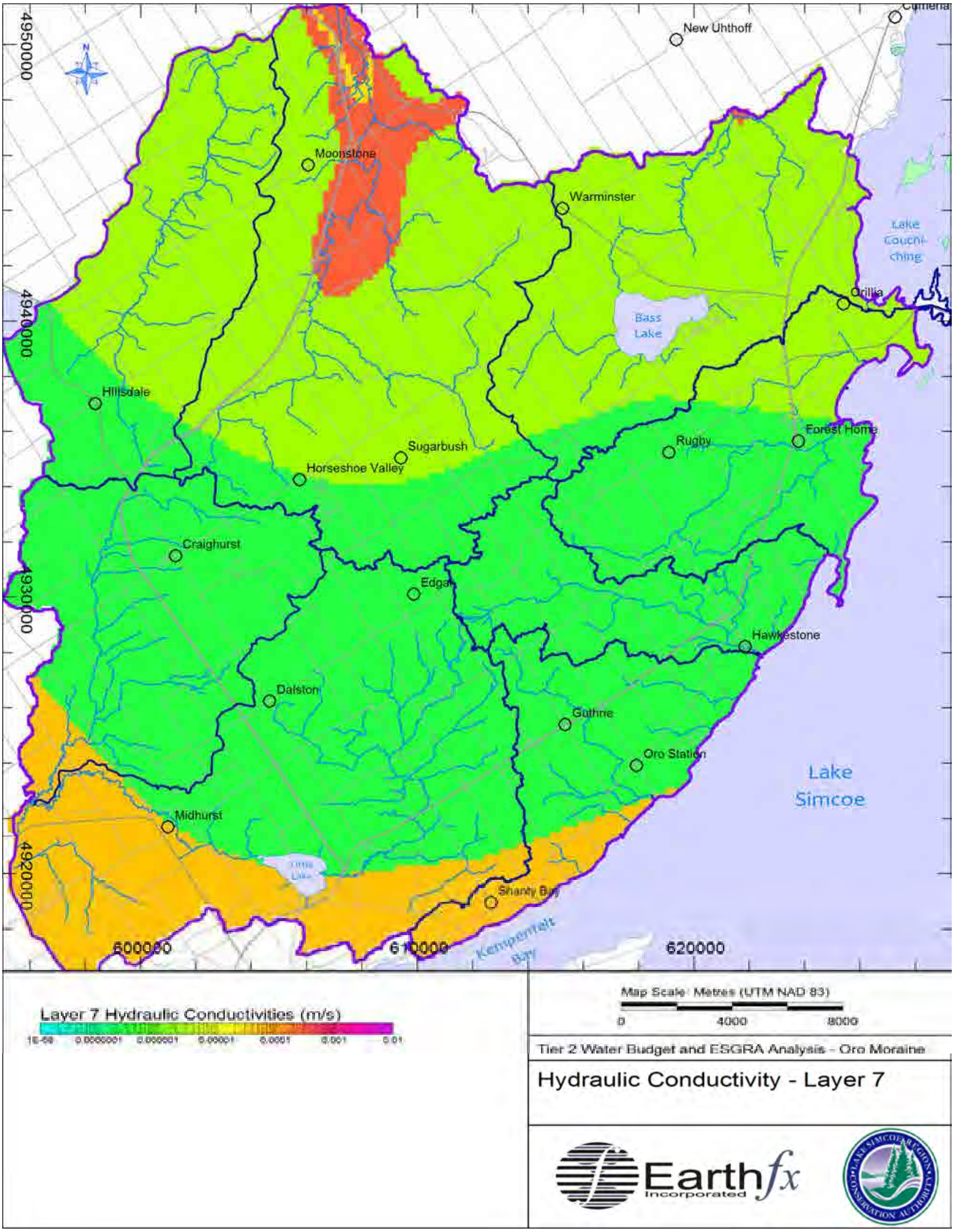


Figure 4-9: Hydraulic conductivity, in m/s, for Layer 7 (Weathered Bedrock) (Earthfx, 2013a).

4.2.3 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 formations mentioned in Section 5.2.2. 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. Simulated and observed water levels (hydraulic heads) for the individual model layers are shown in Figure 4-10 and Figure 4-11.

Due to the presence of permeable surface soils and hummocky topography, the Oro Moraine is the primary recharge area to the underlying aquifers. Groundwater flow within the three major aquifer systems is generally from the topographic highs associated with the Oro Moraine towards the topographic lows associated with the major stream channels and Lake Simcoe. In the shallow groundwater flow system, groundwater flow patterns are influenced by ground surface topography, but are more significantly influenced by the stream network.

Figure 4-11 to Figure 4-16 illustrate the significance of the Oro Moraine on groundwater flow conditions within the subwatersheds. The regional groundwater flow in the area is influenced by the Oro Moraine, resulting in a significant easterly flow component. Groundwater flow within the deeper groundwater flow system, comprised of Regional Aquifer AF4, Lower Drift-Lower Aquifer LAF and Basal Aquifer (Bgravel), exhibit a similar, but more subdued, pattern to the shallow flow system (Earthfx, 2013a).

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 are generally downward over most of the study area and are steepest where the Newmarket Till is thickest (Earthfx, 2013a).

Backward particle tracking analyses were carried out within the subwatersheds. With backward tracking, particles are introduced in a dense distribution at the point of known groundwater discharge or around ecologically significant discharge features and traced back to the point of recharge. Based on reverse particle tracking completed for this area, the regional groundwater flow contribution supports numerous wetland features in the Hawkestone area (Earthfx, 2013b). Based on the integrated groundwater and surface water model, a few wetlands within the subwatershed were identified as functioning as recharge areas for at least part of the year (Earthfx, 2013b). These analyses also indicated that some significant features within the subwatersheds, in particular the headwaters of Hawkestone Creek, are likely receiving significant quantities of lateral groundwater inflow from outside the subwatershed (Earthfx, 2013a).

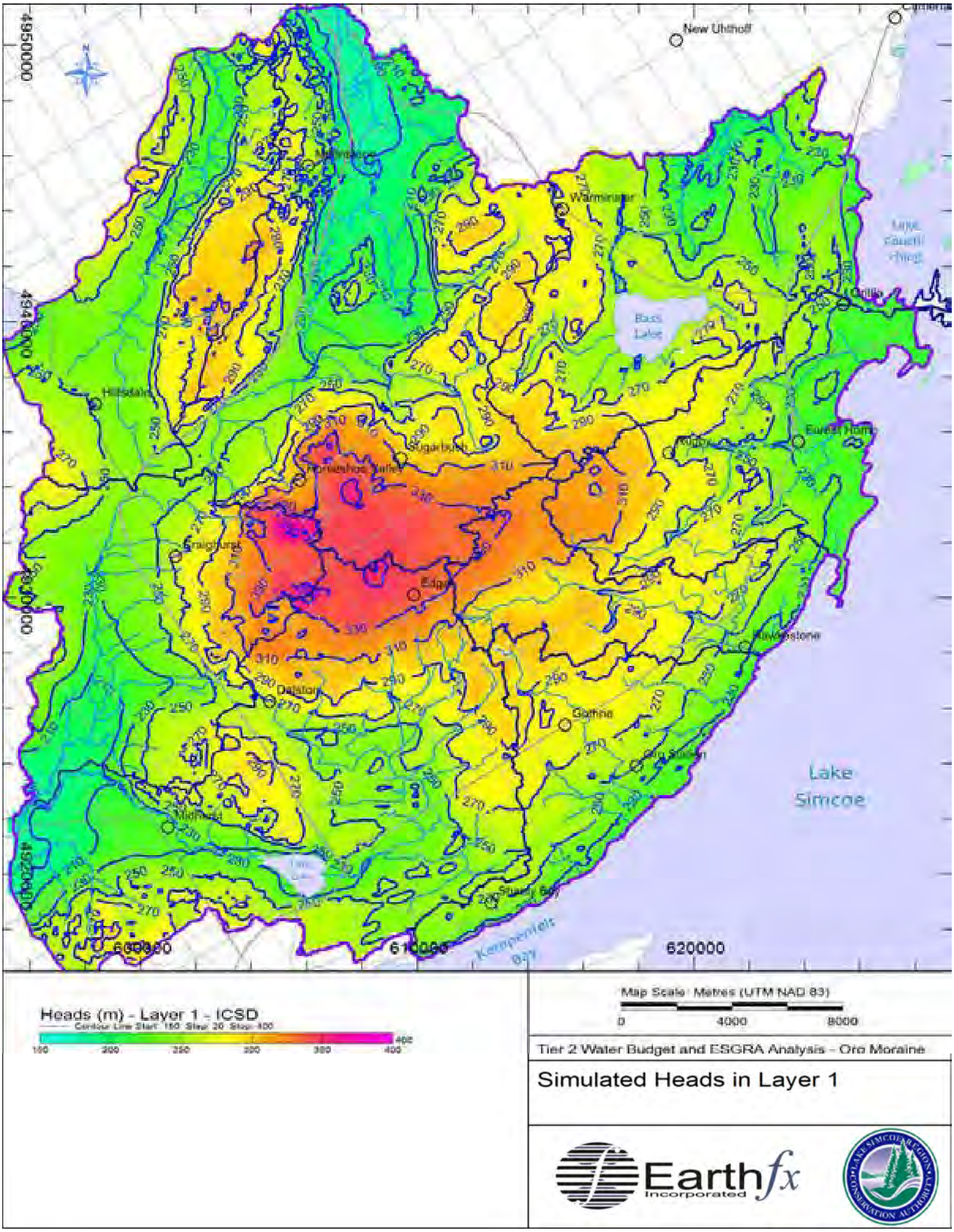


Figure 4-10: Simulated heads in Layer 1 (Earthfx, 2013a).

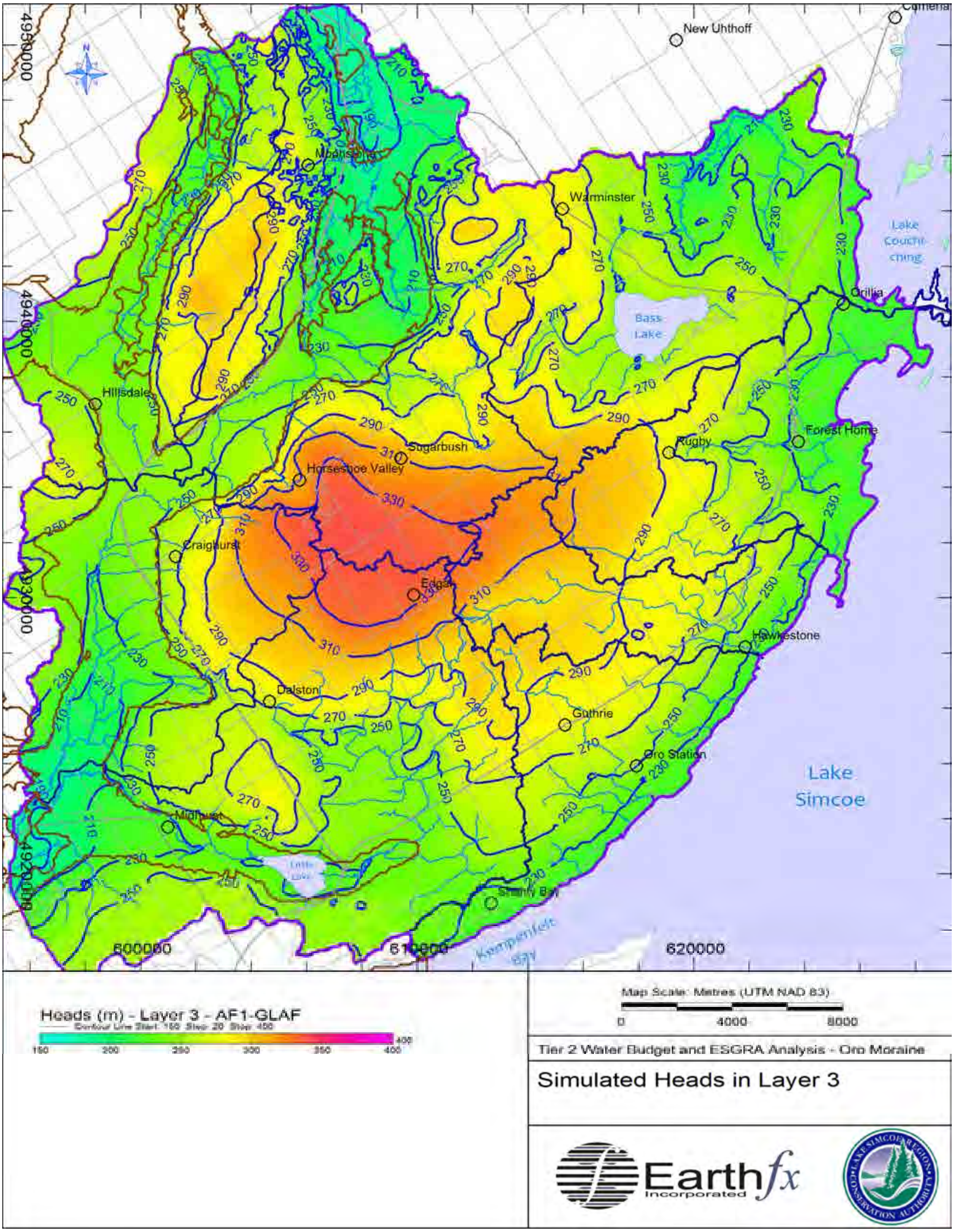


Figure 4-11: Simulated heads in Layer 3 (Earthfx, 2013a).

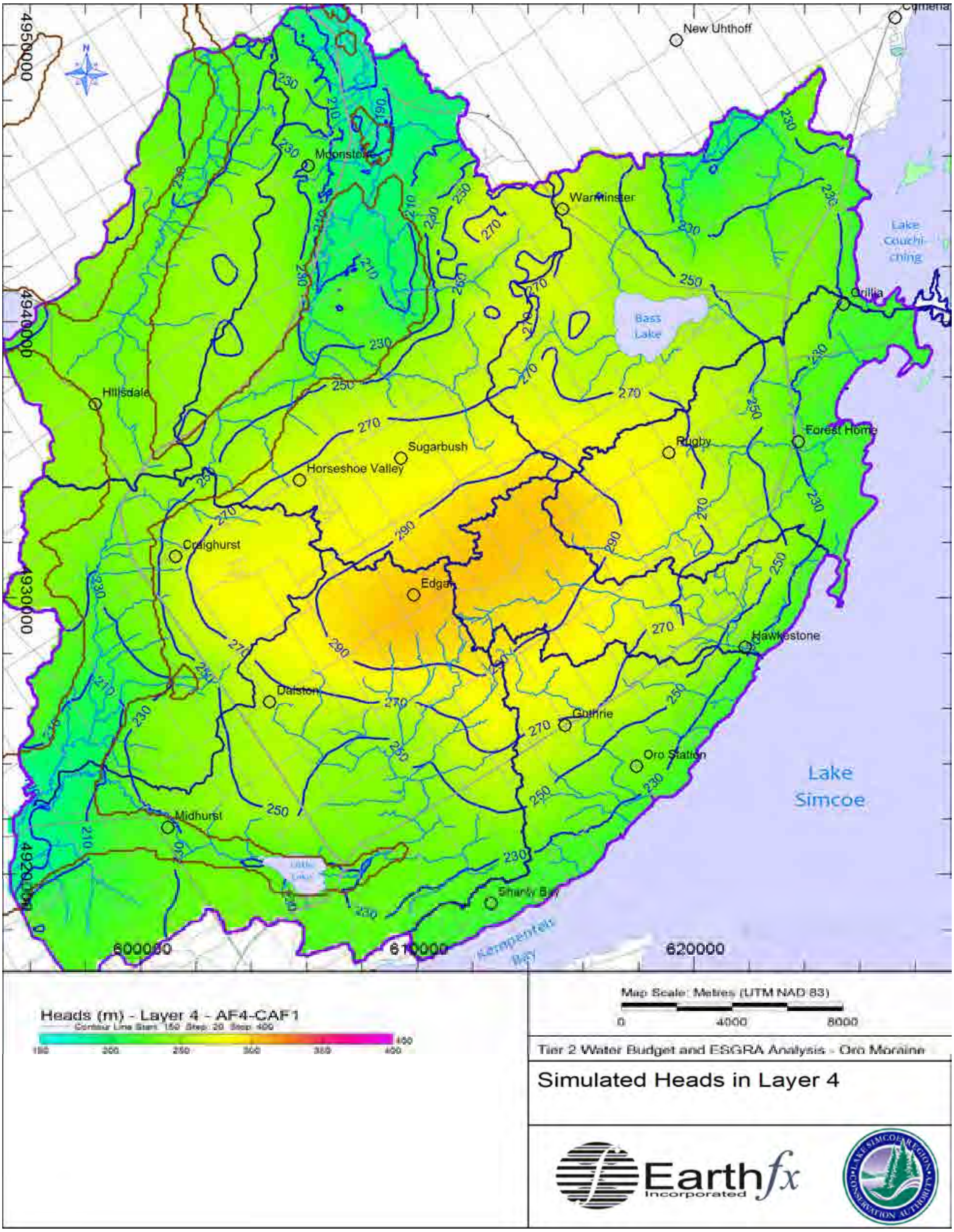


Figure 4-12: Simulated heads in Layer 4 (Earthfx, 2013a).

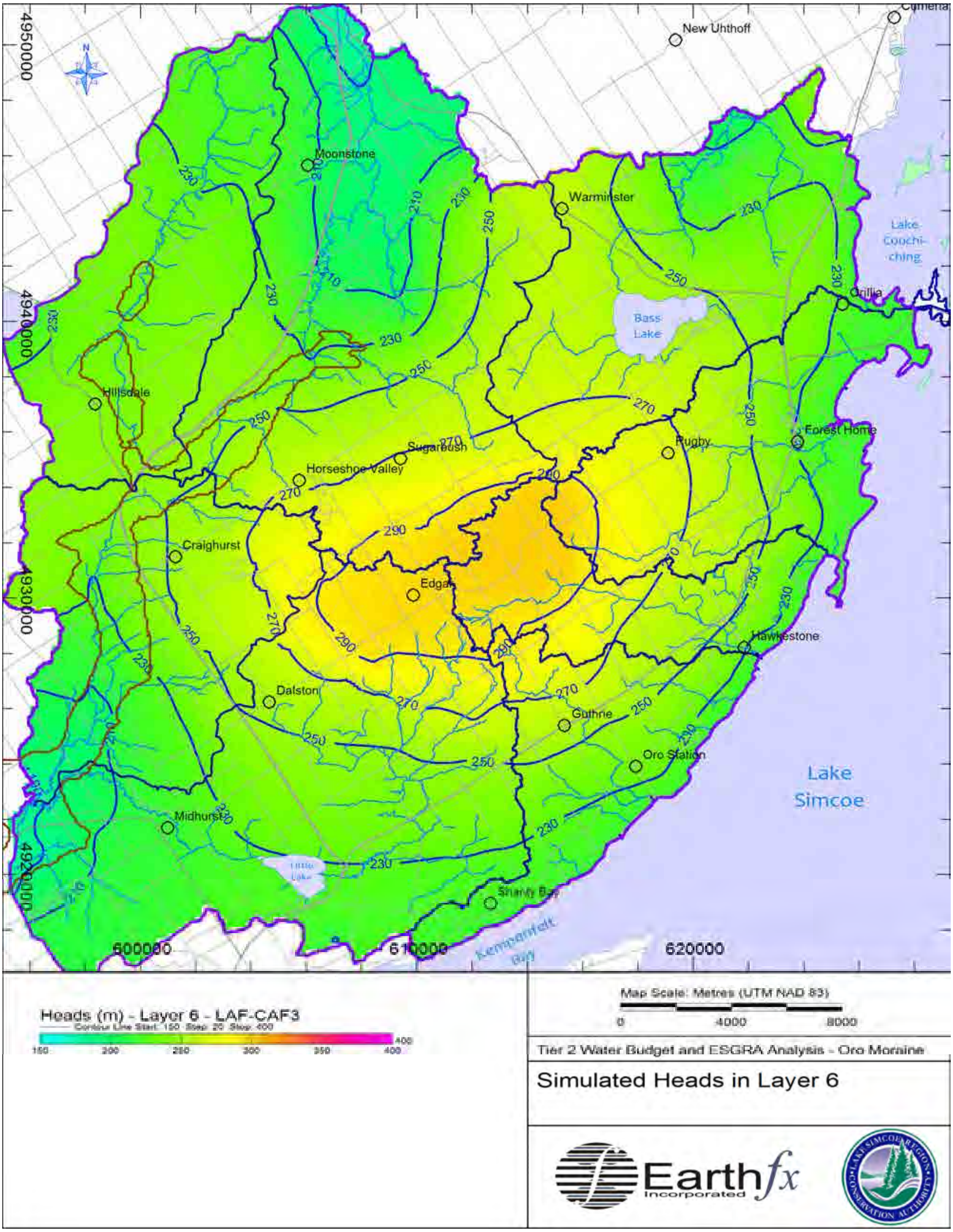


Figure 4-13: Simulated heads in Layer 6 (Earthfx, 2013a).

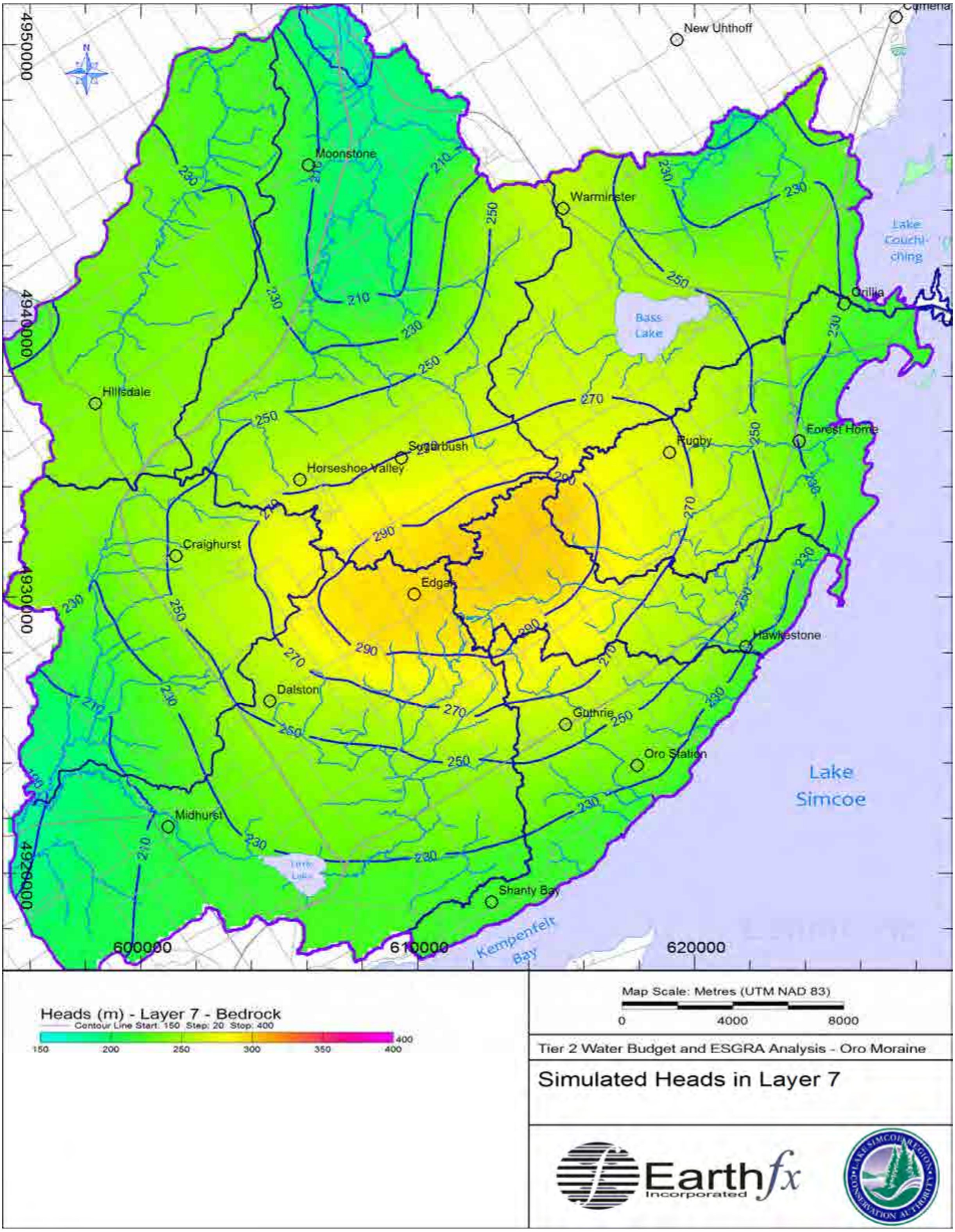


Figure 4-14: Simulated heads in Layer 7 (Earthfx, 2013a).

4.2.4 Streamflow

The Oro Model and related data compilation covers an area well beyond the boundaries of Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds study area. Figure 4-2 shows the locations of the major streams in the model area and their catchment area as defined by land surface topography. Figure 4-18 also shows the location of the HYDAT stream gauges monitored by Environment Canada. There is one stream gauge within the Hawkestone Creek subwatershed, which has been operated by Environment Canada Water Survey since 2005.

The Hawkestone Creek gauge is located approximately 750 m upstream of the outlet of Hawkestone Creek to Lake Simcoe conflux. A continuous record of water elevation (stage) is monitored using a constant flow bubbler and datalogger at Hawkestone Creek. The continuous stage record is converted to discharge (volume per unit time) using an established stage-discharge relationship.

Gauge identification, period of record, and streamflow statistics for the period of record are presented in Table 4-2. The Hawkestone Creek daily average discharge for the 2006 to 2012 period of record is 0.533 m^3/s. Figure 4-15 and Figure 4-16 illustrate the temporal distribution of discharge for the Hawkestone Creek gauge. Typically, the greatest discharge is exhibited in March, however the greatest average monthly discharge occurred in April 2008. The greatest recorded daily discharge for Hawkestone Creek was 9.220 m^3/s (Figure 4-15). This event occurred January 9th, 2008, coinciding with four consecutive days of above 0^oC air temperatures and approximately 65 mm of precipitation on a 30 cm snow pack. Figure 4-17 and Table 4-3 display monthly minimum, mean, and maximum discharges for the Hawkestone Creek period of record.

Table 4-2: Flow statistics for gauged catchments in the model area.

Gauge ID	Gauge Name	Start Year	End Year	Watershed Area [ha]	Mean Annual Flow [m^3/s]	90th % flow (Q90) [m^3/s]	Median Flow (Q50) [m^3/s]
02EC020	Hawkestone Creek at Hawkestone	2005	Present	3954	0.533	0.141	0.556

*Flow statistics have been generated by LSRCA for 2006 to 2012, only 2006 to 2010 have been published by Environment Canada Water Survey and post 2010 is only preliminary data quality.

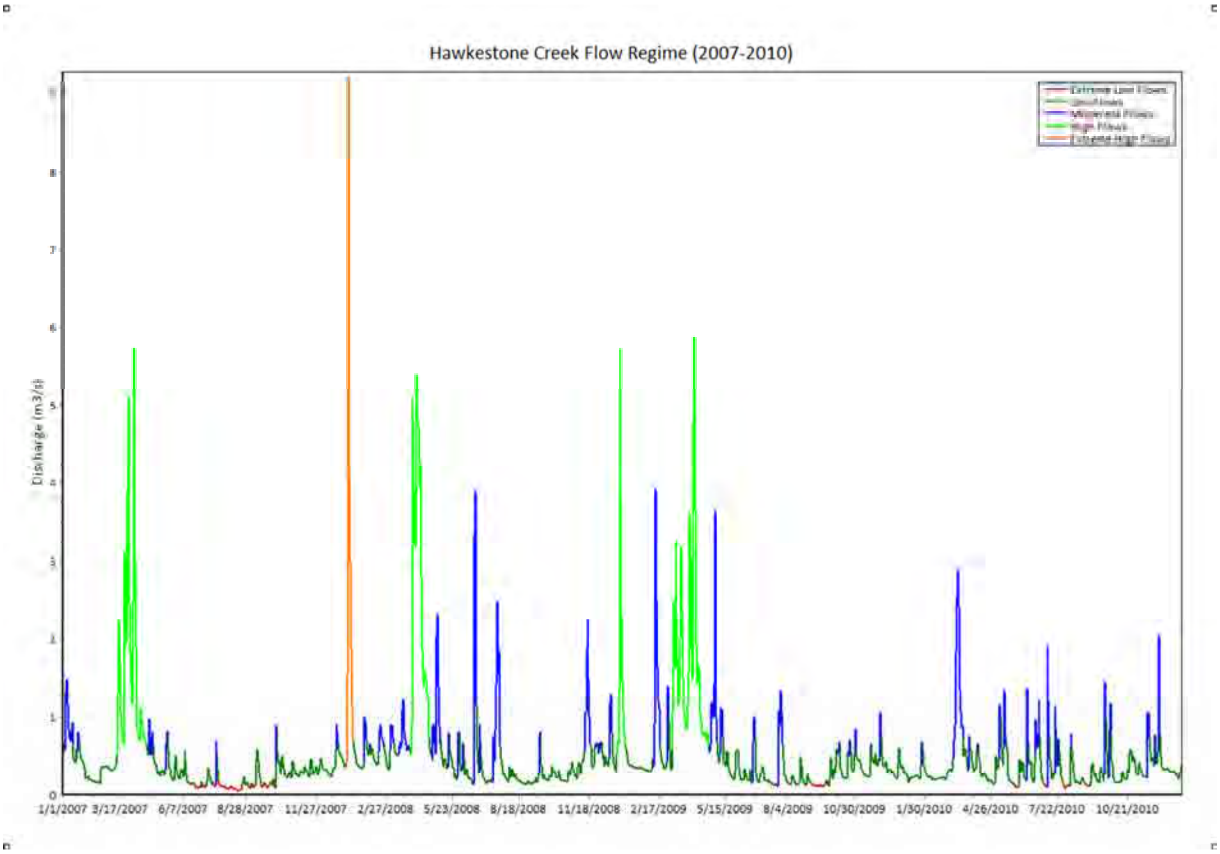


Figure 4-15: Hawkestone Creek flow regime, extreme low flows are flows with a return interval of 10 years, low flows are less than the 75th percentile flow, moderate flows are greater than the 75th percentile flow, high flows have a return interval of 2 years, and extreme high flows have a return period of 10 years or more.

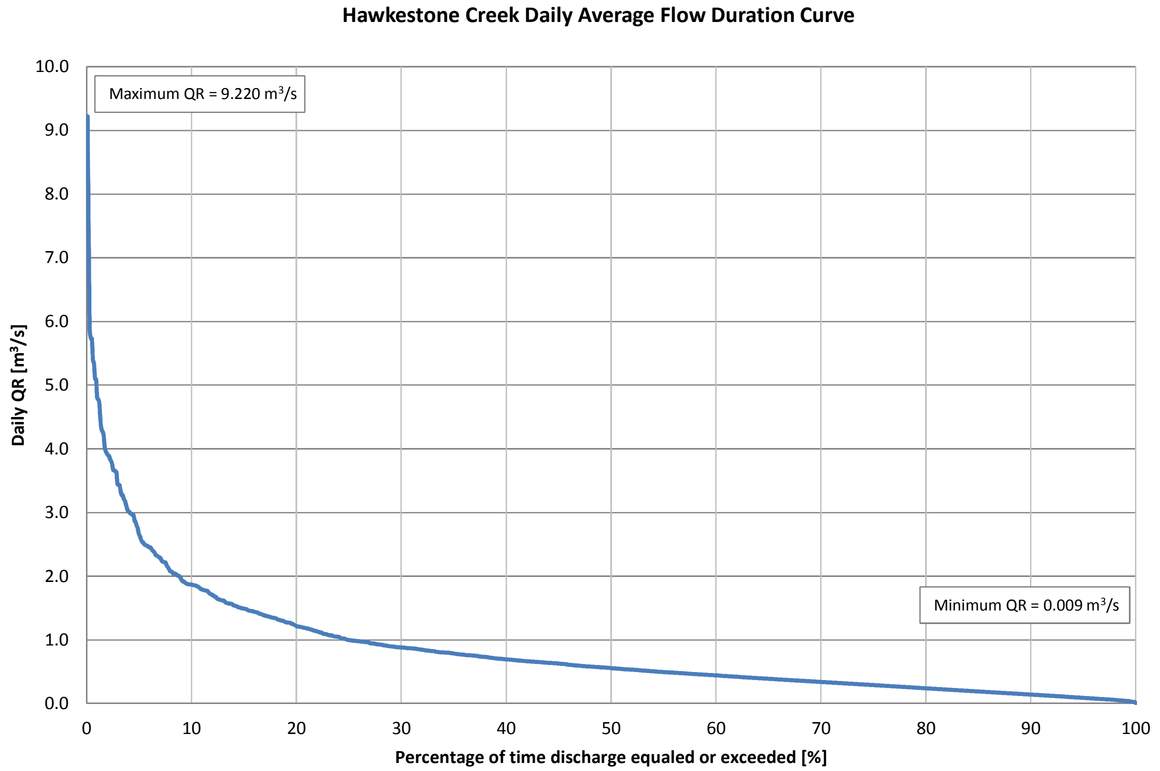


Figure 4-16: Hawkestone Creek daily average flow duration curve for 2006-2012 period of record.

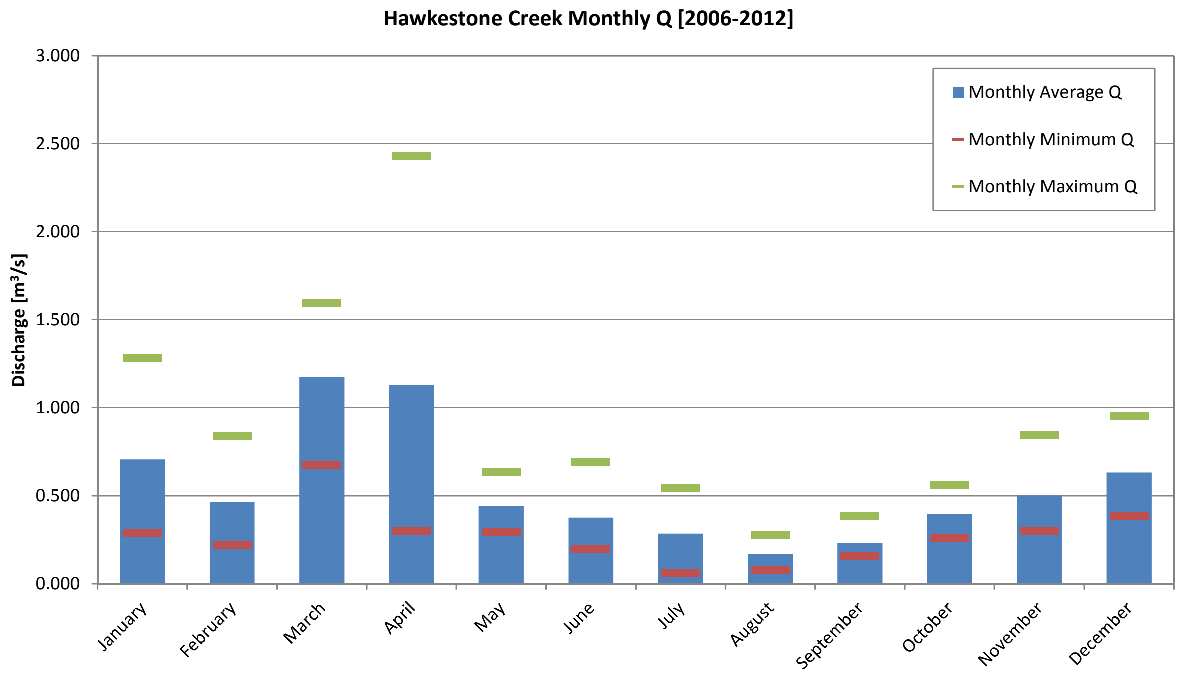


Figure 4-17: Monthly minimum, mean, and maximum discharge (Q) for the Hawkestone Creek gauge including the 2011 and 2012 unpublished data.

Table 4-3: Monthly average discharge for Hawkestone Creek at Hawkestone gauge (m^3/sec)

Year	January	February	March	April	May	June	July	August	Septembe	October	Novembe	December
2006				1.151	0.289	0.304	0.203	0.078	0.198	0.519	0.843	0.873
2007	0.652	0.234	1.361	1.130	0.342	0.194	0.186	0.101	0.170	0.314	0.300	0.406
2008	1.281	0.567	0.670	2.428	0.614	0.688	0.544	0.200	0.251	0.255	0.656	0.953
2009	0.429	0.839	1.595	1.492	0.631	0.288	0.348	0.194	0.154	0.388	0.388	0.383
2010	0.288	0.217	0.876	0.299	0.392	0.497	0.420	0.210	0.381	0.295	0.426	0.406
2011	0.784	0.492	1.325	1.091	0.502	0.338	0.222	0.277	0.207	0.561	0.490	0.839
2012	0.802	0.439	1.209	0.316	0.315	0.326	0.062	0.136	0.266	0.429	0.408	0.556
AVG	0.706	0.464	1.173	1.129	0.441	0.376	0.283	0.171	0.232	0.394	0.502	0.631
MIN	0.288	0.217	0.670	0.299	0.289	0.194	0.062	0.078	0.154	0.255	0.300	0.383
MAX	1.281	0.839	1.595	2.428	0.631	0.688	0.544	0.277	0.381	0.561	0.843	0.953

Figure 4-18: Surface water features and WSC streamflow gauging stations (Earthfx, 2013a).

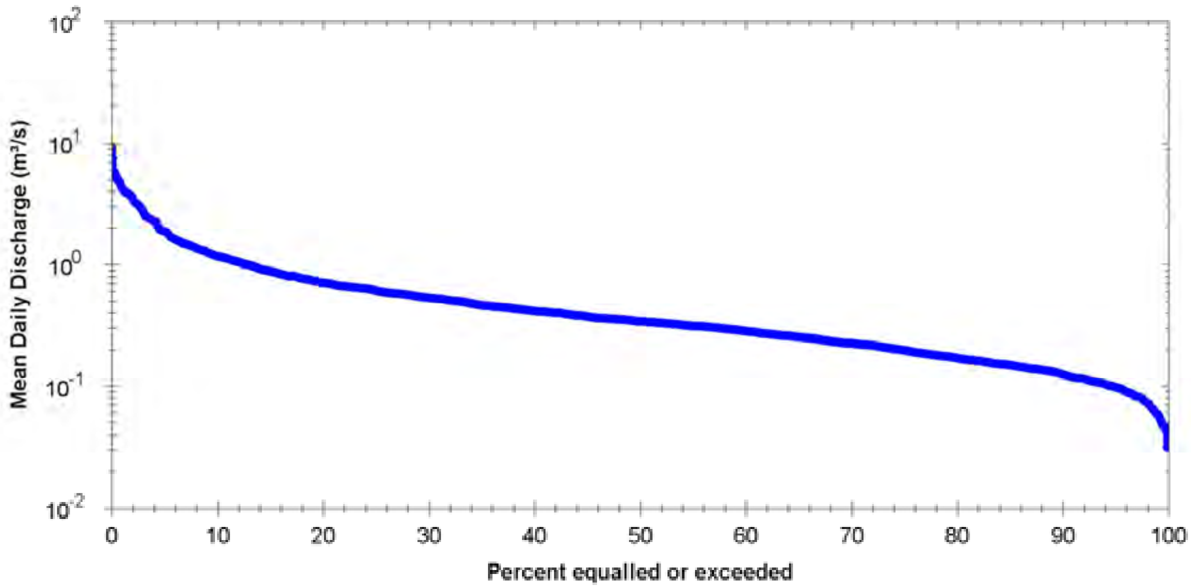


Figure 4-19: Mean daily flow duration curve - Hawkestone Creek at Hawkestone (02EC020) (Earthfx, 2013a)

Baseflow

Baseflow is considered the portion of stream flow that is derived from groundwater discharge, from sources such as springs and seepages that release the cool groundwater. The baseflow component within streams is vital for fish populations that require coldwater habitat. This habitat can be affected by localized pumping as the aquifers are drawn down and less baseflow is released.

Hydrograph separation (Figure 4-20) and baseflow indices (baseflow/total flow) for the Hawkestone Creek subwatershed indicate considerable flow contribution from groundwater sources with a 7-year average baseflow index of 66.3% and annual baseflow indices greater than 60% (Table 4-4). Moreover, annual rainfall:runoff ratios for Hawkestone Creek subwatershed indicate that the subwatershed only discharges about 45% of the rainfall it receives and therefore infiltrates, intercepts or evapo-transpires the remaining 55%. Unlike other, more urban, subwatersheds the Hawkestone Creek subwatershed has undergone limited development with urban landuses (Urban Residential, Estate Residential, Institutional, Commercial, Industrial and Road ELC classification) only comprising 3.6% of the total subwatershed area, which is the reason so little of the rainfall is discharged.

Table 4-4: Annual and average baseflow indices and rainfall runoff ratios for Hawkestone Creek at Hawkestone gauge.

Year	2006*	2007	2008	2009	2010	2011[a]	2012[a]	7-year $\bar{x}$
BFI (%)	64.0	71.4	63.7	69.4	65.9	62.0	67.8	66.3
Rainfall:Runoff (%)	37.2	40.7	52.8	51.7	32.9	53.0	46.5	45.0

*Value calculated using partial year data.
[a]Value calculated using unpublished data.

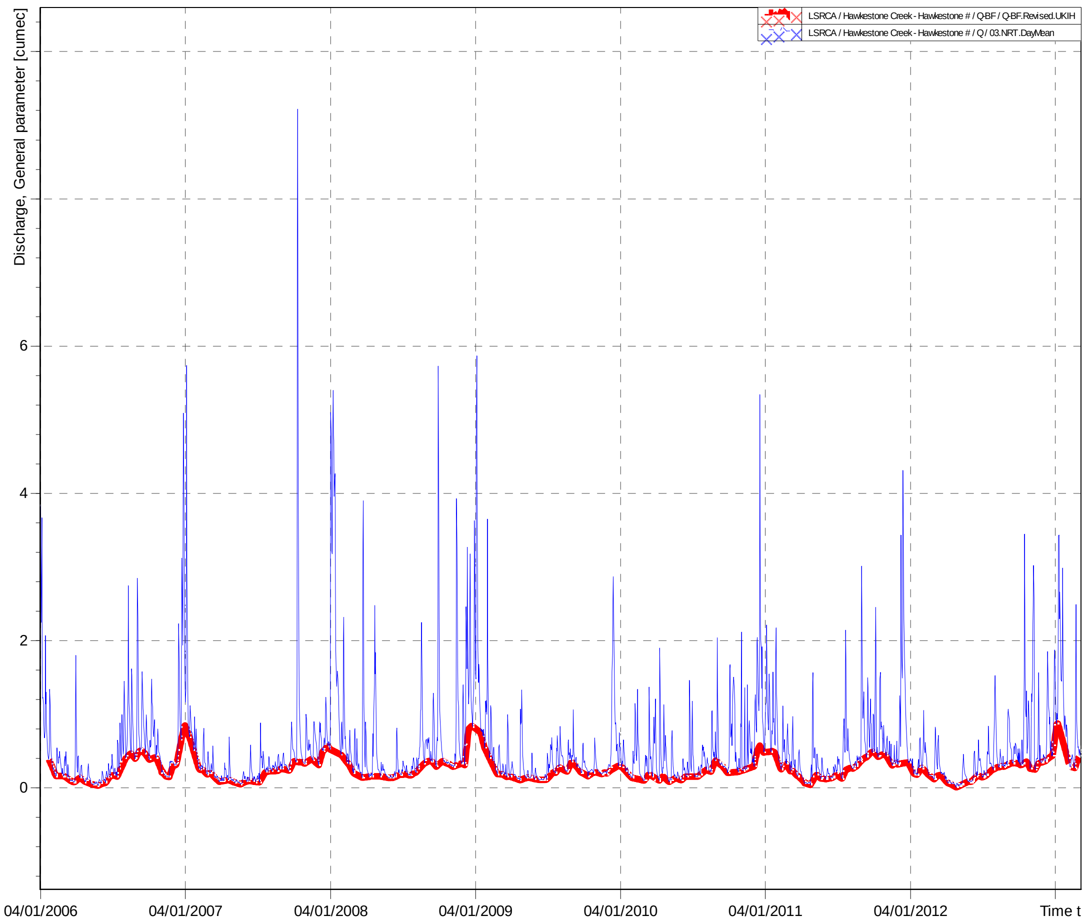


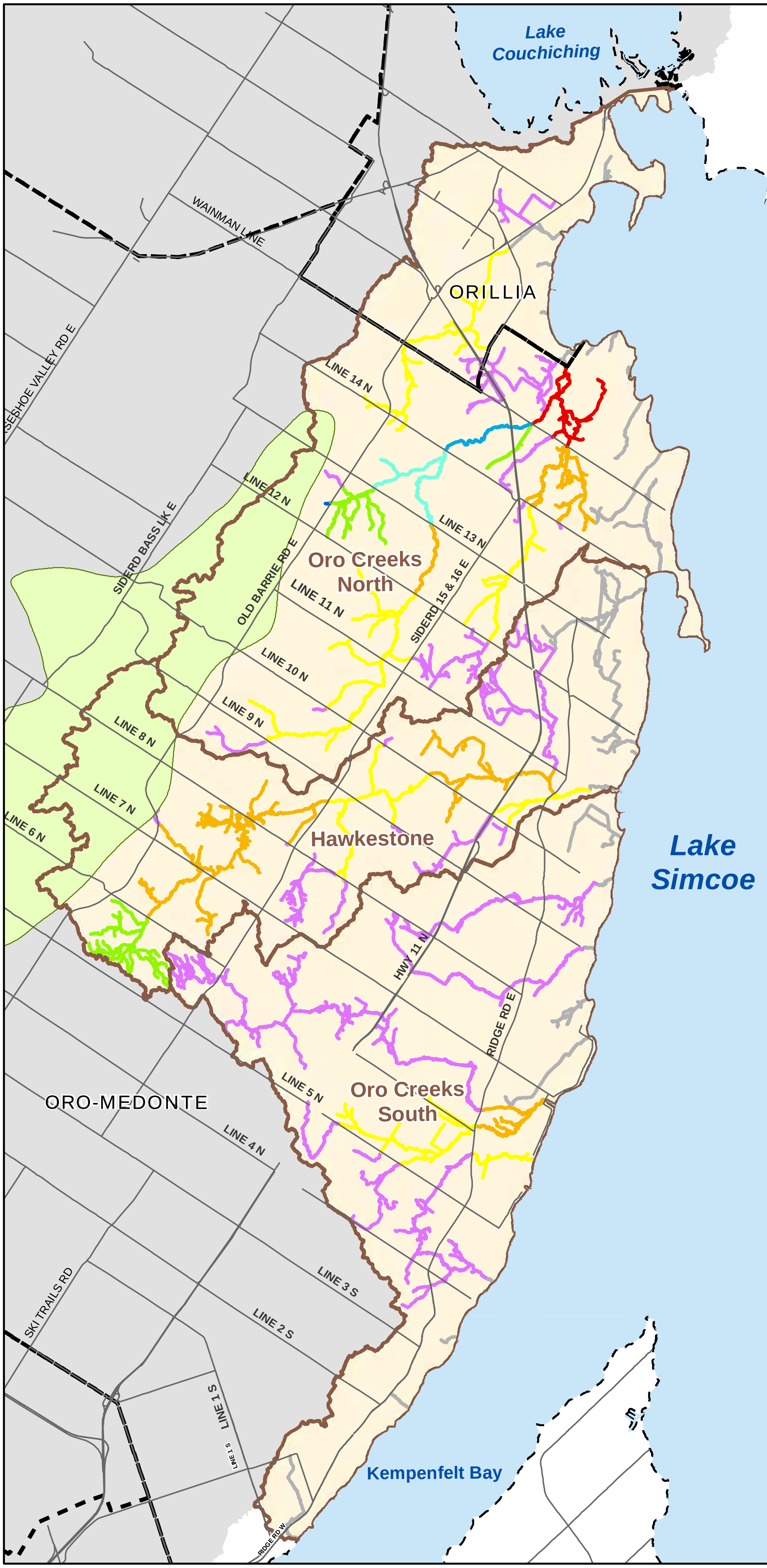
Figure 4-20: Hydrograph separation for the Hawkestone Creek at Hawkestone gauge

While flow gauges are a very effective tool for examining baseflow, only one gauge is present in the Hawkestone Creek subwatershed, which makes an accurate description of baseflow across the entire study area difficult. For this reason discrete baseflow measurements were conducted in the Oro and Hawkestone Creeks subwatersheds. The results of the 2005 survey conducted by the LSRCA are illustrated in the following Figure 4-21.

Discharge measures were performed 72 hours after precipitation to ensure they were representative of baseflow. For the purpose of analysis each measure was compared to the closest upstream measure to determine if the reach between the measures was gaining or losing flow. Gaining reaches indicate groundwater contribution to the stream while losing reaches could indicate water taking, groundwater infiltration, or impoundments. Figure 4-21 indicates that the majority of reaches in the Oro and Hawkestone subwatersheds are gaining reaches which agrees with the baseflow indices calculated for Hawkestone Creek. Also, most of the reaches that indicate a loss coincide with areas with wetland complexes that readily facilitate groundwater recharge and under prolonged drought conditions will help to support baseflow in the stream. Moreover, groundwater influence on these reaches is also evidenced in the thermal stability of the streams and in the coldwater fish species they support (see **Chapter 5 - Aquatic Habitat**).

Gaining and losing reaches within the Oro creeks North, Hawkestone Creek, and Oro creeks South subwatersheds

Figure 4-21



Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Oro Moraine

Base Flow (L/s/km)

- <-20
- -10 to -20
- -5 to -10
- -0.01 to -5
- 0.01 to 5
- 5 to 10
- 10 to 20
- 20 to 30
- >30
- Dry, Standing or Too Low
- No Data

Lake Simcoe Region conservation authority

0 0.5 1 2 3

Kilometres

4.2.5 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 stream gauge in the Hawkestone Creek subwatershed which has been in operation since 2005.

The calibration of the integrated groundwater/surface water model included the groundwater heads and flow patterns observed from wells in the MOE water well database, in conjunction with Water Survey of Canada (WSC) streamflow gauge stations in the area. The direct contribution of groundwater to streamflow was assessed from the integrated model output. This value does not account for the total groundwater contribution to streamflow because it does not include groundwater discharge to wetlands and lakes and does not include discharge of groundwater in riparian areas (surface leakage) that subsequently reaches the stream as Dunnian runoff. Dunnian runoff is typical in humid regions characterised by a high groundwater table. Dunnian runoff is associated with excess saturation mechanism where near the bottom of a hillslope the soil water content is high and gradually decreases upstream of the hillslope. However, direct groundwater discharge to streams provided a good parameter to study the sensitivity of channel features to changes in the groundwater system (Earthfx, 2013a).

The monthly average groundwater discharge to Oro North, Oro South, and Hawkestone Creeks is shown in Figure 4-22. Groundwater seepage to streams is at its minimum in late-summer/early fall in the study catchments and shows a decreasing trend over the drought period. The Oro Creeks North demonstrate the highest net groundwater discharge of the study catchments, followed by Hawkestone Creek and the Oro Creeks South. Groundwater seepage is reduced during 1958 (the driest year on record in the study area). The groundwater system recovered in 1959 and 1960; however Oro South does not appear to rebound to the same extent as the northern catchments. During the period from 1961 to 1964, precipitation is again reduced, which results in a decrease in groundwater seepage. Seepage is reduced to levels below those of 1958, suggesting the study watersheds are more sensitive to periods of prolonged drought than an extreme yearly event. The yearly average total groundwater discharge to Oro North, Oro South and Hawkestone Creeks shown in Figure 4-23 exhibit similar patterns as the monthly average discharge conditions show in Figure 4-22. Groundwater discharge is greatest in Oro North, followed by Hawkestone Creek, while Oro South receives the smallest groundwater contribution (Earthfx, 2013a).

Monthly average groundwater discharge to Oro North, Oro South, and Hawkestone Creeks is presented for the months of April and August on Figure 4-24 and Figure 4-25, respectively.

Groundwater seepage during April was most affected by the extreme 1958 event rather than the prolonged drought. Monthly average seepage during August was consistently low from 1962 to 1966 (Earthfx, 2013a).

To better illustrate the connections between the groundwater system and specific surface features, groundwater seepage can be plotted on a reach-by-reach basis. Figure 4-26 delineates groundwater seepage along the entire main channel of Hawkestone Creek in August 1957 and November 1964. Chainage starts at Lake Simcoe and ends at a first-order stream in the Hawkestone Wetland Complex. Chainage refers to a reach-by-reach distance measured from Lake Simcoe where groundwater seepage measurements were taken . The corresponding cross-section in Figure 4.27 is shown as if the reader is looking in the direction of increasing chainage from left to right (Lake Simcoe to the Oro Moraine). Hawkestone Creek appears well connected to the groundwater system, in particular the Oro Moraine aquifers, with high rates of seepage noted where the overlying till thickens and the shallow aquifer appears to thin further downgradient. Hawkestone Creek appears more sensitive to drought conditions in its lower reaches. This may suggest a reliance on local recharge to support the features lower in the subwatershed that are poorly connected to the available storage within the moraine (Earthfx, 2013a).

A potential discharge map was also created (Figure 4-27) using the potentiometric surface produced from shallow wells in the MOE water well database in conjunction with topographic mapping. Potential discharge zones are where the water levels reported in the MOE database are within a few metres of the ground surface.

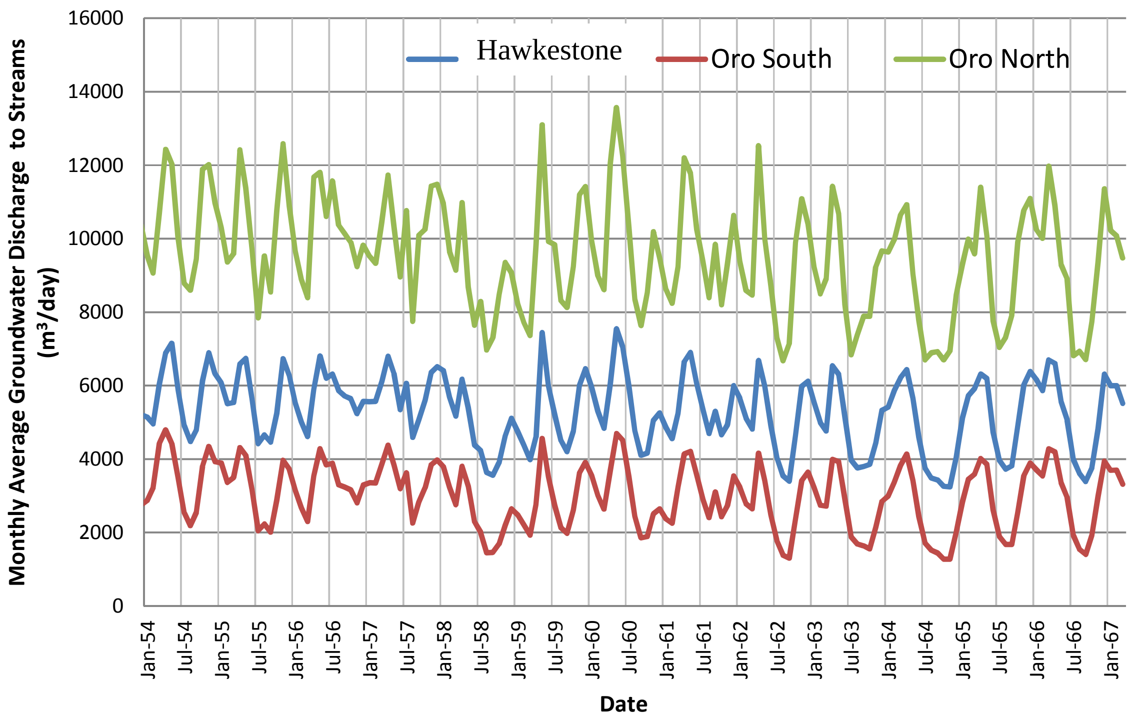


Figure 4-22: Monthly average total groundwater discharge to stream channels (m^3/d) in the study catchments (Earthfx, 2013a).

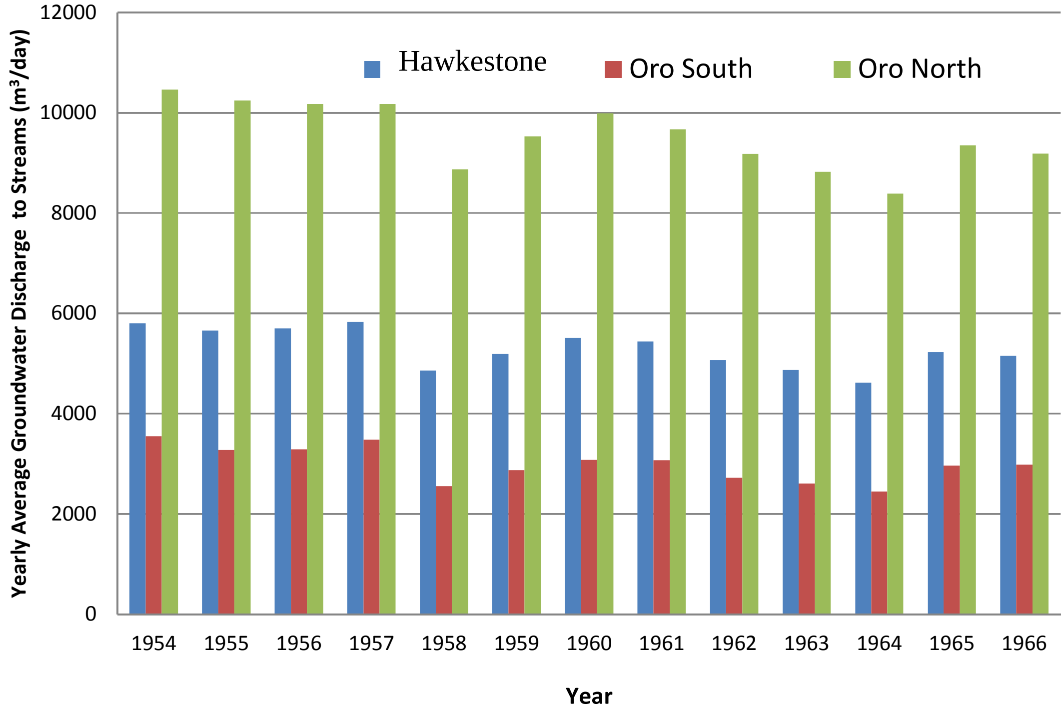


Figure 4-23: Yearly average total groundwater discharge to stream channels (m^3/d) in the study catchments (Earthfx, 2013a).

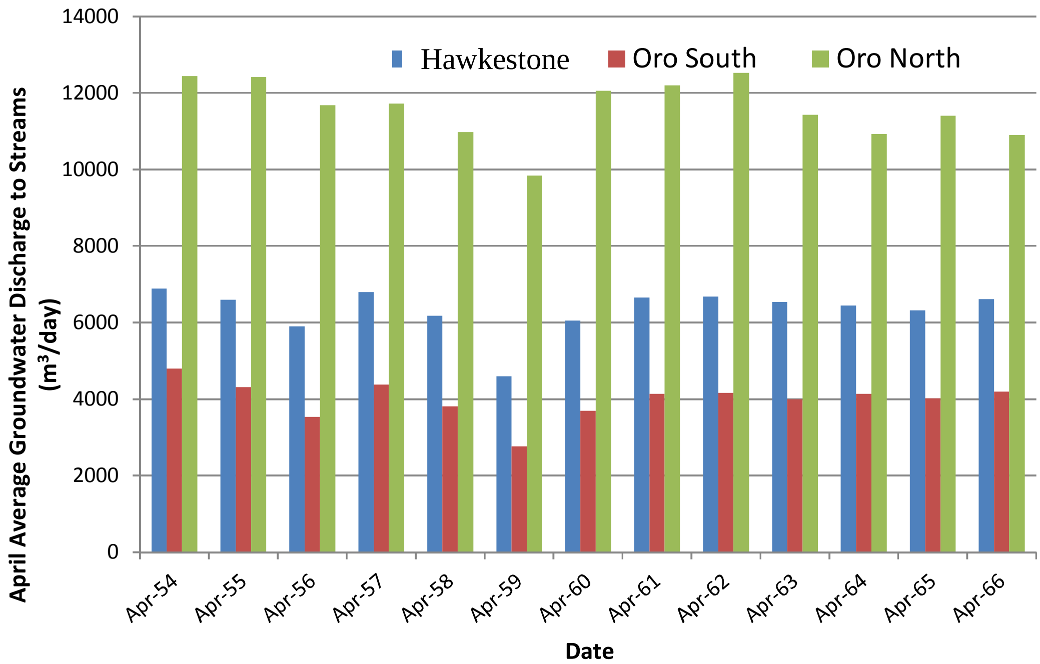


Figure 4-24: Average April total groundwater discharge to stream channels (m^3/d) in the study catchments (Earthfx, 2013a)

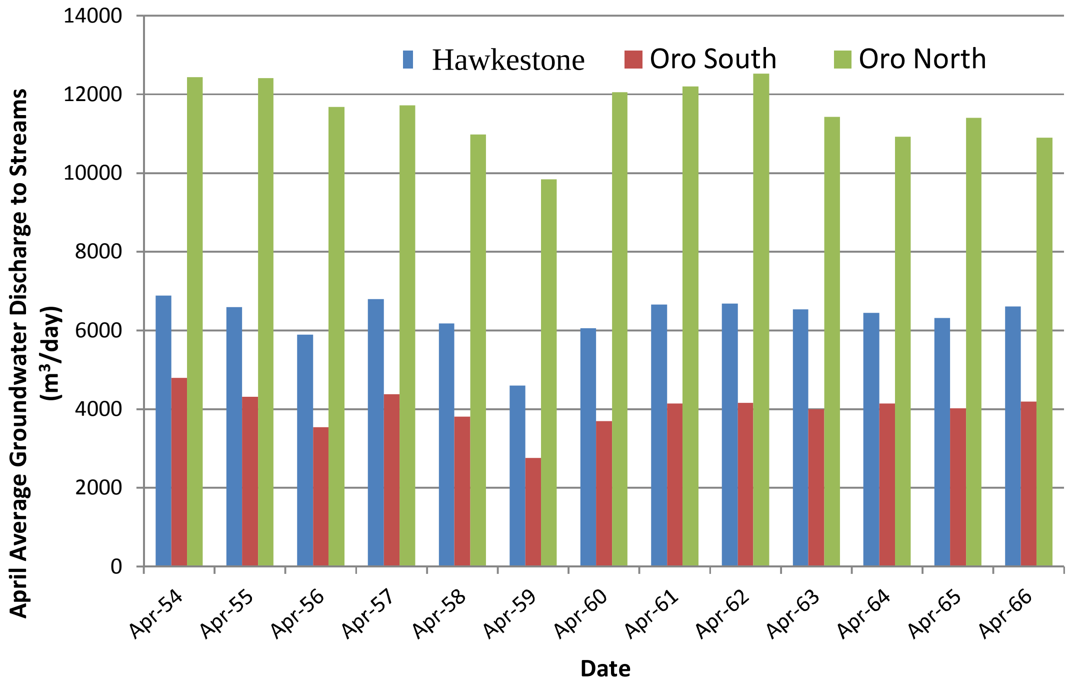


Figure 4-25: Average August total groundwater discharge to stream channels (m^3/d) in the study catchments (Earthfx, 2013a).

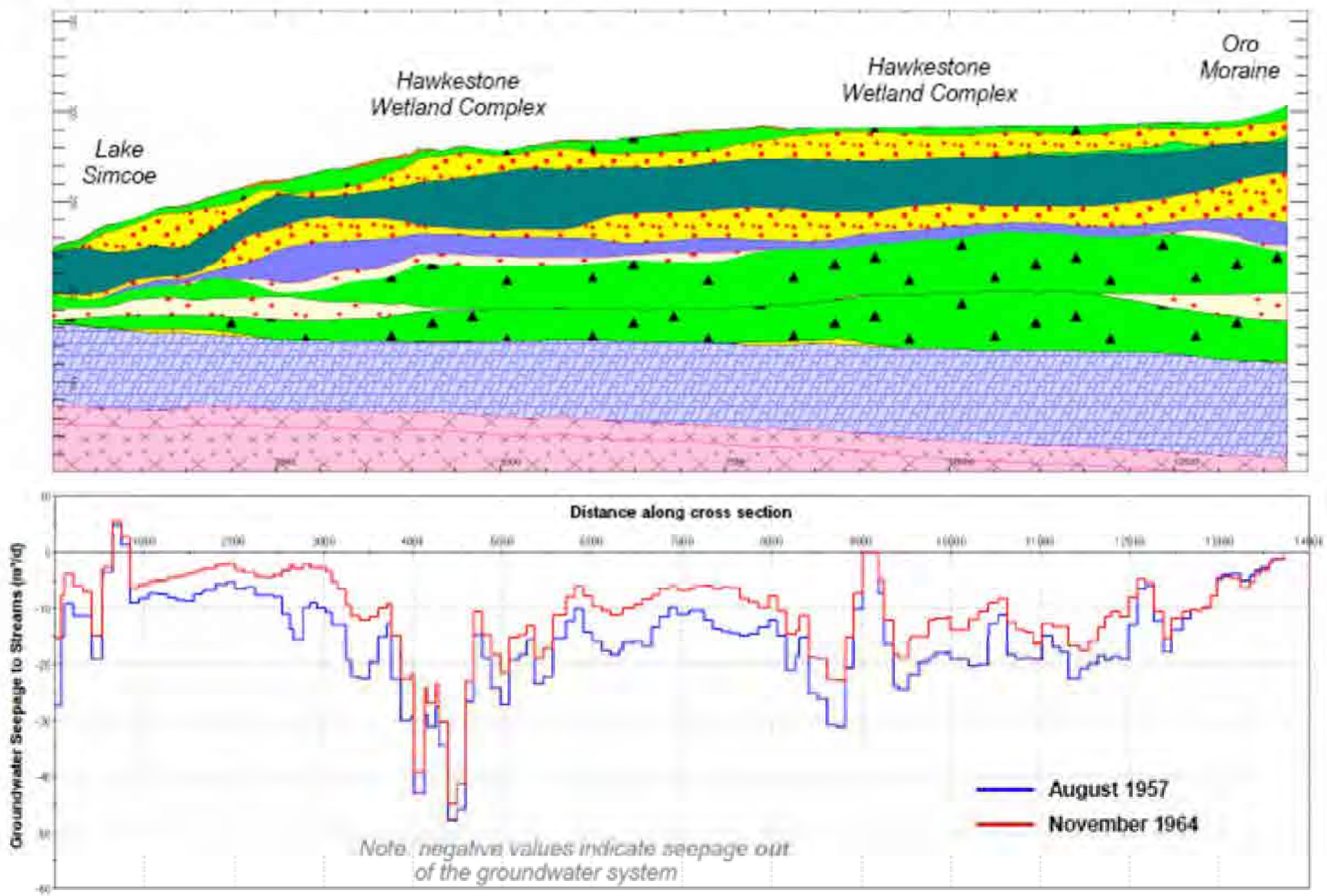


Figure 4-26: Groundwater seepage to the main branch of Hawkestone Creek by chainage (from Lake Simcoe) with geology (Earthfx, 2013a).

Potential discharge to streams within Oro Creeks North, Hawkestone Creeks, and Oro Creeks South subwatersheds

Figure 4-27

Legend

River Discharge (m^3/day)

- > 300
- 300 to 100
- 100 to 0
- < 0

Road

Municipal Boundary

Watercourse

Subwatershed

Oro Moraine

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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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 these ambient groundwater levels can help 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, currently operates two monitoring wells within the Oro Creeks South subwatershed. Wells W0293-2 and W0293-3 are completed to a depth of 16.7 & 25.9 mbgs respectiviely. Both wells are screened in the same aquifer.

4.2.6 Groundwater Recharge

Groundwater is replenished as precipitation or snowmelt 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, particularly within the upland areas to the north of the subwatersheds, infiltration rates are increased. In addition, recharge is enhanced in areas where the ground surface is hummocky (hilly terrain caused by glaciation) and water cannot move as easily to contribute as runoff to nearby creeks and rivers.

The mappings of these 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 Oro North, Oro South, and Hawkestone Creeks subwatersheds were originally predicted by the PRMS model completed by Earthfx (2010), completed for the whole Lake Simcoe basin in order to support the Tier 2 water budget modelling work that was completed in 2010. However, a new, integrated groundwater and surface water model was developed to address the specific requirements of the Tier 2 water budget and stress assessment. The new model GSFLOW represents an integration of the two widely-recognized USGS models: PRMS and MODFLOW (Earthfx, 2013a). The annual average groundwater recharge rates estimated across the subwatershed areas ranged from a low near zero to 600 mm/yr (Earthfx, 2013a) as shown in Figure 4-28.

Groundwater recharge is mostly dominated by surficial geology. The estimated annual average recharge for the subwatersheds is shown in Figure 4-28. The highest recharge tends to occur on the Oro Moraine compared to the quarries and the till regions adjacent to the moraine (Earthfx, 2013a).

Significant Groundwater Recharge Areas

Significant groundwater recharge 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 model developed for through source water protection studies (Earthfx, 2010b). Significant Groundwater Recharge Areas within the Lake Simcoe watershed represent areas where the recharge rate is 15% greater than the average recharge (164 mm/yr) across the watershed. The shaded areas within Figure 4-29 represent a recharge rate of 189 mm/yr.

Both the Significant Groundwater Recharge Areas (Figure 4-29) delineated through Source Water Protection studies and the recharge mapping delineated through the Lake Simcoe Protection Plan Tier 2 study of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds show similar recharge trends, with the Oro Moraine being the significant recharge feature in the study area.

Ecologically Significant Groundwater Recharge Areas

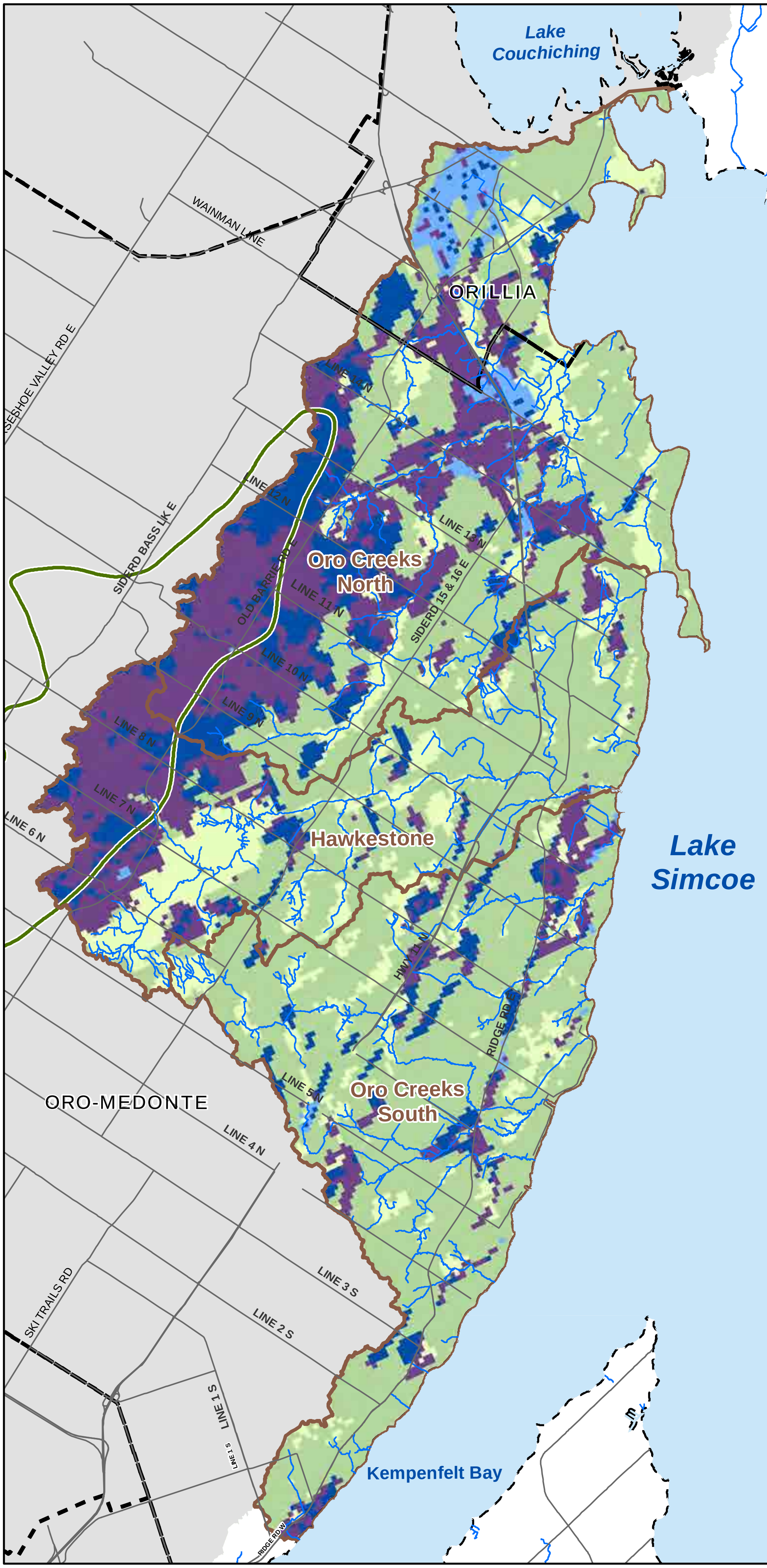
Ecologically Significant Groundwater Recharge Areas (ESGRAs) are identified as areas of land that are responsible for supporting groundwater systems that sustain sensitive features like coldwater streams and wetlands. To establish the ecological significance of a recharge area, a linkage must be present between a recharge area and an ecologically significant feature (e.g. a reach of a coldwater 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds by Earthfx (2013) 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. coldwater streams and wetlands). Particles are then 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.

ESGRAs that support the ecologically significant features within the subwatershed were delineated by a statistical method that analyzes 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 4-30 identifies the endpoints of reverse tracked particles released from ecologically significant features such as streams and wetlands found within the subwatershed. Figure 4-31 illustrates the flow pathlines outlined by reverse tracked particles. It can be observed that some of the outlined ESGRAS are located outside of subwatershed boundaries, west of the Oro Moraine. Figure 4-30 and Figure 4-31 also show that some of these endpoints can be traced back to recharge areas outside of the subwatershed boundary. Approximately 7% of the pathlines leave the watershed boundary for areas west of the Oro Moraine. This indicates that certain ecologically significant features within the subwatershed boundary, particularly the headwaters of Hawkestone Creek, rely on lateral groundwater inflow from recharge areas outside of the subwatershed. Figure 4-32 shows the final ESGRAs areas established through the application of this method.

In addition to the particle tracking method, a validation exercise utilizing a forward particle tracking methodology was employed to ensure that significant recharge areas contributing to ecologically sensitive features were not missed. For forward tracking in the direction of flow, 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. A small percentage of the forward particle tracks cross the topographical watershed divide to the north and west. This suggests that features within the subwatershed may be an important source of recharge to other catchments (particularily the headwaters of Coldwater Creek and Bass Lake). While SGRAs represent high volume recharge areas, ESGRAs better represent areas of land that contribute singificant recharge to sensitive features of ecological significance within the study subwatersheds. These features of ecological signficance may include cold water stream reaches, fish spawning areas or wetlands. Both SGRAs and ESGRAs for the study area are shown in Figure 4-29.



Estimated average annual recharge (mm/yr) in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 4-28

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Recharge (mm/yr)

- -1 - 30
- 30 - 125
- 125 - 250
- 250 - 350
- 350 - 675

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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Significant groundwater recharge areas/ecologically significant groundwater recharge areas in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 4-29

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine
- Ecologically Significant Groundwater Recharge Areas
- Significant Groundwater Recharge Areas

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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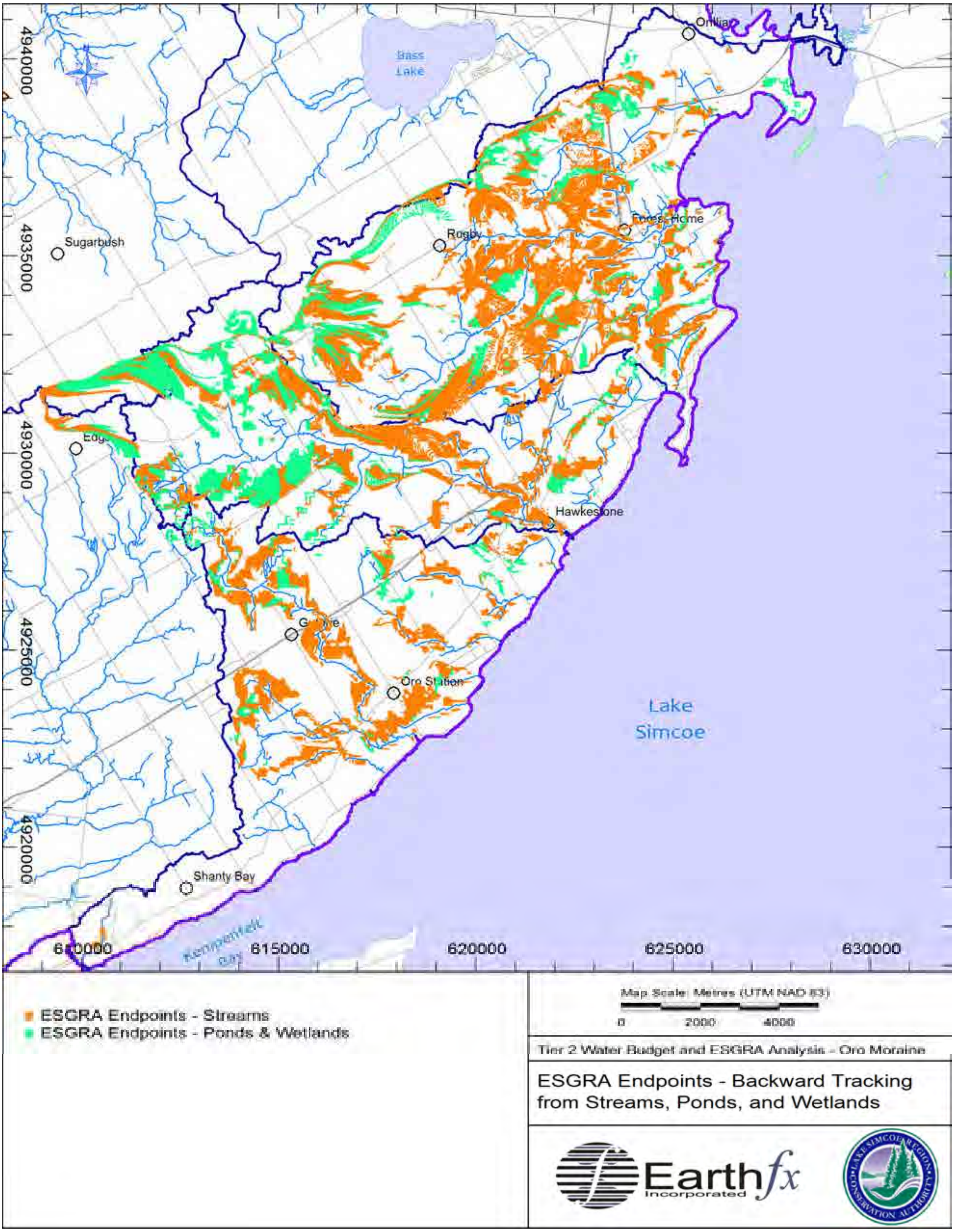


Figure 4-30: Backward tracking pathline endpoints from significant features (Earthfx, 2013a).

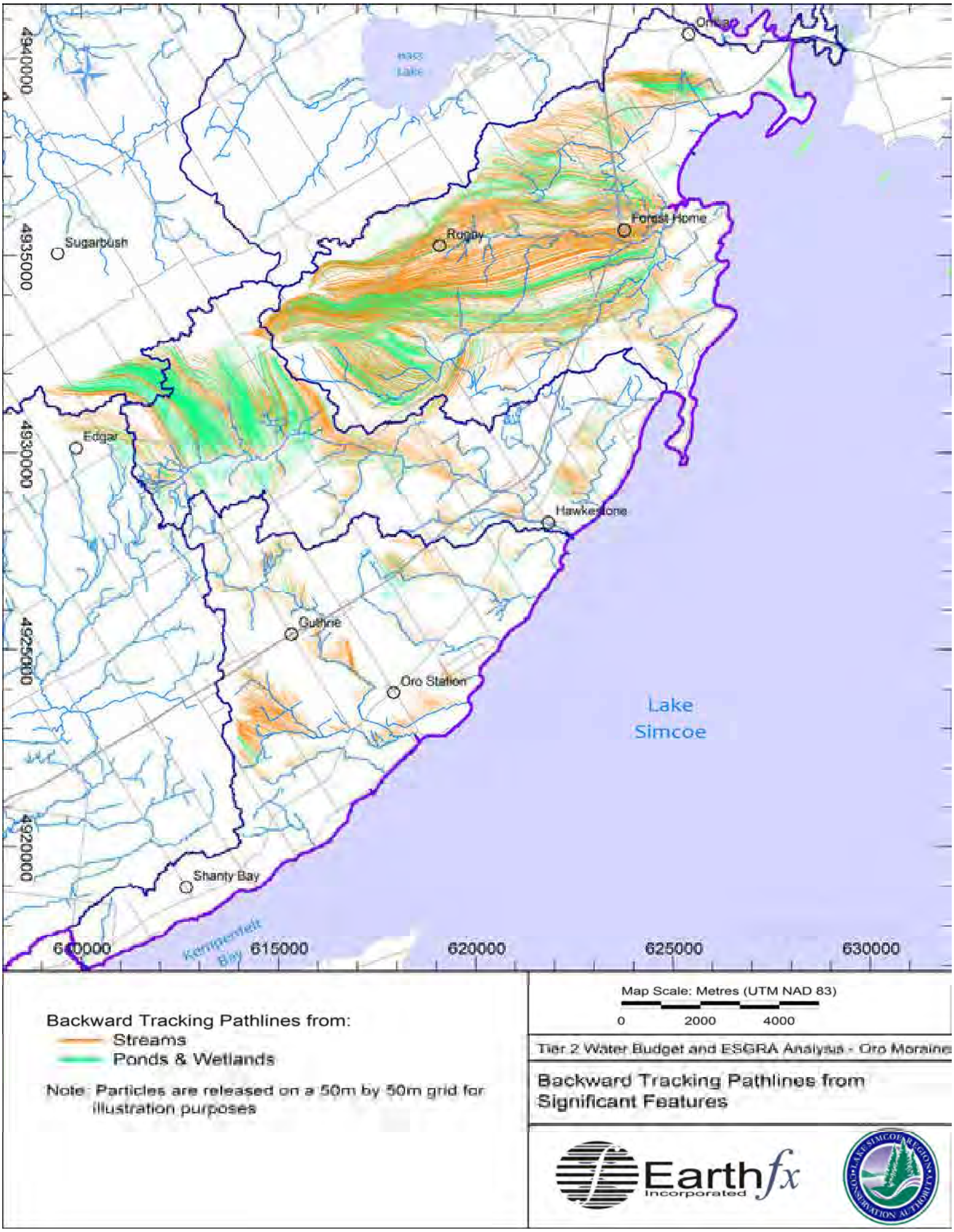


Figure 4-31: Backward tracking pathlines from significant features (Earthfx, 2013a).

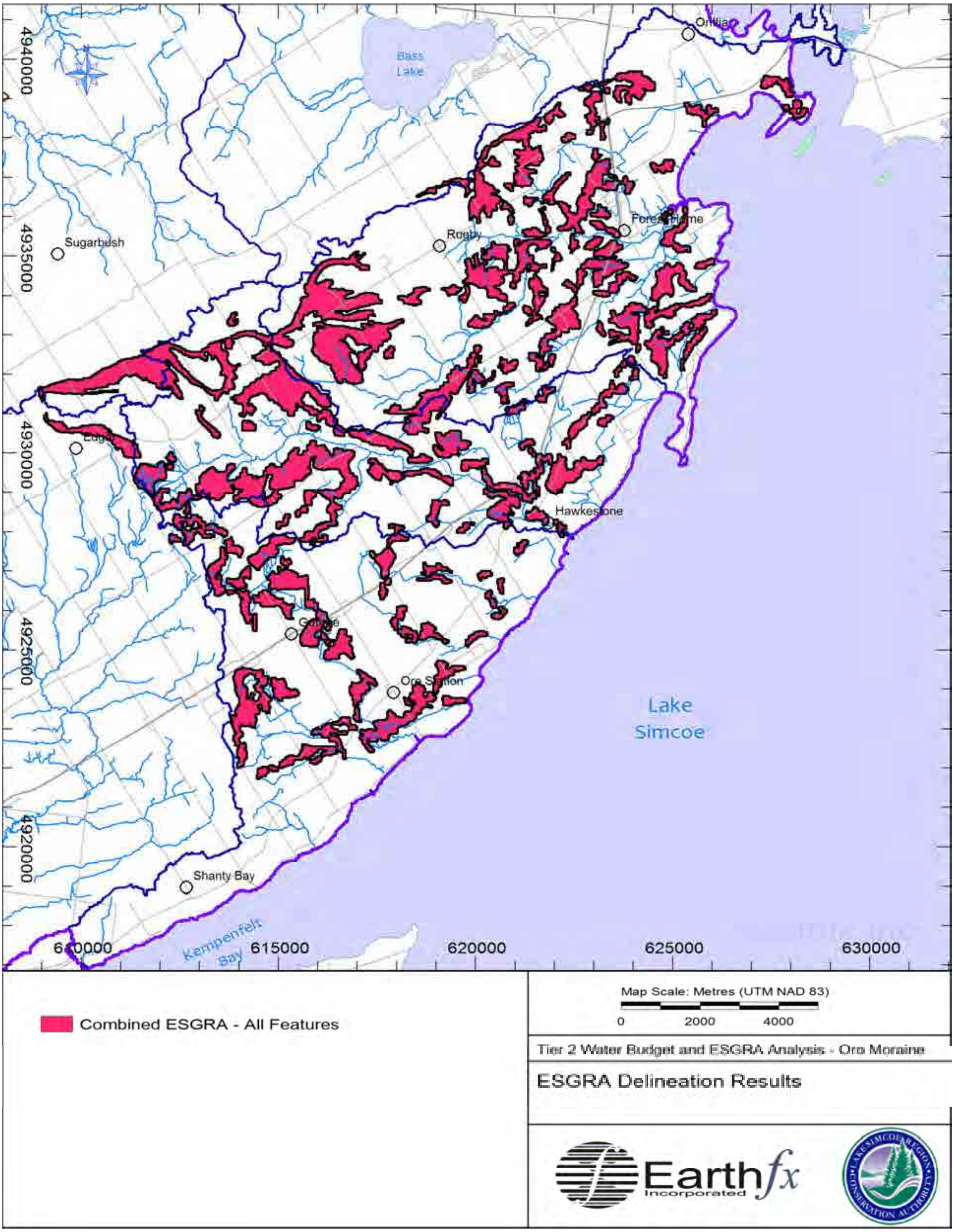


Figure 4-32: Combined ESGRA delineation backward tracking form all features (Earthfx, 2013b).

4.2.7 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.

Climate data (i.e., precipitation as rain, precipitation as snow, daily maximum temperatures, daily minimum temperatures, and daily solar radiation) were collected from a variety of sources. The PRMS model utilized long-term climate data obtained from Environment Canada including monthly average temperature, precipitation, and snowfall for the 29-year period from 1971 to 2000. Climate data was obtained from three active Environment Canada climate stations within the study area. The Barrie WPCC station is located just south of the study area. Climate data with varied periods of record from nine inactive stations also provided historic information. Chapter 2 (Figure 2-24) identifies the location of both active and inactive Environment Canada climate stations.

The monthly average temperature, rainfall, snowfall, and total precipitation values are tabulated in Chapter 2 (Table 2-9). Mean annual precipitation in the immediate region averaged 711 millimetres per year (mm/yr). Precipitation was higher from August to January, averaging 93 mm/month, and lowest from February to April, averaging 63 mm/month. Monthly rainfall rates for the stations are similar, although Orillia TS had generally higher values. The mean annual snowfall within the area averaged 269 centimetres per year (cm/yr). Snowfall rates are more variable with Orillia TS and Coldwater-Warminster being generally high and Barrie WPCC and Midhurst generally low.

Monthly average temperature ranges for the period 1971 to 2000 ranged from -8.3°C in January to 20.2°C in July. Temperature data is consistent between the five stations. The warmest recorded monthly average temperatures were recorded at the Barrie and Orillia stations, while the coldest monthly average temperature was observed at the Shanty Bay station (Earthfx, 2013a).

Evapotranspiration

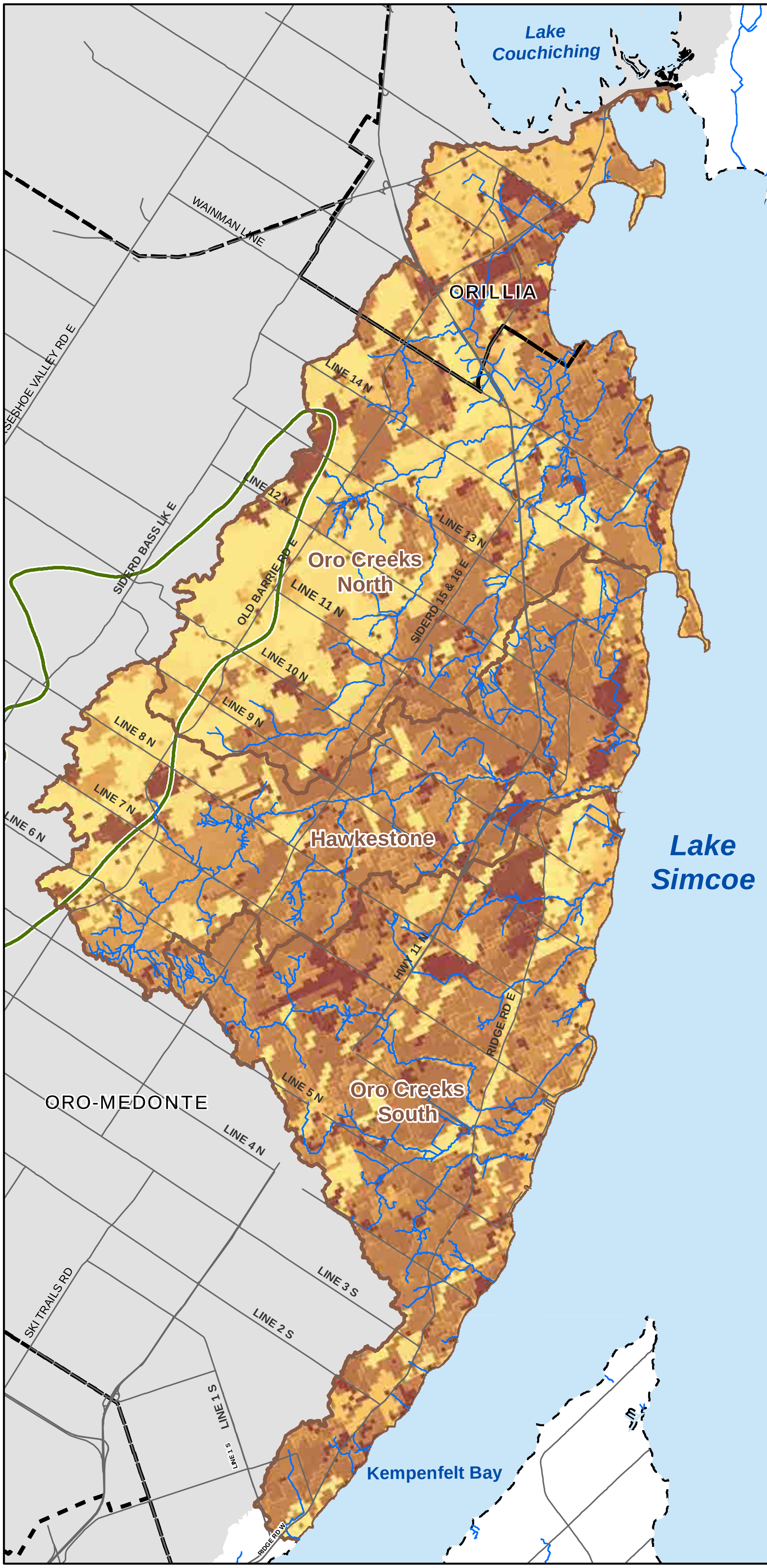
Evapotranspiration (ET) is the water lost to the atmosphere by two processes, evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other 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 suface to the atmosphere. In PRMS, 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, 2013a).

It is evident that low ET (<200 mm/yr) occurs in urban areas. For urban areas, there is a reduction in pervious areas, thus a reduction in soil zone water holding capacity and vegetative surfaces. Atop the Oro Moraine, ET is reduced as this area experiences greater recharge and thus less water is available to evaporate. The average net annual evapotranspiration occurring over the watersheds is displayed in Figure 4-33.

Average net annual evapotranspiration (mm/yr) in the Oro Creeks North, Hawkestone Creeks, and Oro Creeks South subwatersheds

Figure 4-33



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Observed Annual Average Evapotranspiration (mm/yr)

High : 747

Low : 190

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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4.3 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. The findings of the water budget study are discussed within Section 4.4. Earthfx (2013a) completed the water budget study on behalf of the LSRCA, which included the Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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). constructing a new model using the U.S. Geological Survey (USGS) fully-integrated GSFLOW model.

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

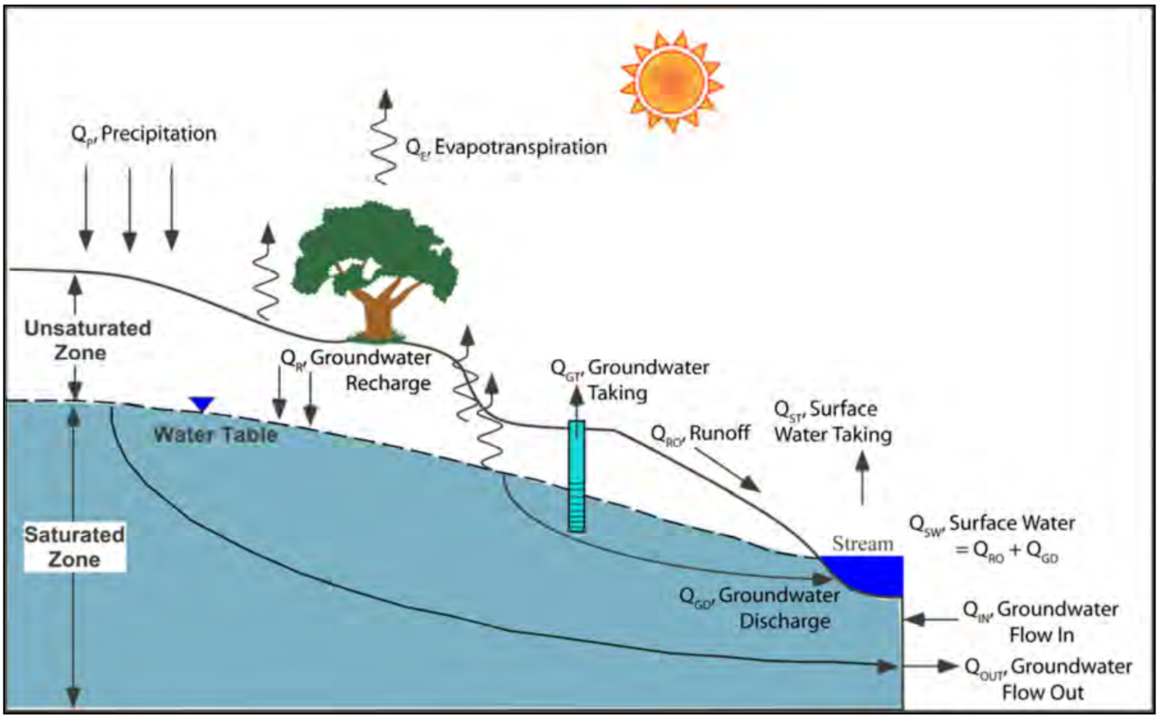

Figure 4-34: Water budget components (Earthfx, and Gerber, 2008).

4.3.1 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds was developed by Earthfx (2013a) and is a new integrated surface water/groundwater model, specifically designed to incorporate the latest Ontario Geological Survey (OGS) Oro Moraine stratigraphy. This model is herein referred to as the Oro Moraine Model.

The modelling approach centered 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 Oro North and South and Hawkestone Creek subwatersheds as part of a larger hydrological model development study for the entire Lake Simcoe basin (Earthfx, 2010a). The PRMS model was extended to cover the other watersheds that include portions of the Oro Moraine. The groundwater model built on the previously developed LSRCA Tier 2 numerical models and, most importantly, incorporated the complete Ontario Geological Survey 2011 conceptual hydrostratigraphic model (Earthfx, 2013a).

The model domain encompasses the entire Oro Moraine and Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. It extends to the stream valleys where Willow Creek, Coldwater Creek, Sturgeon River, and Silver Creek are found. Figure 4-2 shows the Oro Moraine Model boundaries. Further information about the model can be obtained from Earthfx (2013a).

4.3.2 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 Oro Moraine 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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, as indicated on the MODFLOW potentiometric surface maps (Figure 4-10 through Figure 4-14). 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds Tier 2 study. The total current and future lateral inflow for each subwatershed is tabulated in Table 4-5 and Table 4-6, respectively (Earthfx, 2013a).

Together the PRMS groundwater recharge and MODFLOW predicted lateral inflows from the water supply term in the Tier 2 calculation. Table 4-5 and Table 4-6 present the current and future water supply estimates used in the water budget calculation.

Table 4-5: Current water budget estimates (Earthfx, 2013a).

Inflows and Outflows (all values in m^3/day)	**Oro North**	**Hawkestone**	**Oro South**
Inflow Components			
Recharge in	58891	26694	16155
Stream leakage in	39	12	20
Lake leakage in	2	16	3
Lateral inflow	8960	16682	9978
Total Groundwater Inflow:	67698	43404	26155
Outflow Components			
Lateral outflow	12338	15208	2603
Net groundwater discharge to surface features	53215	25839	7895
Net outflow in at constant head cells	2391	2306	15644
Wells	29.3	24.6	235.8
Total Groundwater Outflow:	67973	43378	26378

*values subject to round off

Table 4-6: Future water budget estimates (Earthfx, 2013a).

Inflows and Outflows (all values in m^3/day)	**Oro North**	**Hawkestone**	**Oro South**
Inflow Components			
Recharge in	58790	26673	16105
Stream leakage in	39	15	20
Lake leakage in	3	16	3
Lateral inflow	8907	16683	9980
Total Groundwater Inflow:	67738	43386	26108
Outflow Components			
Lateral Outflow	12195	15206	2602
Net groundwater discharge to surface features	53332	25788	7868
Net outflow in at constant head cells	2402	2306	15615
Wells	29.78	26.11	259.27
Total Groundwater Outflow:	65299	42502	25083

*values subject to round off

4.3.3 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, as well as other permitted takers). The water demand has been estimated from a number of information sources, including the Permit to Take Water database, population estimates, and water well records. Water demand was assessed for all Lake Simcoe subwatersheds in SGBLS (2009) and was reviewed and refined as part of the Tier 2 study for Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds (Earthfx, 2013a).

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. For future scenarios, the consumptive demand was adjusted by increasing unserviced population demand, taking into account population growth estimates within Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. The Tier 2 analysis assumes that the other permitted demands will remain constant with time with no change in the water supply except where significant land-use changes are anticipated (Earthfx, 2013a).

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).

<u>Permit To Take Water (PTTW)</u>

The most important source of consumptive demand information was the MOE Permit to Take Water (PTTW) database and actual municipal water use data. 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 (MOE). 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 (2009), and the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds Tier 2 Water Budget (Earthfx, 2013a).

Verifying and estimating actual consumption is difficult, but recent legislation (387/04) now requires that actual extraction rates be recorded and over time the actual demand estimates will improve. Actual water use was received for some of the permitted water users in the Lake Simcoe subwatersheds. The data for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds were reviewed, corrected as needed, and incorporated into this study to update the water use estimates where possible. A list of the most recent PTTW information is presented in Table 4-10 and Table 4-11. Best available location data for groundwater water permits are shown in Figure 4-35 (Earthfx, 2013a).

The primary source of information for estimating demand is the Permit to Take Water (PTTW) database. A total of seven non-expired groundwater permits were found in the study area governing the use 15 wells. Estimates of actual water use were available for eight permits; the maximum permitted rate was used for the analysis of the remaining wells. A further 21 non-expired groundwater permits (governing 31 wells) were included within adjacent watersheds in the model. Table 4-10 summarizes the permitted groundwater takings within the model area (Earthfx, 2013a).

Two surface water permits to take water were found in the study area. Reported takings were available for one of the permits, the maximum permitted rate was used in the analysis of the other. A further 10 permits were found within the model area and incorporated into the model. Takings were allocated to the model stream reach indicated within the permit. Permitted takings from lakes and ponds were removed from simulated lakes where the feature was present within the model. Table 4-11 summarizes the permitted surface water takings within the model area (Earthfx, 2013a).

<u>Municipal Water Supply</u>

Groundwater is the primary source of municipal supply for the various communities in the study area. Additionally, some of the municipal wells for the City of Barrie and the City of Orillia are located within the Oro Moraine area. A total of 45 municipal wells are located within the model area; 12 within the study area. Average pumping was calculated from data provided in the MOE Water Taking Reporting System (WTRS) database. Where actual pumping data was not available, the average yearly demand was assumed equal to the maximum permitted rate. All municipal wells within the study area have reported takings from WTRS. Table 4-8 summarizes the average pumping values determined for the municipal wells in the model area (Earthfx, 2013a)

Future pumping demand was estimated to be similar to current pumping rates as no major population growth is expected in the future within the study watersheds. An additional increase of 10% was added to the municipal wells to represent possible future increases in demand. Estimating future demand as the maximum permitted pumping rate at each well was considered too conservative for this study given that no major municipal expansion is expected in the study area. It should be noted that the Sandra Drive Well, a part of the Orillia Water Supply System, was discontinued in 2010 and was not considered in the future scenario (LSRCA, 2011). Estimated future pumping rates are summarized in Table 4-9 for the municipal wells within the study area.

<u>Non-Permitted Water Use - Agriculture Consumption</u>

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. Table 4-12 in the preceding section presents the current agricultural demand. As such, the total non-permitted agricultural demand was included as both a groundwater and surface water supply source (Earthfx, 2013a).

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 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 4-12 and Table 4-13 in the preceding section present the current and future unserviced demand. These values were incorporated within the steady state model by decreasing the applied recharge over the each subwatershed by the estimated unserviced demand. Rural areas were defined with SOLRIS land use mapping, version 1.2 (April, 2008) (Earthfx, 2013a).

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 4-7) 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, 2013a).

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

Table 4-7: 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			

<u>Monthly Correction Factor</u>

Many water permit holders do not require the use of water at a constant rate throughout the year. For example, there are several golf course permit and aggregate washing permits in the subwatershed study areas. Additionally, many of the permits in the study area are limited by time, only allowing pumping during a subset of the year. 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 (Earthfx, 2013a).

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, 2013a).

Groundwater takings (m³/day) within the Oro Creeks North, Hawkestone Creeks, and Oro Creeks South subwatersheds

Figure 4-35

Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Oro Moraine

Model Pumping Rate (m³/day)

- < 50
- 50 - 100
- 100 - 250
- 250 - 500
- > 500

General Purpose of Taking

- Agricultural
- Commercial
- Dewatering
- Industrial
- Institutional
- Miscellaneous
- Municipal
- Recreational
- Remediation

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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Table 4-8: Pumping rates for municipal supply wells within the model area (Earthfx, 2013a).

User	Well Name	Subwatershed	Permit Number	Model Layer	Easting Zone 17 (m)	Northing[1] Zone 17 (m)	Reported Pumping Rate (m^3/day)	Maximum Pumping Rate (m^3/day)
Barrie Well Supply	Well #9 (168 Johnson Street)	Willow Creek	8433-6QSRX5	6	607044	4917651	1127.6	6552
Barrie Well Supply	Well #13 (168 Johnson Street)	Willow Creek	8433-6QSRX5	6	607013	4917660	865.5	6552
Bass Lake Woodlands Well Supply	Well No. 1	North River	87-P-3051	6	619709	4941714	29.3	436
Bass Lake Woodlands Well Supply	Well No. 2	North River	87-P-3051	6	619720	4941704	34.4	280.8
Bass Lake Woodlands Well Supply	Well #3	North River	87-P-3051	6	619710	4941724	48.2	494.4
Canterbury Subdivision Well Supply	Well 1	**Oro South**	92-P-3028	4	617805	4924105	4.9	105
Canterbury Subdivision Well Supply	Well 2	**Oro South**	92-P-3028	4	617799	4924108	6.1	105
Cedar Brook Subdivision Well Supply	Well No.2	**Hawkestone**	4817-6HJPXP	4	621415	4928437	8.0	104
Cedar Brook Subdivision Well Supply	Well No.1	**Hawkestone**	4817-6HJPXP	4	621408	4928432	7.1	104
Coldwater Well Supply	Swaile Well (Standby)	Coldwater	93-P-3071	7	607215	4951223	2.2	982
Coldwater Well Supply	Well PW93-4	Coldwater	93-P-3071	7	607157	4951179	300.5	2141
Coldwater Well Supply	Well PW 93-2	Coldwater	93-P-3071	7	607154	4951202	177.8	982
Craighurst Well Supply	Well No.2	Willow Creek	4624-6HKPJW	4	600813	4931476	7.9	140
Craighurst Well Supply	Well No.1	Willow Creek	4624-6HKPJW	4	600813	4931474	0.2	64
Craighurst Well Supply	Well No.3	Willow Creek	4624-6HKPJW	4	600816	4931483	13.4	229
Del Trend Subdivision Well Supply	Del Trend Well #2	Willow Creek	2372-75VHJ5	6	601788	4920236	23.8	467
Del Trend Subdivision Well Supply	Del Trend Well #1	Willow Creek	2372-75VHJ5	6	601776	4920232	19.4	467
Del Trend Subdivision Well Supply	Del Trend Well #3	Willow Creek	2372-75VHJ5	6	601768	4920256	86.0	786
Harbourwood	Well No.3	**Oro South**	8643-	6	617853	4922342	47.2	921

User	Well Name	Subwatershed	Permit Number	Model Layer	Easting Zone 17 (m)	Northing[1] Zone 17 (m)	Reported Pumping Rate (m^3/day)	Maximum Pumping Rate (m^3/day)
Well Supply			6HKK9K					
Harbourwood Well Supply	Well No.2	**Oro South**	8643-6HKK9K	6	617919	4922286	46.8	921
Horseshoe Highlands Subdivision Well Supply	Well #2 Standby Well	Coldwater	0404-5UHQDN	4	605958	4934353	1.4	527
Horseshoe Highlands Subdivision Well Supply	Well #1	Coldwater	0404-5UHQDN	4	605950	4934348	289.9	3371
Lake Simcoe Regional Airport	Well #3	**Oro South**	5348-6HKP2G	4	615660	4926265	1.1	36
Lake Simcoe Regional Airport	Well #2	**Oro South**	5348-6HKP2G	4	615711	4926394	3.3	36
Maplewood Estates	Well #1	**Oro North**	02-P-1314	6	625395	4932101	4.7	164
Maplewood Estates	Well #2	**Oro North**	0825-89BLY7	6	625444	4932170	0	164
Medonte Hills Well Supply	Well 2	Coldwater	92-P-3029	6	605966	4943401	38.3	393
Medonte Hills Well Supply	Well 1	Coldwater	92-P-3029	6	605961	4943415	28.8	327
Midhurst Well Supply	Greenpine Well 4	Willow Creek	0507-6B9S5G	6	601425	4921887	205.7	2000
Midhurst Well Supply	Idlewood Well 3	Willow Creek	0507-6B9S5G	6	601898	4921952	345.5	2900
Midhurst Well Supply	Idlewood Well 2	Willow Creek	0507-6B9S5G	6	601912	4921975	108.6	622
Midhurst Well Supply	Carson Road Well 5 (formerly Well 4)	Willow Creek	0507-6B9S5G	6	601516	4920130	242.4	1068
Orillia Water Supply System	Well 1 & 2	Lake Couchiching	91-P-3036	4	625757	4941830	98.1	5683
Orillia Water Supply System	Well #3	North River	99-P-1256	6	622904	4940267	712.4	7920
Orillia Water Supply System	Sandra Drive Well	**Oro North**	99-P-1256	6	623594	4939744	12.0	4390
Shanty Bay Well Supply	Well No. 1	**Oro South**	7520-6LJTGX	3	613048	4918904	7.7	305
Shanty Bay Well Supply	Well No. 2	**Oro South**	7520-6LJTGX	3	613048	4918904	39.4	305
Shanty Bay Well Supply	Well No. 3	**Oro South**	7520-6LJTGX	4	613028	4918911	78.2	610
Snow Valley Highlands Well Supply	Well 1	Willow Creek	7650-6CFRPK	6	597079	4919327	41.9	700
Snow Valley Highlands Well Supply	Well 2	Willow Creek	7650-6CFRPK	6	597078	4919342	42.0	700

User	Well Name	Subwatershed	Permit Number	Model Layer	Easting Zone 17 (m)	Northing[1] Zone 17 (m)	Reported Pumping Rate (m^3/day)	Maximum Pumping Rate (m^3/day)
Sugar Bush Well Supply	Well #2	Coldwater	1483-5MYQ36	4	609404	4934974	187.6	1636
Sugar Bush Well Supply	Well #1	Coldwater	1483-5MYQ36	4	609032	4935460	48.6	851
Sugar Bush Well Supply	Well #3	Coldwater	1483-5MYQ36	6	609787	4934894	4.5	1636
Warminster Well Supply	Well #1	North River	4686-7BQS3T	4	616590	4944537	147.2	890
Warminster Well Supply	Well #3	North River	4686-7BQS3T	6	616571	4944540	2.4	890

***BOLD** indicates a permit within the study area

Table 4-9: Future pumping rates for municipal supply wells within the study area (Earthfx, 2013a).

User	Well Name	Subwatershed	Permit Number	Model Layer	Easting Zone 17 (m)	Northing[1] Zone 17 (m)	Future Pumping Rate (m^3/day)
Orillia Water Supply System	Sandra Drive Well	Oro North	99-P-1256	***Discontinued in 2010***			
Maplewood Estates	Well #1	Oro North	02-P-1314	6	625395	4932101	5.2
Cedar Brook Subdivision Well Supply	Well No.1	Hawkestone	4817-6HJPXP	4	621408	4928432	8.8
Cedar Brook Subdivision Well Supply	Well No.2	Hawkestone	4817-6HJPXP	4	621415	4928437	7.8
Lake Simcoe Regional Airport	Well #2	Oro South	5348-6HKP2G	4	615711	4926394	1.2
Lake Simcoe Regional Airport	Well #3	Oro South	5348-6HKP2G	4	615660	4926265	3.6
Canterbury Subdivision Well Supply	Well 1	Oro South	92-P-3028	4	617805	4924105	5.4
Canterbury Subdivision Well Supply	Well 2	Oro South	92-P-3028	4	617799	4924108	6.7
Shanty Bay Well Supply	Well No. 1	Oro South	7520-6LJTGX	4	613048	4918904	8.5
Shanty Bay Well Supply	Well No. 2	Oro South	7520-6LJTGX	3	613048	4918904	43.3
Shanty Bay Well Supply	Well No. 3	Oro South	7520-6LJTGX	4	613028	4918911	86.0
Harbourwood Well Supply	Well No.2	Oro South	8643-6HKK9K	6	617919	4922286	51.9
Harbourwood Well Supply	Well No.3	Oro South	8643-6HKK9K	6	617853	4922342	51.5

Table 4-10: Permitted groundwater takings (PTTW) within the model area (Earthfx, 2013a).

Permit Number*	Model Layer	UTM Easting (m)	UTM Northing (m)	Subwatershed	Category	Specific Purpose	Consumption Factor	Reported Consumption (m^3/day)	Max Consumption (m^3/day)
1664-6W3MCU	4	596800	4934500	Sturgeon River	Agricultural	Field and Pasture Crops	0.8	7.1	2071.2
0628-78CJEN	6	613527	4937148	North River	Commercial	Bottled Water	1	75.0	873.0
0628-78CJEN	6	613503	4937188	North River	Commercial	Bottled Water	1	83.7	873.0
0040-733RE2	3	603079	4932549	Willow Creek	Commercial	Golf Course Irrigation	0.7	1.2	45.8
0040-733RE2	3	603729	4933020	Willow Creek	Commercial	Golf Course Irrigation	0.7	105.7	687.4
0386-7AMLUY	4	598296	4919981	Willow Creek	Commercial	Golf Course Irrigation	0.7	21.1	687.4
0386-7AMLUY	6	598296	4919981	Willow Creek	Commercial	Golf Course Irrigation	0.7	37.2	1145.6
1510-7DCLKQ	4	620200	4928057	**Hawkestone**	Commercial	Golf Course Irrigation	0.7	0.1	6.3
1510-7DCLKQ	4	620123	4928370	**Hawkestone**	Commercial	Golf Course Irrigation	0.7	0.3	6.3
1510-7DCLKQ	4	620460	4928540	**Hawkestone**	Commercial	Golf Course Irrigation	0.7	0.0	6.3
1510-7DCLKQ	7	620742	4928397	**Hawkestone**	Commercial	Golf Course Irrigation	0.7	0.7	179.2
3474-759GY9	7	610681	4920539	Willow Creek	Commercial	Golf Course Irrigation	0.7	11.1	140.0
3524-73QQUA	7	607930	4949745	Coldwater	Commercial	Golf Course Irrigation	0.7	1.9	4.2
5066-7Y3MJ9	4	606404	4924599	Willow Creek	Commercial	Golf Course Irrigation	0.7	0.7	30.2
5307-7GVLJL	4	604861	4933832	Coldwater	Commercial	Golf Course Irrigation	0.7	44.6	1427.1
2742-7E5LEK	4	612130	4930583	**Hawkestone**	Commercial	Snowmaking	0.5	6.2	9.0
01-P-1049	3	612906	4932955	**Hawkestone**	Dewatering	Pits and Quarries	0.25	1.1	97.3
0716-8SMQ4H	1	619156	4943970	North River	Dewatering	Pits and Quarries	0.25	59.1	5400.0
4043-8JHKVC	4	612384	4933016	Coldwater	Dewatering	Pits and Quarries	0.25	1.8	163.7
01-P-1157	1	619553	4935633	**Oro North**	Industrial	Aggregate Washing	0.25	10.13	925.0
1156-7WTJXC	4	613162	4931320	**Hawkestone**	Industrial	Aggregate Washing	0.25	1.0	95.6
1635-8PSQJU	6	605713	4941832	Coldwater	Water Supply	Campgrounds	0.2	*No Data*	51.8
3772-6EQGSY	5	597740	4923757	Willow Creek	Water Supply	Campgrounds	0.2	0.1	7.8

Permit Number*	Model Layer	UTM Easting (m)	UTM Northing (m)	Subwatershed	Category	Specific Purpose	Consumption Factor	Reported Consumption (m^3/day)	Max Consumption (m^3/day)
3772-6EQGSY	5	597684	4923768	Willow Creek	Water Supply	Campgrounds	0.2	0.1	9.2
3772-6EQGSY	7	597843	4923884	Willow Creek	Water Supply	Campgrounds	0.2	0.2	13.6
5353-5W4LB8	3	598021	4922077	Willow Creek	Water Supply	Campgrounds	0.2	7.7	71.4
5431-6LRLAA	6	620822	4940037	North River	Water Supply	Campgrounds	0.2	3.5	16.4
5701-6NLJ99	3	621250	4937050	**Oro North**	Water Supply	Campgrounds	0.2	0.2	16.4
5701-6NLJ99	3	621328	4937321	**Oro North**	Water Supply	Campgrounds	0.2	0.5	17.0
5701-6NLJ99	3	621250	4937050	**Oro North**	Water Supply	Campgrounds	0.2	0.4	14.4
5701-6NLJ99	4	621328	4937321	**Oro North**	Water Supply	Campgrounds	0.2	0.2	17.0
5701-6NLJ99	4	621400	4937100	**Oro North**	Water Supply	Campgrounds	0.2	0.1	7.2
5701-6NLJ99	5	621250	4937050	**Oro North**	Water Supply	Campgrounds	0.2	0.6	13.0
77-P-3033	5	606119	4945205	Coldwater	Water Supply	Campgrounds	0.2	19.3	115.2
99-P-1053	3	626042	4935947	**Oro North**	Water Supply	Campgrounds	0.2	0.2	10.6
7528-8M5QPX	7	621947	4927551	**Oro South**	Water Supply	Campgrounds (assumed)	0.2	0.538	39.3
0077-79UPRS	5	605590	4944977	Coldwater	Water Supply	Communal	0.2	26.1	168.4
1586-62FLP2	4	611554	4918074	**Oro South**	Water Supply	Communal	0.2	0.6	16.2
4076-7HFJB6	6	612542	4937184	North River	Water Supply	Communal	0.2	5.5	202.2
8786-7GVNFK	3	605451	4933595	Coldwater	Water Supply	Communal	0.2	0.3	178.8
8786-7GVNFK	4	605423	4933719	Coldwater	Water Supply	Communal	0.2	0.8	1112.8
8786-7GVNFK	4	605467	4933708	Coldwater	Water Supply	Communal	0.2	0.8	59.0

***BOLD** indicates a permit within the study area

Excludes permitted municipally water supply takings.

Table 4-11: Permitted surface water takings (PTTW) within the model area (Earthfx, 2013a).

Permit Number*	UTM Easting (m)	UTM Northing (m)	Subwatershed	Category	Specific Purpose	Consumption Factor	Days per year	Reported Consumption (m^3/day)	Max Consumption (m^3/day)
1510-7DCLKQ	620200	4928057	**Hawkestone**	Commercial	Golf Course Irrigation	0.7	100	19.7	194
3041-77VHXW	603690	4920430	Willow Creek	Commercial	Golf Course Irrigation	0.7	35	*No Data*	103
3041-77VHXW	604034	4920278	Willow Creek	Commercial	Golf Course Irrigation	0.7	120	114.4	403

3474-759GY9	610681	4920539	Willow Creek	Commercial	Golf Course Irrigation	0.7	42	69.4	230
3524-73QQUA	607930	4949745	Coldwater	Commercial	Golf Course Irrigation	0.7	160	110.4	637
5205-6CJH4Y	623231	4941925	North River	Commercial	Golf Course Irrigation	0.7	60	127.7	298
6556-83SQ94	609691	4923429	Willow Creek	Commercial	Golf Course Irrigation	0.7	180	28.8	202
84-P-3007	614658	4939586	North River	Commercial	Golf Course Irrigation	0.7	150	69.9	224
8680-6A9M3V	606404	4924599	Willow Creek	Commercial	Golf Course Irrigation	0.7	127	1	63
1635-8PSQJU	606475	4942498	Coldwater	Commercial	Snowmaking	0.5	90	*No Data*	2014
7166-7F3L2Q	614125	4929975	**Hawkestone**	Miscellaneous	Other - Miscellaneous	1	365.25	*No Data*	114
5353-5W4LB8	597977	4922110	Willow Creek	Recreational	Other - Recreational	0.1	365.25	169	1890

***BOLD** indicates a permit within the study area

4.3.4 Water Reserve Estimation

The MOE 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.

Key points – Current Hydrogeologic and Water Quantity 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.
- Monitoring groundwater levels can characterize baseline conditions, and assess how groundwater is affected by climate change, seasonal fluctuations, and land and water use. Monitoring groundwater levels can help identify trends and emerging issues, and can provide a basis for making informed resource management decisions, and also measure the effectiveness of the programs and policies that are designed to protect these groundwater resources.
- A refined understanding of the aquifer systems and groundwater flow as part of the subwatershed components and processes is vital in maintaining the ecological balance and sustainability of resources within a watershed.
- The water level maps for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds show that on a regional scale groundwater flow within the major aquifer systems is generally from the topographic highs associated with the Oro Moraine towards the topographic lows associated with the major stream channels and Lake Simcoe.
- Groundwater discharge is the main component of streamflow during dry periods and as such maintains an environment that allows cold water fish to survive even during the dry summer months.
- 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 show that the most significant recharge within the subwatershed occurs on the Oro Moraine.
- Surface water flows are a function of overland runoff and groundwater discharge (baseflow). The Hawkestone Creek hydrograph shows that the river is able to respond to most precipitation events with a slow gentle rise and descent in water levels.
- The groundwater model estimated that more than half of the total stream flow has been attributed to groundwater discharge (baseflow) within the Hawkestone Creek subwatershed.
- An examination of the Baseflow Index at a yearly scale consistently show that greater than 50% of the flow in the Hawkestone Creek subwatershed comes from baseflow as opposed to surface runoff. This is a good indication of stable year round flow, which is important for maintaining the ecological functions of the river.
- 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.
- With minimal urban growth and impervious surfaces, the amount of water available for infiltration to the groundwater system has remained relatively constant.

4.4 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.

4.4.1 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 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 (2013a). Considerable effort was made in the Tier 1 (LSRCA, 2009) and Tier 2 (Earthfx, 2013a) water budgets discussed in previous sections to document the various sources of water demand.

The results of the water demand 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 4-12 and Table 4-13 current and future scenarios. All values were corrected for consumption factors (i.e., locally returned flow is not included). The total groundwater demand from all sources is 982.27 m³/d in the three study subwatersheds.

Table 4-12: Current groundwater consumption summary (Earthfx, 2013a).

Current groundwater consumption (m³/annum)					
Subwatershed Name	**Municipal**	**Unserviced**	**PTTW**	**Agricultural**	**Total Consumption**
Oro North	6,100	64,390	4504	15000	89,994
Hawkestone	5,515	33,185	3433	10000	52,133
Oro South	85,724	117,482	197	13000	216,403
Total	97,339	215,057	8134	38000	358,530

Table 4-13: Future groundwater consumption summary (Earthfx, 2013a).

Future groundwater consumption (m³/a)					
Subwatershed Name	**Municipal**	**Unserviced**	**PTTW**	**Agricultural**	**Total Consumption**
Oro North	2,089	90,146	4,504	15,000	111,739
Hawkestone	6,067	46,460	3,433	10,000	65,960
Oro South	94,296	164,475	197	13,000	271,968
Total	102,452	301,081	8,134	38,000	449,667

Currently permitted and municipal uses account for 11% and 17% of the consumptive groundwater demand within the Oro North and Hawkestone Creek subwatersheds respectively. Agriculture accounts for 16% and 19% of the groundwater consumption, and domestic uses account for 71% and 63% Oro North and Hawkestone Creek subwatersheds, respectively. These values are not predicted to change much in the future.

Within the Oro Creeks South subwatershed, municipal supply currently accounts for 40% and unserviced domestic supply accounts for 54% of consumptive groundwater use. Agriculture and permitted uses account for the remaining 6% and 0.1% respectively. In the future, municipal demand and unserviced domestic supply is anticipated to see a slight increase.

The Tier 2 future demand analyses consider only increases in municipal demand and un-serviced domestic consumption. The population-adjusted calculation details for the future water demand scenarios were completed assuming a 30% increase to represent the unserviced future demand. No other components of the water demand were increased with the exception of the anticipated future takings of municipal pumping wells. Unserviced human consumptive demand is a large proportion (60%) of the total current water demand due to a large urban population with in the study area.

<u>Municipal Water Supplies</u>

There are 12 municipal water supply wells that service communities within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds (Table 4-8 and Table 4-9). The municipal groundwater takings account for approximately 27% of the estimated total groundwater taking within the subwatersheds. Municipal well locations are shown on Figure 4-35. The data presented in this report were analyzed to estimate actual annual average pumping rates which are often less than the permitted rates. The numerical groundwater flow model, discussed in Section 4.3, incorporated average pumping rates where the data were available.

<u>Agricultural</u>

The total consumption for agricultural use is estimated at 38,000 m^3/yr, which is approximately 11% of the total water taking within the subwatersheds. However, this water for irrigation is consumed only through the growing season, from May through mid-October. Therefore, the average daily water consumption for the growing season can be much higher. 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. 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.

<u>Other Permitted Uses</u>

The granular material that comprises the Oro Moraine makes the setting ideal for aggregate extraction. Several aggregate pits and quarries have a permit to supply water for irrigation within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. This water is used for dewatering or aggregate washing activities, or for dust suppression.

In addition, there are a number of permits related to golf course irrigation and campground facilities. As with the agricultural irrigation some of the water applied over the golf courses will infiltrate back into the 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.

4.4.2 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 (Oro North, Hawkestone, and Oro South watersheds). SOLRIS data (MNR, 2008) was used to infill the remaining areas outside of the Lake Simcoe watershed (Earthfx, 2013a).

The predominant land cover is natural heritage features such as forests (i.e. coniferous, deciduous, mixed.) and wetlands (i.e., swamps, fens, bogs, marshes, open aquatic), covering approximately 50% of the study area (See **Chapter 8 - Terrestrial Natural Heritage System** for further information on land use). Settled areas (i.e., urban, rural, transportation, golf courses, etc.) cover only 3.6% of the study area.

Impervious areas were estimated based on the land use data for the Lake Simcoe basin as well as for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. Table 4-14 illustrates the percentage of impervious land cover within the basin (the surface of the lake was not included for the purpose of this analysis) and within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

It should be noted that the percentage of impervious surfaces used in the surface water model (PRMS) developed by Earthfx (2013a) for the water budget exercise (Table 4-14) differs from the percentage discussed in Chapter 2. The percent impervious cover reported in **Chapter 2** assumes specific landuses are 100% impervious, whereas the model assumes that each type of landuse varies in the percentage of impervious area. It should be noted that although the most accurate available land use information was used, these numbers will continue to change as development occurs.

Table 4-14: Comparison of impervious land cover within the Lake Simcoe watershed and Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds (Earthfx, 2013a).

	Area (km^2)	Impervious (km^2)	Impervious (%)
Lake Simcoe watershed	2,601*	238	9.2
Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds	180	12	6.7

* Area does not include the surface of Lake Simcoe

The following will discuss the various landuses within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds in the context of Significant Groundwater Recharge Areas. The subwatershed contains a low level of impervious (hardened) surfaces due to the lack of urban areas. Figure 4-36 and Figure 4-37 illustrate the distribution of land uses for recharge areas within the subwatersheds. Urban areas comprise 1% of the landuses within Significant Groundwater Recharge Areas (SGRAs) and Ecologically Significant Groundwater Recharge Areas (ESGRAs) and rural development comprises 4%.

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. Intensive and non-intensive agricultural land uses account for close to 40% of the landuses within the SGRAs and ESGRAs at 10% and 28%, 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 4.4.1 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 landuse within the significant groundwater recharge areas and ecologically significant recharge areas, at 50% cover (Figure 4-36 and Figure 4-37). The natural heritage features leave the landscape in a natural state, promoting infiltration. Active aggregate operations are the next largest land use within these recharge areas at 4%. Future land development plans should focus on promoting land use activities that maintain and protect the recharge occurring within the SGRAs and ESGRAs.

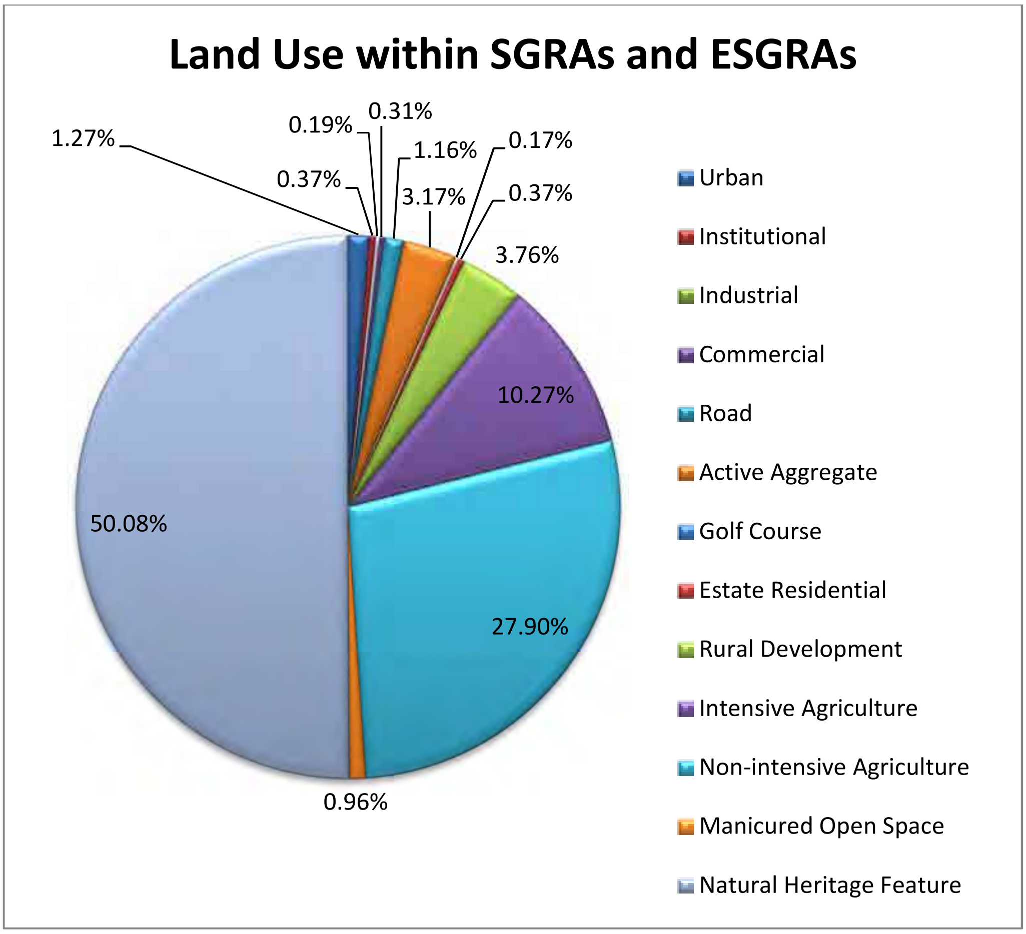
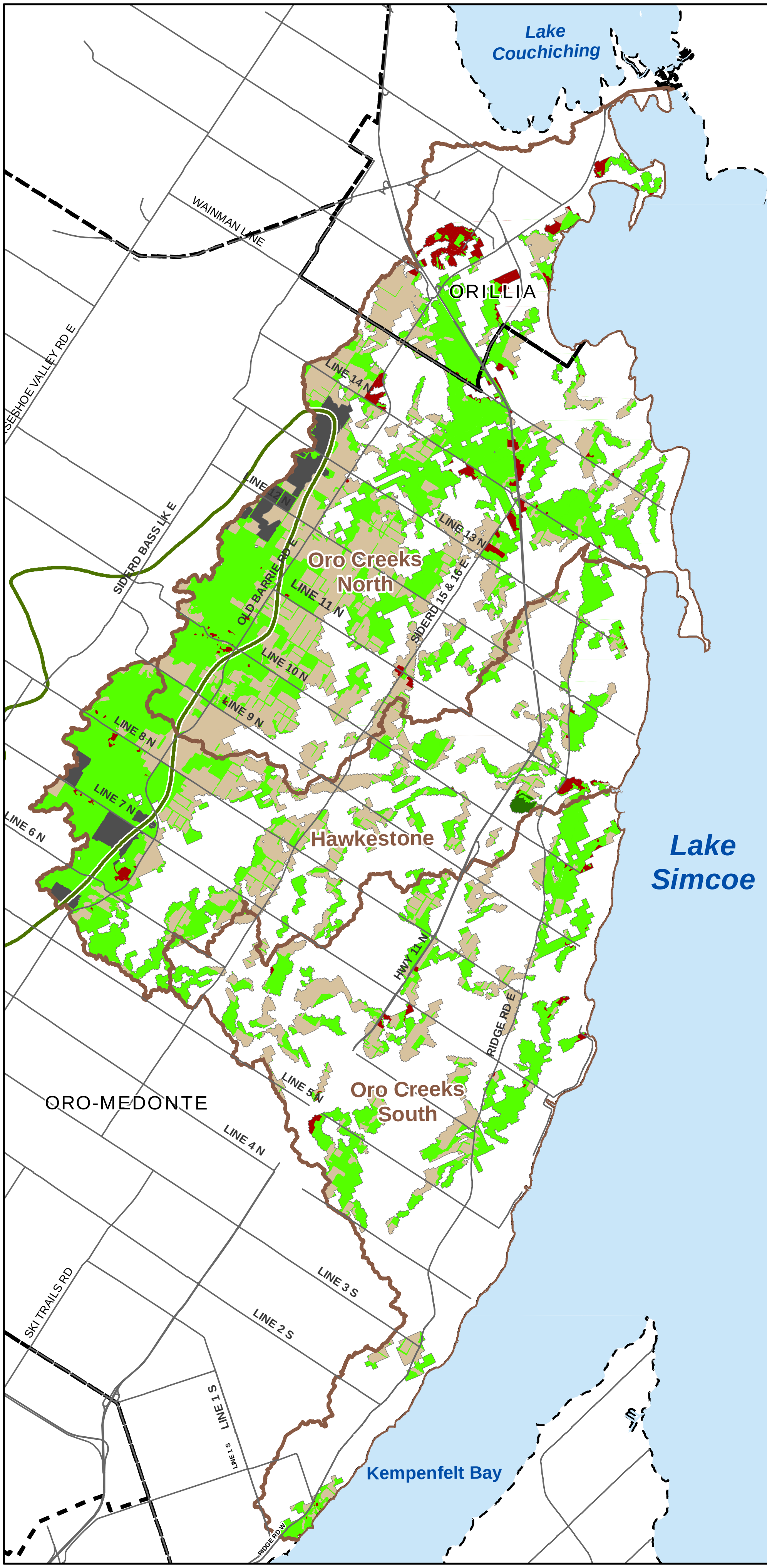


Figure 4-36: Land use distribution within Significant Groundwater Recharge Areas and Ecologically Significant Recharge Areas for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

Spatial distribution of land use within SGRA/ESGRAs in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 4-37



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Land Use

- Urban
- Rural
- Natural Cover
- Golf Course
- Aggregate

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

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 December 2013.

4.4.3 Climate

The climate of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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 branch of the river.

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.

4.4.4 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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), Earthfx (2013a).

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

<u>Tier 1 Water Budget Results</u>

The Tier 1 Water Budget Study (LSRCA, 2009) conducted a comparison of current conditions and future demand, 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 4-15 and Table 4-16. All three subwatersheds had a potential stress level of 1% therefore were found not to be stressed with regard to average annual stress for current demand. For future demand Oro Creeks North and Hawkestone Creek stress level remained the same, while Oro Creeks South had an increase from 1 to 6% but remained with a low stress level.

Results of the current monthly groundwater stress assessments are shown in Table 4-17. Only the Oro Creeks South subwatershed was found to have a potential for stress with regard to surface water during the summer months (June to September). The lack of seasonal changes in stress levels is a result of a fairly consistent groundwater and surface water supply and consistent water demand within these subwatersheds.

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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds 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 4-15: Tier One results - current annual groundwater stress assessment (LSRCA, 2009)

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available Supply				Reserve				Groundwater Consumption		GW Stress
									GW		SW		GW		SW				
	km^2	mm/a	mm/a	mm/a	m^3/s	mm/a	m^3/s	mm/a	mm/a	m^3/s	mm/a	m^3/s	mm/a	m^3/s	mm/a	m^3/s	m^3/a	mm/a	%
Hawkestone Creek	48	960	563	397	0.4	246	0.2	119	269	0.4	199	0.3	12	0.02	78	0.1	69,000	1	1%
Oro Creeks North	75	975	564	411	0.6	254	0.3	122	279	0.7	180	0.4	12	0.03	83	0.2	118,000	2	1%
Oro Creeks South	57	940	563	377	0.3	191	0.1	77	263	0.5	122	0.2	8	0.01	56	0.1	215,000	4	1%

Note: Values rounded for presentation purposes

10 - 24% of available supply being taken
25% or more of available supply being taken

AET - Actual Evapotranspiration
GW - Groundwater
SW - Surface Water

Table 4-16: Tier One results - future annual groundwater stress assessment (LSRCA, 2009).

Subwatershed	Area	Precip	AET	Surplus Water	Annual Mean Flow		Baseflow		Available Supply				Reserve				Groundwater Consumption		GW Stress
									GW		SW		GW		SW				
	km^2	mm/a	mm/a	mm/a	m^3/s	mm/a	m^3/s	mm/a	mm/a	m^3/s	mm/a	m^3/s	mm/a	m^3/s	mm/a	m^3/s	m^3/a	mm/a	%
Hawkestone Creek	48	960	563	397	0.4	246	0.2	119	269	0.4	199	0.3	12	0.02	78	0.1	149,000	3	1%
Oro Creeks North	75	975	564	411	0.6	254	0.3	122	279	0.7	180	0.4	12	0.03	83	0.2	146,000	2	1%
Oro Creeks South	57	940	563	377	0.3	191	0.1	77	263	0.5	122	0.2	8	0.01	56	0.1	876,000	15	6%

Note: Values rounded for presentation purposes

10 - 24% of available supply being taken
25% or more of available supply being taken

AET - Actual Evapotranspiration
GW - Groundwater
SW - Surface Water

Table 4-17: Tier One results - current monthly groundwater stress assessment (LSRCA, 2009).

Subwatershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hawkestone Creek	1%	1%	0%	0%	0%	1%	1%	1%	1%	0%	0%	1%
Oro Creeks North	1%	0%	1%	0%	1%	1%	1%	1%	1%	1%	0%	1%
Oro Creeks South	1%	1%	1%	1%	1%	2%	2%	2%	2%	1%	1%	1%

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 is similar to that 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds Tier 2 Water Budget (Earthfx, 2013a) conducted a comparison analysis of current and future conditions for average annual, monthly basis, 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 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 inTable 4-18 and Table 4-19. This assessment suggests that the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds are not stressed from a groundwater perspective. The percent water demand indicates that there is less than a 1% change in overall groundwater demand between current and future conditions (Earthfx, 2013a).

Table 4-18: Percent water demand stress assessment – current conditions (Earthfx, 2013a).

Component		Oro North	Hawkestone	Oro South
Groundwater Supply	Recharge In	56437	25429	14516
	Stream Seepage	39	12	20
	Lake Seepage	2	16	3
	Lateral Inflow	8865	16966	9348
	Total:	67698	43404	26155
Groundwater Reserve		5322	2584	790
Consumptive Demand		246	143	592
Percent Water Demand		**0.4%**	**0.4%**	**2.3%**

Table 4-19: Percent water demand stress assessment – future conditions (Earthfx, 2013a)

Component		Oro North	Hawkestone	Oro South
Groundwater Supply	Recharge In	58790	26673	16105
	Stream Seepage	39	15	20
	Lake Seepage	3	16	3
	Lateral Inflow	8907	16683	9980
	Total:	67738	43386	26108
Groundwater Reserve		5333	2579	789
Consumptive Demand		306	181	745
Percent Water Demand		**0.5%**	**0.4%**	**2.9%**

*values subject to round off

Drought Scenarios

As part of the Tier 2 Water Budget Analysis for the Oro North and South and Hawkestone Creeks subwatersheds (Earthfx, 2013a), a stress assessment on current and future conditions was completed. 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 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 (MODFLOW-NWT only) for a two-year period. Under the extreme conditions, the water table is seen to decline and groundwater discharge to streams is also significantly reduced. Model results show that the largest relative impact on streamflow occurs in the headwater tributaries. Many of these tributaries have flow only when the stream bottom intersects the water table and therefore were sensitive to small changes in aquifer heads. Groundwater levels are depressed on the east and west flanks of the Oro Moraine and significant head change is observed adjacent to the Shanty Bay municipal well system; however no municipal pumping wells went dry during the two-year drought assessment. Table 4-20 summarizes the change in the groundwater discharge to surface features on a subwatershed basis (Earthfx, 2013a).

Table 4-20: Two-year drought assessment – impact on groundwater discharge to surface features (Earthfx, 2013a).

Component	Oro North	Hawkestone	Oro South
Average groundwater discharge (m^3/d)	53215	25839	7895
Groundwater discharge at end of 2-year drought (m^3/d)	16166	9781	1205
Percent Reduction	**70%**	**62%**	**85%**

The 10-year drought scenario utilized the transient GSFLOW model. A model run spanning from October 1954 to April 1967 was executed using MNR 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 by the two-year drought scenario, with a 2.5-m drawdown predicted on the moraine rather than the 6.5 m predicted by the two-year simulation. As with the previous scenario, no municipal pumping wells went dry during the 10-year drought assessment. Table 4-21 summarizes the change in total streamflow on a subwatershed basis (Earthfx, 2013a).

Table 4-21: Ten-year drought assessment – Impact on groundwater discharge to stream channels (Earthfx, 2013a).

Component	Oro North	Hawkestone	Oro South
Monthly groundwater discharge to streams August 1957 (m^3/d)	7750	4593	2259
Monthly groundwater discharge to streams November 1964 (m^3/d)	6945	3242	1278
Percent Reduction	**10%**	**29%**	**43%**

Under both current and future conditions, all of the subwatersheds were assessed at the low stress level. Overall, both Hawkestone Creek and Bluffs Creek appear to be well connected to the groundwater system. Groundwater seepage occurs along the entire length of these stream channels. The headwaters of the Hawkestone and Oro North subwatersheds are well connected to the Oro Moraine aquifers. As seen in Figure 4-38 and Figure 4-39, Hawkestone Creek appears to be more sensitive to drought conditions in its lower reaches; this may suggest a reliance on local recharge to support the features lower in the subwatershed that are poorly connected to the available storage within the moraine. Shellswell Creek is poorly connected to the groundwater system, receiving substantially less groundwater seepage than channels in the northern catchments. Also, the seepage it does receive appears to be very sensitive to drought conditions. The tills at surface likely retard flow from the groundwater system and lower-order streams positioned in the till units would be sensitive to drought conditions (Earthfx, 2013a).

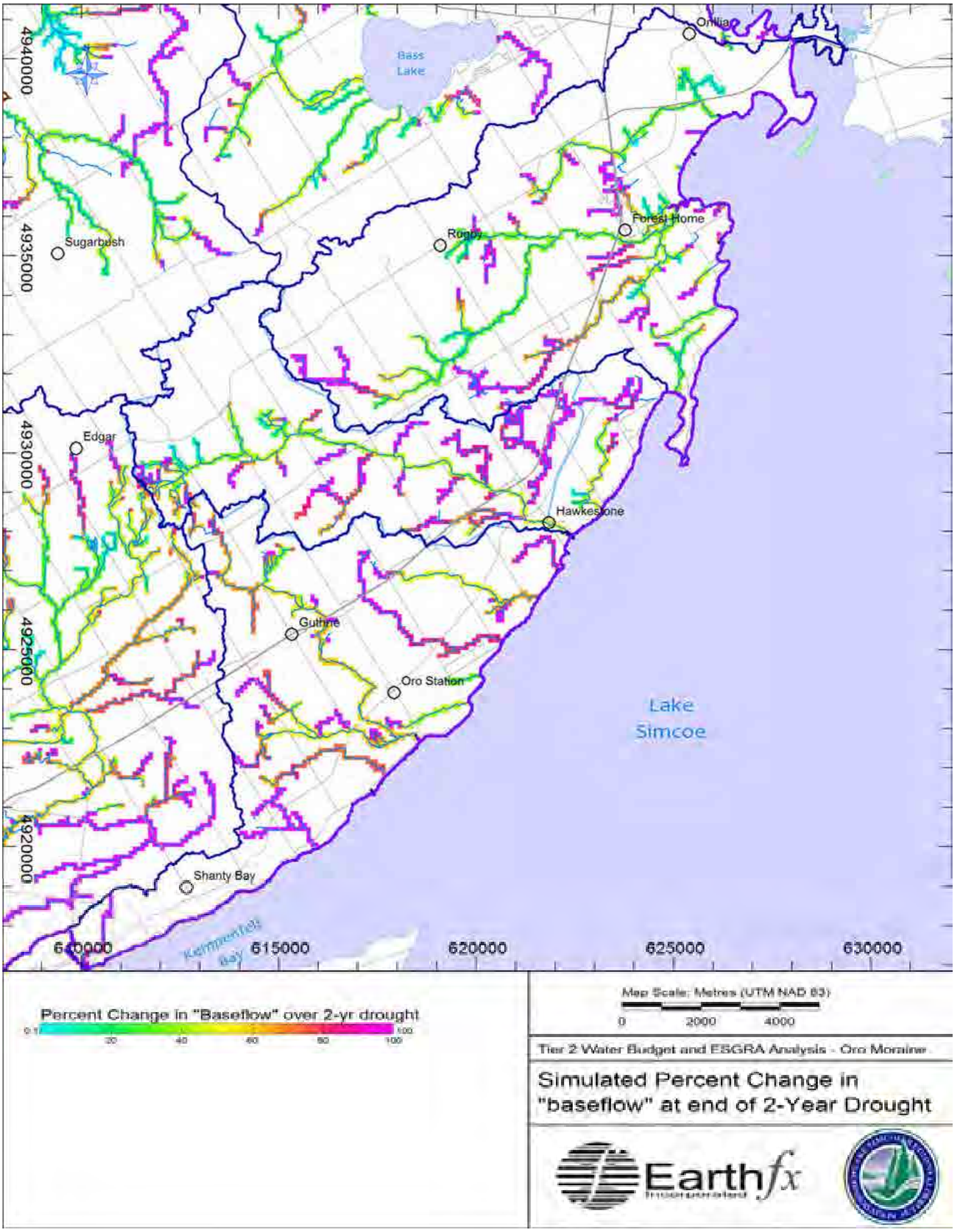


Figure 4-38: Simulated percent change in streamflows for a two-year drought (worst case scenario) (Earthfx, 2013a).

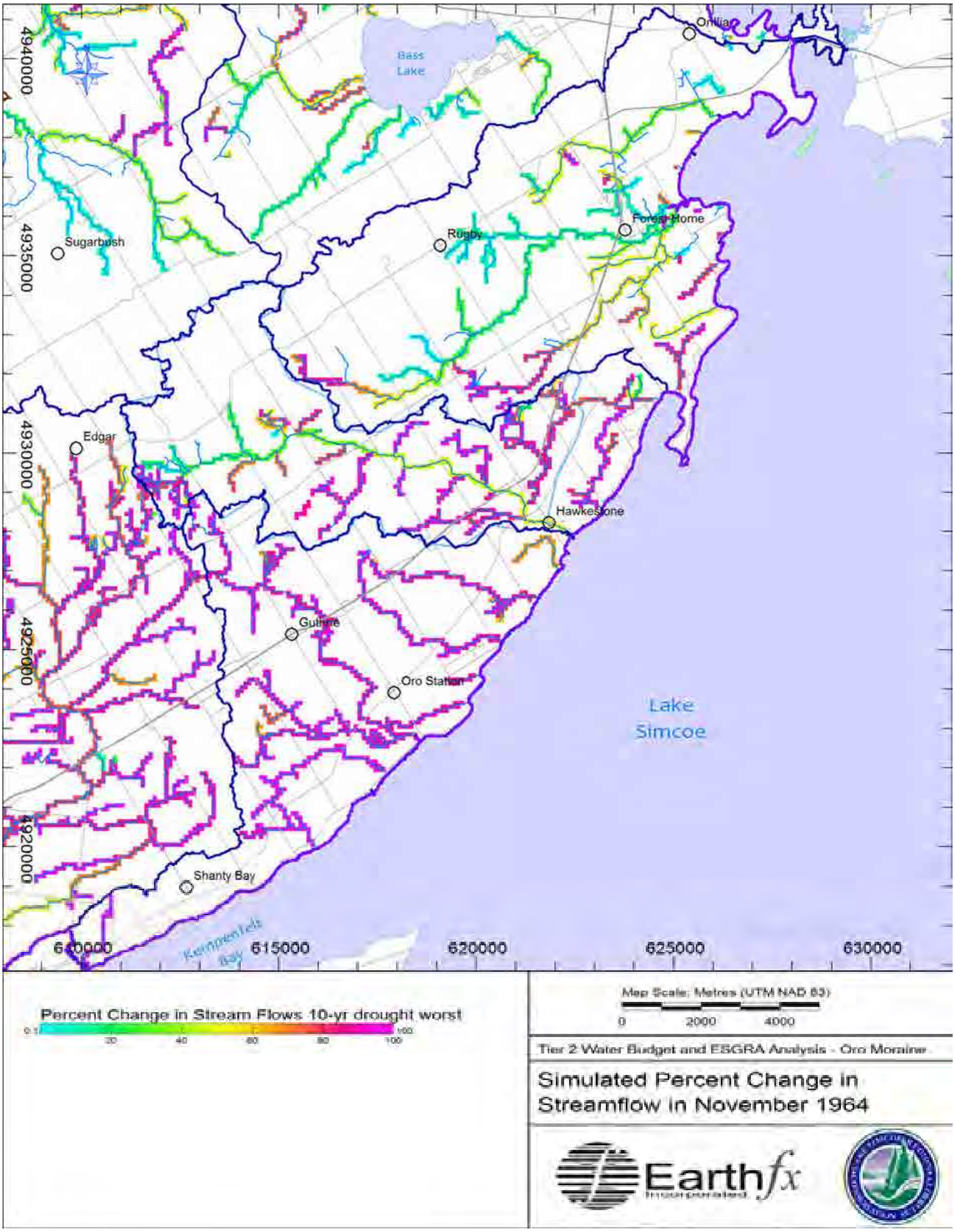


Figure 4-39: Simulated percent change in streamflows for a 10-year drought based on November 1964 data (worst case scenario) (Earthfx, 2013a).

Key points – Factors Impacting Water Quantity status - stressors:

- The water demand estimates for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds suggests that water demand is relatively uniform over the year, with minor increases in the summer months due to some seasonal permitted uses.
- The total current groundwater demand from all sources in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds subwatersheds is 358,065 m^3/yr.
- Permitted and domestic wells account for 89% of the current groundwater consumption within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. Oro Creeks South accounts for approximately 60% of the overall consumption as a result of municipal and domestic groundwater uses.
- The predominant land use type is natural heritage features, covering close to 50% of the entire study area.
- The Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds are predominantly rural with settlement areas accounting for less than 4% of the total area. The subwatershed contains a low level of impervious surfaces due to the lack of urban areas.
- The Tier 1 water budget estimated the current surface water use in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds to be 347,000 m^3/annum, which represents 2.5% of the available surface water supply. During September the Oro Creek North subwatershed exhibited a moderate potential for surface water stress.
- The Tier 1 water budget for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds estimated the current groundwater use to be 403,000 m^3/annum, which represents 1% of the available groundwater supply. Future groundwater use is projected to be 1,171,000 m^3/annum which represents 1% of the available groundwater supply for Hawkestone Creek and Oro Creeks North and 6% of the supply for Oro Creeks South. Overall, the Tier 1 indicated that the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds were not stressed from a groundwater perspective.
- The Tier 2 water budget for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds estimated the current groundwater use to be 358,065 m^3/annum, which represents 0.4%, 0.4%, and 2.3% the available groundwater supply for the three subwatersheds, respectively. Future groundwater use is projected to be 449,680 m^3/annum which represents 0.5%, 0.4%, and 2.9% the available groundwater supply for Oro Creeks North, Hawkestone Creek and Oro Creeks South respectively. Overall, the Tier 2 indicated that the subwatershed is not stressed from a groundwater perspective.

4.5 Current Management Framework

4.5.1 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 4-22 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 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 4-22: 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)	Proposed South Georgian Bay Lake Simcoe Source Protection Plan (2012)	LSRCA Watershed Development Policies (2008)	City of Orillia Official Plan (2011)	Simcoe County Official Plan (2007)	Township of Oro-Medonte Official Plan (2007)
Impervious surfaces	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	No applicable policies	No applicable policies	Restrictive policies in place	Restrictive policies in place	No applicable policies	Restrictive policies in place	No applicable policies
Agricultural water demand	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	No applicable policies	No applicable policies	No applicable policies	No applicable policies	No applicable policies	No applicable policies
Commercial and residential water demand	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	Restrictive policies in place	No applicable policies	No applicable policies	No applicable policies	Restrictive policies in place [2]
Climate change	Restrictive policies in place	No applicable policies	No applicable policies	No applicable policies	No applicable policies	Restrictive policies in place [1]	No applicable policies	No applicable policies	No applicable policies	No applicable policies

Legend: Restrictive policies in place | No applicable policies

[1] No policies to prevent climate change, but policies include an assessment of possible impacts
[2] Requires water resource management report for development of any new use in the Secondary Plan Area

As can be seen in Table 4-22, a number of Acts, plans, and policies already exist to protect surface and ground water quantity in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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.

Under the 2011 City of Orillia Official Plan (OP), the City identifies environmental protection areas, including wetlands, significant woodlots, and signficiant ANSIs; limiting the activities that can take place in these areas. The protection of these features and their functions will be necessary to protect the hydrological integrity of the watershed. The OP also contains a number of policies around the protection of Significant Groundwater Recharge Areas, around protecting and and restoring the quality and quantity of groundwater in these areas and the function of the recharge areas. The OP also notes that urban settlement area expansions should avoid SGRAs, but does note that an application for major development with an SGRA is to be accompanied by an Environmental Impact Study that demonstrates that the quality of groundwater and the function of the recharge areas will be protected, improved, or restored. Finally, under their Municipal Services policies, the City states that existing infrastructure for water resources should be used, where possible, prior to the construction of new facilities; and that when water or wastewater expansions are considered, that methods to increase the efficient use of water and recycling of water should be explored.

The Township of Oro-Medonte’s 2007 Official Plan contains many policies around protecting the function of significant recharge and discharge areas such as the Oro Moraine, which is an extremely important feature for maintaining the wetlands and streams that rely on the groundwater that the moraine provides. The OP also contains a number of policies around managing groundwater to ensure their continued viability and quality. In addition, the protection of other important natural features through the *Environmental Protection One* and *Two* designations will ensure that the recharge and retention functions of these features will be 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.

Furthermore, the draft South Georgian Bay – Lake Simcoe Source Protection Plan prohibits an increase in impervious cover in vulnerable areas around municipal wells, unless it can be demonstrated pre-development recharge can be maintained, and also prohibits designating new land uses that result in recharge reduction that would create a 'significant threat', unless the proponent can demonstrate that post-development recharge will match pre-development recharge.

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 MOE related to these Permits. The LSPP also directs the MOE and MNR 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 Oro-Medonte and City of Orillia 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.

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.

4.5.2 Restoration and remediation

Although neither the Provincial government (through the Lake Simcoe Community Stewardship Program) nor the LSRCA (through the Landowner Environmental Assistance Program) 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.

4.5.3 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 modeling, 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.

4.6 Management Gaps and Limitations

4.6.1 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.

4.6.2 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.

4.6.3 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. This will include an assessment of the risks of climate change impacts, additional research 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.

4.6.4 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.

4.7 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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

4.7.1 Water Demand

Recommendation 4-1 - That the MOE be encouraged to 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 4-2 - That the MNR and MOE, in partnership with LSRCA, develop a more detailed surface water budget for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds that will provide the basis of actions needed to determine ecological (instream) flow targets.

Recommendation 4-3 – That the MOE, with the assistance of MNR and LSRCA, determine if the Oro Creeks South, Oro Creeks North, or Hawkestone Creeks subwatersheds are water quantity stressed and require the development of in-stream flow targets

Recommendation 4-4 – That the MOE Director consider sensitive hydrogeologic and hydrologic features (e.g. SGRAs, and ESGRAs that support wetlands and coldwater reaches) identified in the Oro and Hawkestone Creeks subwatershed plan, in the review of Permit to Take Water applications.

Recommendation 4-5 – That the issue of 'mobile' water takers (e.g. water trucks) be assessed and that the MOE, in order to minimize the potential impact of these activities on aquatic biota, ensure that permits are being obtained, where required; that permit limits are being adhered to; and finally that permitted takings from individual watercourses are sustainable.

4.7.2 Reducing Impact of Land Use – groundwater recharge and discharge

Recommendation 4-6 – Where not already noted in their Official Plans, municipalities should generally direct development and incompatible land uses away from Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas.

Recommendation 4-7 – Where avoidance is not possible, municipalities shall only permit new development or redevelopment in significant recharge areas, where it can be demonstrated through the submission of a hydrogeological study and water balance, that the existing groundwater recharge will be maintained (i.e. there will be no net reduction in recharge).

Recommendation 4-8 - Municipalities should amend their planning documents to require the treatment of all contaminated runoff, prior to it being infiltrated. The treated runoff must meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-9 - That municipalities incorporate the requirement for the re-use or diversion of roof top runoff (clean water diversion) from all new development in significant recharge areas away from storm sewers and infiltrated to maintain the pre-development water balance (except in locations where a hydrogeological assessment indicates that local water table is too high to support such infiltration) in their municipal engineering standards.

Recommendation 4-10 – That MOE, in the context of LSPP Policy 6.37-SA, consider adopting the 'Guidance for the protection and restoration of significant groundwater recharge area in Lake Simcoe' document, following its completion. Further, that subwatershed municipalities utilize this document to incorporate policies around significant groundwater recharge areas into their official plans, as per LSPP Policy 6.38-DP.

Recommendation 4-11 – That the MOE, in partnership with LSRCA, promote stormwater management technologies that maintain pre-development groundwater recharge conditions.

Recommendation 4-12 – That the MOE consider amending the Environmental Compliance Approvals application form and Guide to recognize the importance of protecting Ecologically Significant Groundwater Recharge Areas and Significant Groundwater Recharge Areas.

Recommendation 4-13 – Municipalities, in collaboration with the Lake Simcoe Region Conservation Authority, shall undertake an education and outreach program focusing on the importance of significant recharge areas, and the actions residents and businesses can take to maximize infiltration from impervious surfaces while minimizing contamination such as salt. Activities could include website postings, newsletter inserts in municipal mail-outs, or school outreach. Education of municipal staff in all applicable departments should also be undertaken to ensure consistent messaging within the municipality.

Recommendation 4-14 - The Lake Simcoe Region Conservation Authority should create eligibility for infiltration projects and stormwater management system retrofits under the LEAP, giving priority to those in significant groundwater recharge areas where possible.

Recommendation 4-15 - Municipalities shall collaborate with the Lake Simcoe Region Conservation Authority to promote infiltration of clean water in significant recharge areas, and prioritize stormwater retrofits utilizing water quality controls, and ultimately infiltration devices for treated stormwater runoff.

Recommendation 4-16 – The Federal and Provincial governments should consider extending programs like Lake Simcoe Clean Up Fund and Showcasing Water Innovation that make investments into stormwater management facility retrofits and infiltration projects within recharge areas.

Recommendation 4-17 – The LSRCA and other stewardship groups should undertake works to increase natural cover in SGRAs/ESGRAs.

Recommendation 4-18 – Local and county municipalities and MTO should include significant recharge areas in their assessment of areas vulnerable to road salt, and modify their Salt Management Plans and snow disposal plans as necessary. The work currently being completed by LSRCA on identifying salt vulnerable areas should be considered in these assessments.

4.7.3 Climate Change

Recommendation 4-19 –That the LSRCA, in collaboration with the MNR and MOE, utilize the recently developed, fully integrated groundwater and surface water model to predict how stream flow volumes will respond to the seasonal and ecological impacts of climate change, in terms of increased peak flows, reduced baseflows, and increased water demand. This information will be used in the development of in-stream flow targets and the development of management strategies to address climate change impacts.

Recommendation 4-20- That the LSRCA work with its 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 other BMP implementation in conjunction with the protection of current hydrologic functions and water conservation initiatives and practices.

5 Aquatic Natural Heritage

5.1 Introduction

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.

The following sections in this chapter highlight the current status (Section 5.2) of each of the main watercourses in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds, as well as the stressors impacting them (Section 5.3), and the current management framework in place to protect and restore them (Section 5.4).

5.2 Current Status

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 that are relevant for the 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.

5.2.1 Overview of aquatic communities – Tributaries

5.2.1.1 Fish Community

Studying the health of the fish community of the Oro Creeks and Hawkestone 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 to one that is more tolerant of lower quality conditions. Long term monitoring will identify changes and trends occurring in the fish community the subwatershed, and will help to identify and guide restoration works.

A total of 28, 34, and 20 species, respectively, have been captured from the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds since 1975 (Table 5-1 to Table 5-3). Sampling effort has not been consistent in the three subwatersheds, with only Oro Creeks North having data for the full period from 1975 to 2011; there is no data for Hawkestone Creek for the period from 1990-2002, and no data prior to 1990 for Oro Creeks South. In addition, data collection methods have only been undertaken in a consistent manner since LSRCA began sampling in 2002, data prior to this is provided by the Ministry of Natural Resources, and is a compilation of all sampling completed by any person or group in the subwatershed, using a variety of sampling methods, for a variety of purposes. It is thus difficult to compare the results beyond a cursory presence/absence observation. The majority of the species that were captured historically continue to be found in current sampling efforts, with the exception of three species in the Hawkestone Creek subwatershed. There were a number of species that have been caught in current sampling (since 1990) but were not caught in samples prior to this; however, this is likely due to different sampling methods and locations than a lack of species. The fish communities in the subwatersheds range from coldwater communities featuring such species as brook trout (*Salvelinus fontinalis*) and mottled sculpin (*Cottus bairdii*) to diverse warm large order systems containing such species as largemouth bass (*Micropterus salmoides*) and brown bullhead (*Ameiurus nebulosus).*

The water temperature of a system can dictate the composition of the fish community, as well as determine the way systems are managed. Figure 5-1 below illustrates the combination of maximum air temperatures versus water temperature at 4 pm (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.

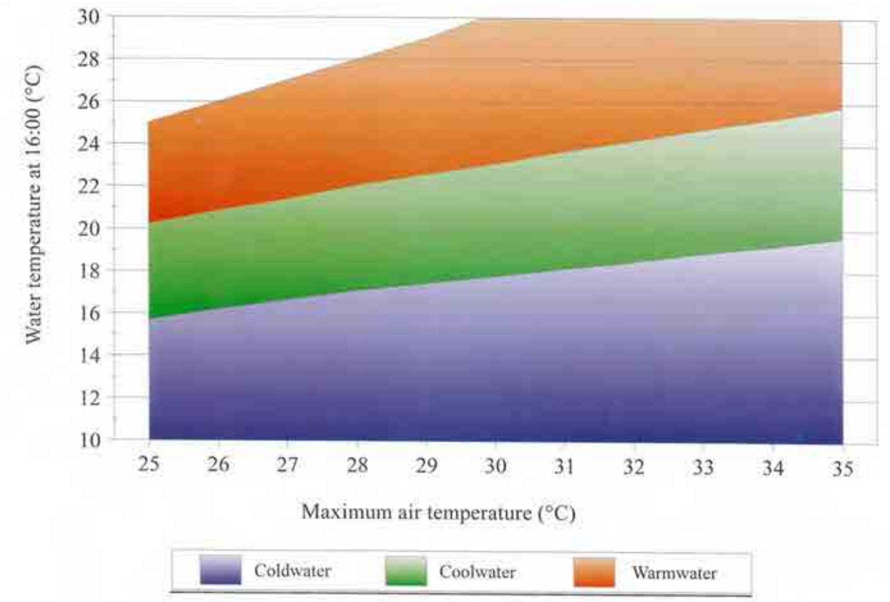


Figure 5-1: Cold, cool, and warm water trout stream temperature ranges (Stoneman and Jones, 1996).

Table 5-1: Fish species captured in the Oro Creeks North subwatershed from 1975-2011[+].

Common Name	Scientific Name
Rainbow Trout ^	*Oncorhynchus mykiss*
Brook Trout	*Salvelinus fontinalis*
Central Mudminnow	*Umbra limi*
Common White Sucker	*Catostomus commersoni*
Northern Redbelly Dace	*Phoxinus eos*
Finescale Dace	Phoxinus neogaeus
Common Carp^*	*Cyprinus carpio*
Hornyhead Chub	*Nocomis biguttatus*
River Chub	*Nocomis micropogon*
Golden Shiner	*Notemigonus crysoleucas*
Emerald Shiner	*Notropis atherinoides*
Common Shiner	*Luxilus cornutus*
Blackchin Shiner	*Notropis heterodon*
Blacknose Shiner	*Notropis heterolepis*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Blacknose Dace	*Rhinichthys atratulus*
Creek Chub	*Semotilus atromaculatus*
Pearl Dace	*Margariseus margarita*
Stoneroller	*Campostoma anomalum*
Banded Killifish	*Fundulus diaphanus*
Brook Stickleback	*Culaea inconstans*
Rock Bass	*Ambloplites rupestris*
Pumpkinseed	*Lepomis gibbosus*
Yellow Perch	*Perca flavescens*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Mottled Sculpin	*Cottus bairdi*

^ = Not native to Lake Simcoe watershed
** = Invasive species*
+= Two sources of data were used for this table: 1) LSRCA data from 2002 to present and 2) MNR data prior to 2002

Table 5-2 Fish species captured in the Hawkestone Creek subwatershed from 1975-2011[+,1]

Common Name	Scientific Name
Rainbow Trout ^,2	*Oncorhynchus mykiss*
Brown Trout^	*Salmo trutta*
Brook Trout	*Salvelinus fontinalis*
Rainbow Smelt^	*Osmerus mordax*
Central Mudminnow	*Umbra limi*
Common White Sucker	*Catostomus commersoni*
Goldfish^	*Carassius auratus*
Northern Redbelly Dace	*Phoxinus eos*
Finescale Dace	Phoxinus neogaeus
Eastern Silvery Minnow[2]	*Hybognathus regius*
Hornyhead Chub	*Nocomis biguttatus*
River Chub	*Nocomis micropogon*
Emerald Shiner	*Notropis atherinoides*
Common Shiner	*Luxilus cornutus*
Sand Shiner	*Notropis stramineus*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Blacknose Dace	*Rhinichthys atratulus*
Longnose Dace	*Rhinichthys cataractae*
Creek Chub	*Semotilus atromaculatus*
Pearl Dace	*Margariseus margarita*
Stoneroller	*Campostoma anomalum*
Brown Bullhead	*Ameriurus nebulosus*
Brook Stickleback	*Culaea inconstans*
Rock Bass	*Ambloplites rupestris*
Pumpkinseed	*Lepomis gibbosus*
Smallmouth Bass	*Micropterus dolomieu*
Largemouth Bass	*Micropterus salmoides*
Yellow Perch	*Perca flavescens*
Rainbow Darter	*Etheostoma caeruleum*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Logperch[2]	*Percina caprodes*
Mottled Sculpin	*Cottus bairdi*

^ = Not native to Lake Simcoe watershed
+= Two sources of data were used for this table: 1) LSRCA data from 2002 to present and 2) MNR data prior to 2002
[1]= No data available between 1990 and 2002
[2]=Only captured historically (prior to 1990)

Table 5-3 Fish species captured in the Oro Creeks South subwatershed from 1990-2011

Common Name	Scientific Name
Brook Trout	*Salvelinus fontinalis*
Rainbow Smelt^	*Osmerus mordax*
Central Mudminnow	*Umbra limi*
Common White Sucker	*Catostomus commersoni*
Northern Redbelly Dace	*Phoxinus eos*
Brassy Minnow	*Hybognathus hankinsoni*
River Chub	*Nocomis micropogon*
Emerald Shiner	*Notropis atherinoides*
Common Shiner	*Luxilus cornutus*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Blacknose Dace	*Rhinichthys atratulus*
Longnose Dace	*Rhinichthys cataractae*
Creek Chub	*Semotilus atromaculatus*
Pearl Dace	*Margariseus margarita*
Brook Stickleback	*Culaea inconstans*
Pumpkinseed	*Lepomis gibbosus*
Yellow Perch	*Perca flavescens*
Johnny Darter	*Etheostoma nigrum*
Mottled Sculpin	*Cottus bairdi*

^ = Not native to Lake Simcoe watershed
+= Two sources of data were used for this table: 1) LSRCA data from 2002 to present and 2) MNR data prior to 2002

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], 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 as locating any barriers to the movement of some or all fish species (Figure 5-3). 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 barriers are present fish may eventually disappear from an area.

Figure 5-3 shows the variation in temperature among the watercourses. Despite this variability, cold water species, such as brook trout and mottled sculpin, can be found in all three subwatersheds. Of note in the Hawkestone and Oro Creeks South subwatersheds is that the

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[1] Cold water species are indicators of cold water habitat. Coldwater species found in these subwatersheds include: rainbow trout*, brook trout, rainbow smelt *, mottled sculpin, and slimy sculpin (*not native to the Lake Simcoe watershed). All others listed in Table 5-2 are either cool or warm water species.

[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.

majority of the sites found to have coldwater fish communities are found in the lower reaches of the subwatersheds, not in the headwaters where they would typically be expected. There are also a number of sites that either have only warm water species or no fish being found; this is likely due to the presence of barriers. The map also shows where the major barriers to the movement of fish are located.

There are a few anomalies where cold water species are found within warm water habitat or warm water species in cold water habitat. The most likely reason that cold water species would be found in warm water habitat is the presence of small nearby temperature micro habitats, such as undercut banks and heavily shaded areas with cold water upwellings, springs, or seeps. It is also possible that a species was passing through or leaving the warm water habitat at the time of sampling, but this would be more unusual. It is not as unusual to find warm water species in cold or cool water habitats, as warm water species are habitat generalists and are able to survive in warm, cool, or cold water conditions.

LSRCA field crew - electrofishing

An Index of Biotic Integrity (IBI) was used to assess the ecological integrity of the creeks through the composition of fish communities within the system (Figure 5-3). 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

While the IBI is suitable for use in the Lake Simcoe watershed, there is potential for improvement by including a greater range of top predators into the IBI calculations. Currently only brook trout are weighed and measured individually. This may skew the results as warm water predators are not included in the IBI calculations.

Overall, Figure 5-3 shows that the ecological integrity of the systems varies spatially across the subwatersheds, with the majority of the sites showing fair conditions. Many of the sites displaying 'Good' IBI scores were found near the outlets of the tributaries to the lake, not in the headwater areas where the healthiest habitats are generally found. The likely reason for this anomaly in these subwatersheds is that a large proportion of the area on the lake side of Ridge Road East within the study area has retained its natural heritage features, which would help to maintain healthy stream habitat. Many of the sites rated 'poor' are in the vicinity of roadways, and agricultural and urban areas. Barriers such as dams and perched culverts also play a significant role in affecting the health of the aquatic community in some areas in these subwatersheds. None of the sites in these subwatersheds were rated 'Very Good' according to the IBI, likely due to a combination of the above factors.

Habitat varies in the Oro Creeks North subwatershed, with healthy coldwater habitat found at sites in both Bluff's Creek and Mill Creek, with sites in Bluff's Creek supporting successfully reproducing populations of brook trout, indicating areas of extremely healthy habitat in the vicinity of these sites, and both tributaries supporting other coldwater species such as mottled sculpin. However, several barriers in the upper end of Mill Creek degrade habitat and block fish passage, preventing populations of sensitive species, such as brook trout, from utilizing these areas, which is why there are currently no records of coldwater fish. The sampling sites on some of the smaller tributaries are found near their outlets into the lake, as these systems tend to dry up and these are the only sites where fish can be found.

Hawkestone Creek, with its high levels of natural cover and relatively undisturbed conditions, would be expected to support a healthy cold water stream supporting species such as brook trout; however, the presence of numerous barriers and warm stream temperatures prevent these species from thriving throughout much of the system. For example, there are five barriers in the lower section between Ridge Road East and the mouth, which significantly limits the migration of fish from the lake to the upper reaches of the system. Brook trout have been captured in the extreme upper reaches, as well as in the extreme lower reaches along with brown trout, and young of the year brook trout have been caught at one site in the lower reaches near the outlet. Cold water species have not been captured in the middle sections of this subwatershed, likely due to barriers to passage at the lower end of the subwatershed as well as warm water temperatures, which have been recorded at these sites. Anecdotal evidence also suggests that water takings are an issue in this subwatershed, although these can be difficult to track if the water is being taken by users that don't require a permit because they are taking less than 50,000 L; it is therefore difficult to

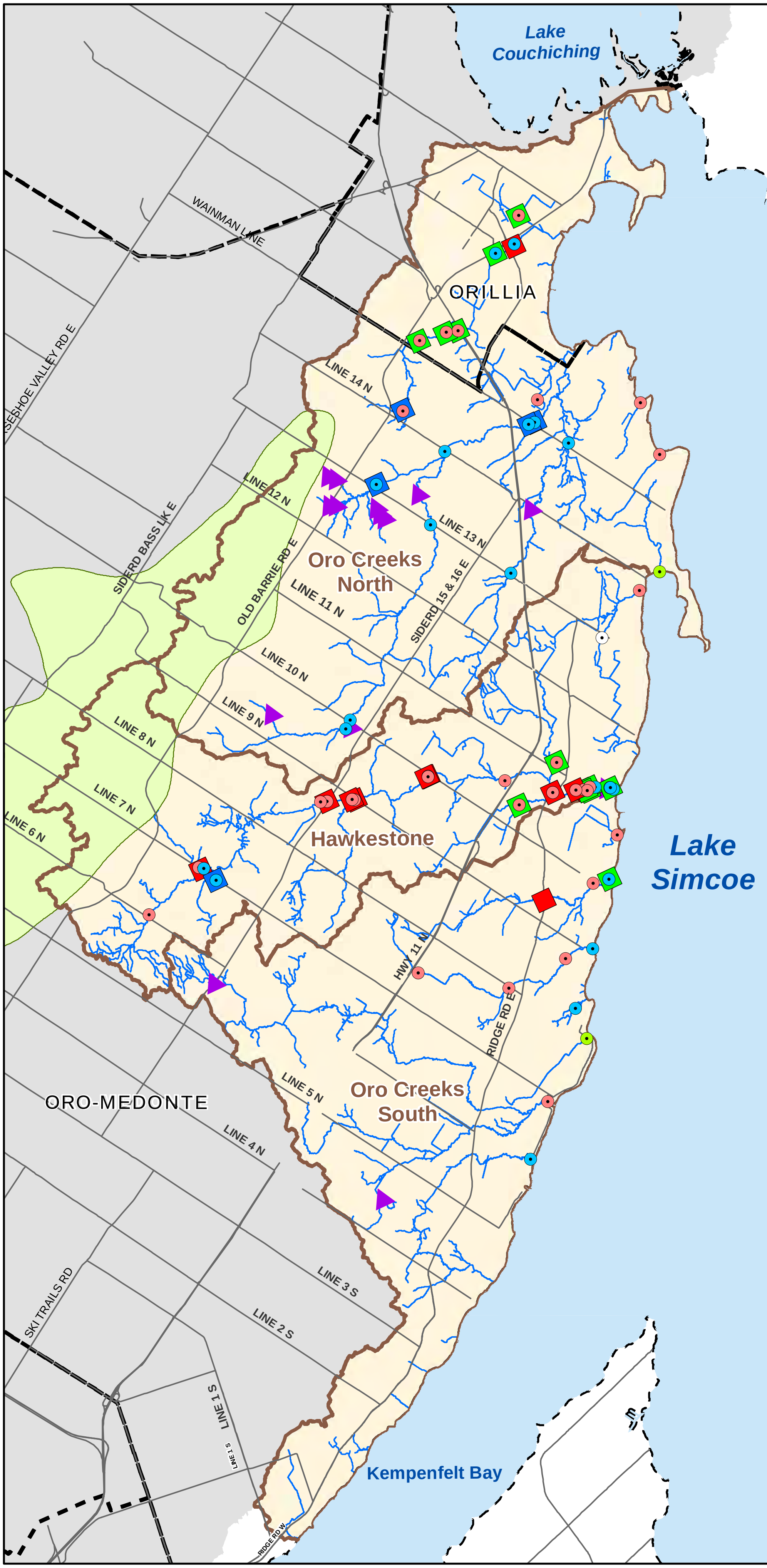
> **Brown trout**, a non-native species which has become naturalized in the area, is also an indicator of high quality coldwater habitat. It is native to Europe, but was introduced into Ontario waters in 1913 (Scott and Crossman, 1973), and stocked by MNR into Hawkestone Creek in 1988. This species can exist as resident fish and do not necessarily need to return to large bodies of water after spawning. This resident status often leads to detrimental competition with the less voracious brook trout; however, the successful co-habitation of these species in heavily fished waters has been documented (Marshall and McCrimmon, 1970).

conclusively state that this is a stressor in this subwatershed, but these concerns warrant further study.

A number of systems in the Oro Creeks South subwatershed contain habitat that is healthy enough to support coldwater fish species. Coldwater species have been found in Lakeview Creek, Allingham Creek, Burls Creek, and Braden's Creek, with both Burl's and Braden's containing brook trout, and Braden's Creek containing young of the year brook trout, indicating extremely healthy habitat. Many of the catchments in this subwatershed, however, dry up during the summer months, so the only sampling sites are near the mouths where flow remains; these results may therefore not be representative of the health of the entire system. In addition, both Burl's Creek and Shelswell's Creek contain barriers that limit the movement of fish, likely limiting the extent of healthy fish populations throughout certain sections of these catchments.

Occurence of fish communities in relation to measured in-stream water temperatures in the study area

Figure 5-2



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine
- Dam

Fish

- Cold
- Cool
- No Fish
- Warm

Temperature

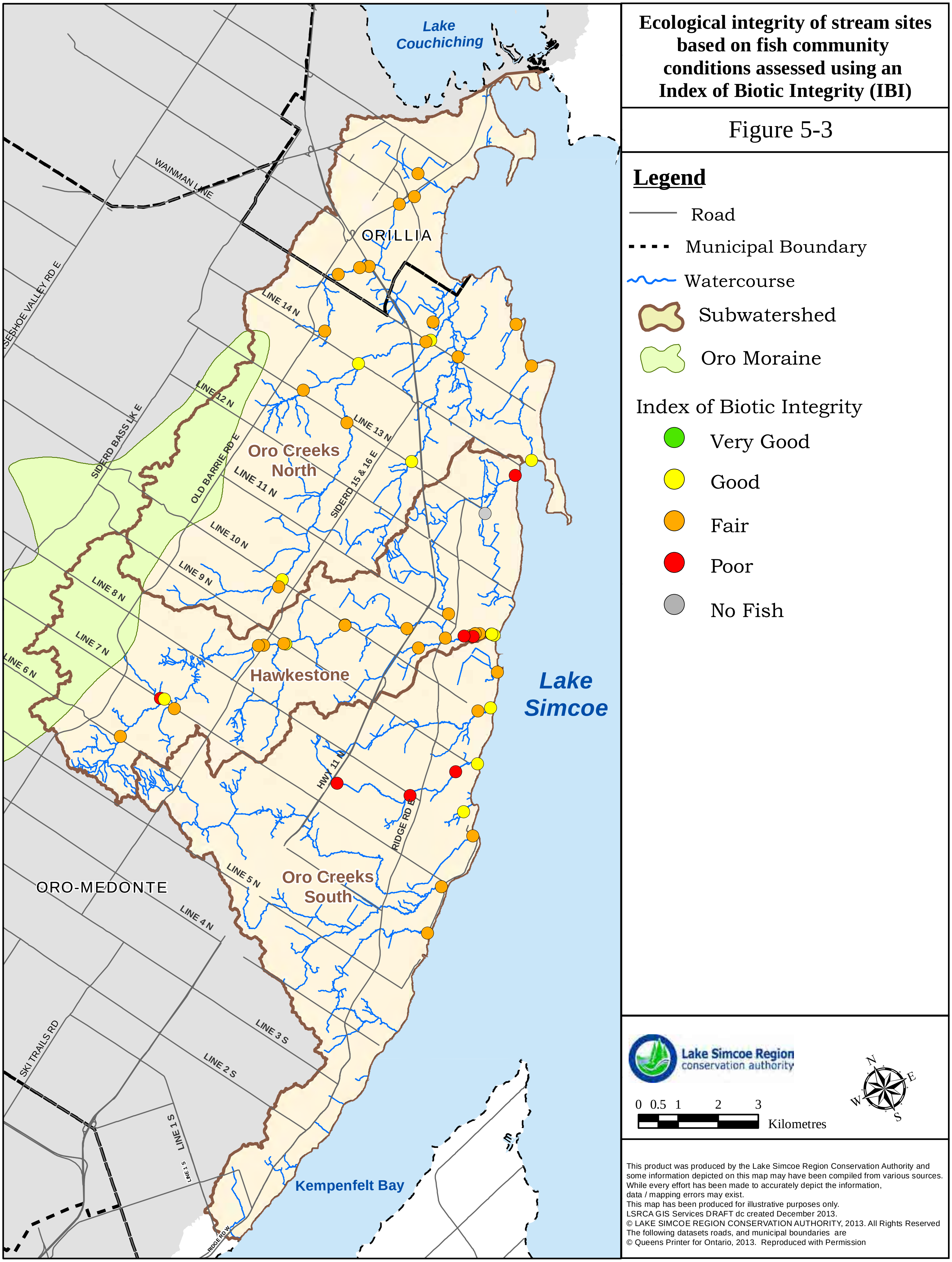
- Cold
- Cool
- Warm

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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 December 2013.



Ecological integrity of stream sites based on fish community conditions assessed using an Index of Biotic Integrity (IBI)

Figure 5-3

Figure 5-4 shows the historic and current presence of coldwater fish communities (those containing brook trout and/or mottled sculpin) in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds. This figure shows that, in general, the fish communities have not changed significantly since sampling began in these subwatersheds, with the majority of the sites that are sampled historically and at present maintaining their warm water or cold water status. There are five sites that showed different results in the current sampling than in the historic sampling, one in Oro Creeks South, two in Hawkestone, and two in Oro Creeks North. Brook trout and mottled sculpin were not found historically at these sites, and the fish communities were classified as warm water; however, one or both of these species is now found at these sites, and they are now classified as being coldwater. It should be noted that the lack of coldwater species presence at the historical sampling sites may be due to sampling effort or equipment and not due to a lack of fish presence. This figure also points out that all streams with historic coldwater communities have maintained these attributes, and have supported these communities over the last 10-35 years (depending on the system).

The reasoning for selecting brook trout as a key indicator species is provided in the following case study.

Significance of brook trout in the tributaries of Lake Simcoe

The brook trout (*Salvelinus fontinalis)* is a native fish species that inhabits the Lake Simcoe watershed in cold, clear gravel-based tributaries. They are a member of the Char family, which also includes arctic char, bull trout, and lake trout. Brook trout characteristically have fairly specific coldwater life history requirements. As they are considered the proverbial "canary in the coal mine" indicator for local rivers and streams, the presence of brook trout in a local stream is an indicator of high quality water and habitat features. As a result, only the healthiest tributaries in the Lake Simcoe watershed can support brook trout.

Brook trout (*Salvelinus fontinalis*)

Because of their need for the cold water habitat, typically created by spring stream bank seepage entering streams at the surface or groundwater upwelling through the streambed substrate, brook trout populations are closely linked to the geology of the watershed. They are commonly found in aquatic habitats with porous substrates, in the form of sands and gravels, and with the presence of groundwater that reaches the surficial soil layers.

Groundwater-based streams tend to be less variable both in flow and temperature. Because groundwater originates below ground surface, it is not subject to the extremes in heat and cold that a watercourse would be. Typically the temperature of groundwater is cooler in the summer and warmer in the winter than ambient surface stream temperatures. Groundwater adds to the volume of flow of the stream as baseflow, and contributes to a significant moderating thermal influence on the system.

These changes are most often related to changes in land use through land development or intensified agricultural practices, which can include: cutting of stream bank vegetation,

Brook trout spawning over groundwater upwelling

excess sedimentation and the interception of close-to-surface groundwater, all of which contribute to cumulative change in tributaries. On-stream barriers such as dams are also another significant factor, as they warm downstream temperatures, act as a silt trap for sediment moving downstream and prevent movement of fish to colder upstream reaches. The decrease in water quality also tends to create a more suitable habitat for non-native fish species (such as brown trout and rainbow trout) that may out-compete the native brook trout for resources.

Successful brook trout reproduction has specific physical requirements. Between October and December, mature brook trout seek out areas of upwelling groundwater in the streambed to spawn.

These sites may be distributed evenly throughout a tributary or there may be very limited locations where upwelling can be detected. While they prefer to spawn over a gravel/sand substrate, the size of the substrate is of less importance than the presence of upwelling activity. Eggs deposited in a 'nest' (commonly known as a redd) are flushed by constantly moving interstitial groundwater which is stable in temperature and normally slightly warmer than ambient stream temperature during the winter months. This condition allows the eggs to develop more quickly, resulting in the emergence of larval brook trout in late March. Compared to other resident fish species and to the non-resident trout species, this is very early in the season and provides the young brook trout with a competitive advantage in terms of food availability and time to grow and mature.

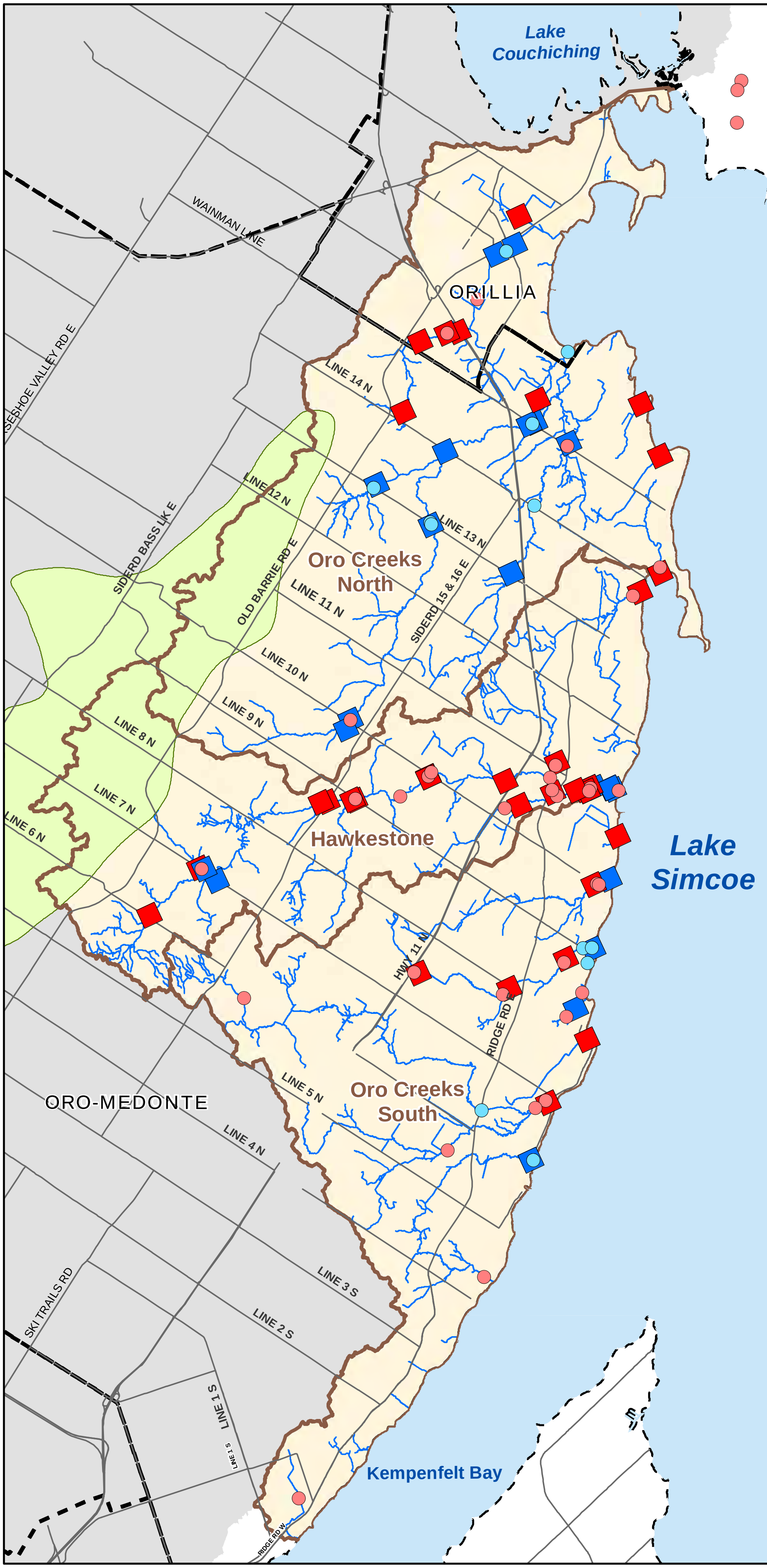
Typical brook trout habitat

Despite their sensitivity to change, brook trout and their habitat respond well to stream rehabilitation. Efforts are focused primarily on reducing thermal and sediment impacts and improving in-water habitat. Typical techniques like adding instream structures, such as bank stabilizers, deflectors, cedar sweepers, overhead cover, half logs, and strategic rock and gravel placement, are used. In addition, planting stream banks with appropriate native vegetation, restricting livestock access with fencing and enhancing spring seeps adjacent to the channel are often undertaken as part of a stream rehabilitation plan. These methods are particularly effective where groundwater continues to provide baseflow and where other local biophysical features have not been impacted.

Today, it is important that we protect, restore and maintain current and historic brook trout habitat, as these are areas that are, or have the potential to be, high quality aquatic habitats, in terms of both water quality and habitat features. As such, additional efforts need to be undertaken to protect the tributaries of the Lake Simcoe watershed that support these native fish.

Historic and current presence of warm and cold water fish communities in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 5-4



Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Oro Moraine

Current Fish

Cold

Warm

Historic Fish

Cold

Warm

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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.
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LSRCA GIS Services DRAFT dc created December 2013.

5.2.1.2 Benthic 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 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.

Benthic invertebrates have been collected from these subwatersheds since 2002 employing a consistent and standard collection method (Ministry of the Environment, 2003). Figure 5-5 is an assessment of the ecological integrity of the creeks through the composition of the benthic invertebrate communities within the system. 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

Figure 5-5 shows the ecological integrity of the watercourses, based on benthic analysis, across the subwatersheds. The sites in the Oro Creeks North subwatershed vary from Excellent, at a site on Mill Creek, to Very Poor, at the mouth of Cedarmount Creek. The healthiest sites in Mill Creek can be found in the upper reaches, located in areas of natural heritage and rural development; the lowest rating in this catchment is a 'Fair' in the vicinity of Highway 12 and Memorial Avenue, surrounded by rural development. In Bluff's Creek, the sites range from Good to Fairly Poor, due to the mainly sandy substrates that do not generally support the benthic invertebrate species that substantiate higher scores. The sites on the smaller catchments, including Pointview Creek, Cedarmount Creek, and Carthew Creek are rated Fair to Very Poor, likely due to the low flows and mucky substrates that do not support the more sensitive benthic invertebrate species, and possibly due the cumulative effects of upstream land uses, including large areas of agriculture.

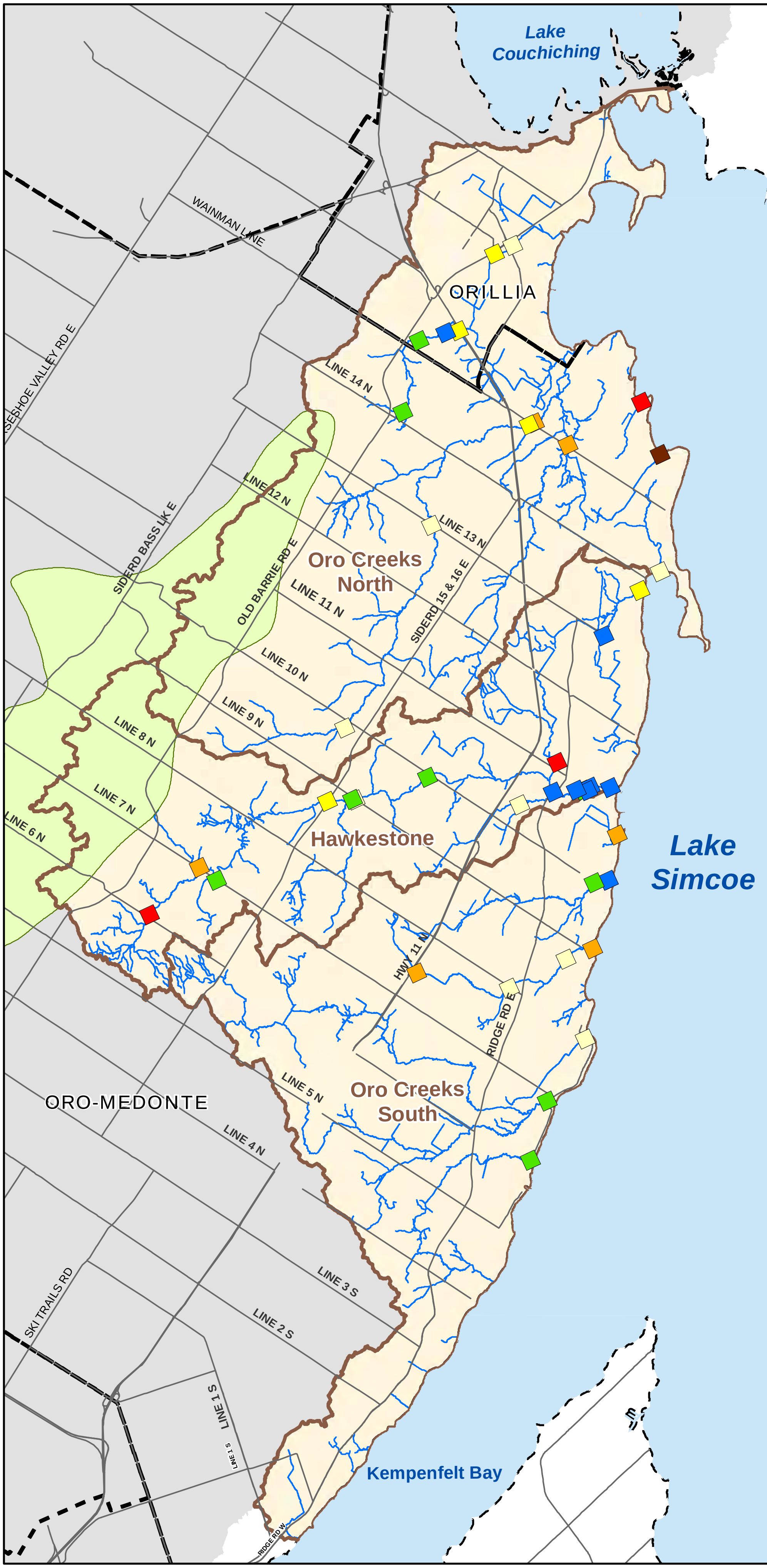
The Hawkestone Creek subwatershed has sites varying from Excellent to Very Poor ratings, but the majority of the sites are rated Excellent and Very Good due to the good flow, rocky substrates, cool water, and lack of inputs of organic pollution in the vicinity of these sites. Both Maplewood Creek and Wriglew's Creek show healthy benthic invertebrate communities, with 'Good' and 'Excellent' ratings, respectively. Both of these catchments flow mainly through natural heritage features, likely the reason for the healthy aquatic communities. Hawkestone Creek, with a large number of sampling stations along its length, shows a wide variety of conditions. As with the fisheries results, the communities within the Hawkestone Creek subwatershed are not what would be expected in a typical watershed, with the downstream segments showing healthier scores than the sites in the headwaters. The site furthest upstream received a ‘Poor’ rating, with the next downstream showing ‘Fairly Poor’. Just downstream of this site there is a station rated ‘Very Good’ on a tributary draining from the south. The sites through the middle section of the main branch, which flow through a mixture of natural heritage and agricultural land uses, range from ‘Fair’ to ‘Very Good’. There is a ‘Fair’ station in the middle of a golf course on a southern tributary and a ‘Poor’ site on a tributary draining from the north approximately one kilometre from the mouth. From here all of the sites in the downstream portion of Hawkestone Creek are ‘Excellent,’ with the exception of one rated ‘Very Good,’ in terms of their benthic invertebrate index scores.

There are several sampling sites across the many catchments that make up the Oro Creeks South subwatershed, displaying a range of conditions. The single station on Simcoeside Creek, which flows mostly through urban areas and rural development, is ‘Fairly Poor;’ this station is noted to have high water takings and high nutrient inputs, possibly due to poorly functioning septic systems. Allingham Creek, the next catchment to the south, which flows through natural heritage features and agricultural areas, has two sites, both fairly near the mouth of the catchment. The upstream site is rated as ‘Very Good’, and the site nearest the mouth is rated ‘Excellent;’ the natural heritage features, steady flow, and rocky substrates appear to be having a positive influence on the conditions in this catchment. Burl’s Creek contains four benthic invertebrate sampling sites, which receive ratings ranging from ‘Fair’ to ‘Fairly Poor’ in spite of significant portions of the watercourse flowing through natural features, particularly in the vicinity of some of the monitoring sites. These ratings are likely due to the lack of flow in the catchment during the summer months. Further south, the station on Barillia Creek is rated ‘Fair’, and has mostly natural heritage features and a small section of agriculture upstream and the urban area along the lakeshore in the vicinity of the site. The sites on Shelswell’s Creek and Lakeview Creek, both of which are located in the urban area near the lakeshore, were both rated ‘Very Good’, with a mixture of natural heritage and agriculture upstream.

When using fish and benthic indices to evaluate the ecological integrity of a system, it is likely that there will be some discrepancies between the data. For example, there may be a poor rating of a site by the IBI and a good rating by the Hilsenhoff index. A possible explanation may be that while warm temperatures can limit the number of cold water indicator fish species at a site (resulting in a lower IBI score), some highly sensitive insects are not affected by temperature. There may also be the opposite scenario where the IBI gives a good rating and Hilsenhoff a poor rating. A likely explanation for this is that fish are more mobile than benthic invertebrates, and in times where habitat conditions have deteriorated (low oxygen, low water levels, high temperatures, or poor water quality), benthic invertebrates are unable to move as quickly to better conditions and whole populations can be wiped out. If this occurs, benthic communities will likely not return the following year, whereas fish will return if habitat conditions have improved. The last scenario is at sites where no fish have been caught. Conditions at a site could include low flow, high gradient, or have barriers to fish passage.

While these conditions are not favourable to fish, benthic invertebrates can still have healthy populations at these sites, which will be reflected in a higher Hilsenhoff rating. These types of occurrences happen at several sites in the subject subwatersheds, including:

- On the southern tributary of Mill Creek, where the HBI scores are mostly ‘Very Good’, with an ‘Excellent’ and a ‘Good’ site, and the fish sites in the same area are rated ‘Fair’
- In Cedarmount Creek the fisheries site is rated ‘Fair’ whereas the benthic invertebrate site is ‘Very Poor’
- In the sites starting approximately 0.5 km upstream from the mouth of Hawkestone Creek, the benthic scores are ‘Excellent’ and ‘Very Good’ and the fish are rated ‘Fair’ and ‘Poor’



Ecological integrity of stream sites based on benthic community conditions assessed using the Hilsenhoff Biotic Index (HBI)

Figure 5-5

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Hilsenhof Biotic Index

- Excellent
- Very Good
- Good
- Fair
- Fairly Poor
- Poor
- Very Poor

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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5.2.1.3 Algae as an indicator of ecological condition

Diatoms (in the class Bacillariophyceae) and scaled-chrysophytes (in the class Synurophyceae) are single-celled algae encased in frustules of silicon dioxide that live free-floating in the water column or attached to rocks, plants, sand grains, and other substrates. As these algae have well-studied ecological optima and tolerances to most limnological variables, as well as rapid response times to changing conditions (less than 24 hours), the species assemblages can be related to environmental conditions and used to assess and track a wide variety of environmental changes. The LSRCA Lake Science Research and Monitoring Program has, since May 2008, been developing these algal groups as key indicators in monitoring environmental conditions in Lake Simcoe and its tributaries. The importance of these indicators has been recognized by the development of an Ontario Provincial Algae Bioassessment Protocol, and their inclusion and wide application across the United States and Europe. In general, these indicators can detect statistically significant environmental changes which directly impact the biological communities of the ecosystem of interest. In the Lake Simcoe watershed, diatoms are collected annually at 51 sites and used to track changes in biological communities, water quality, and phosphorus concentrations. Three of the sites are located in the subwatershed plan study area, two on Hawkestone Creek and one on the Oro Creeks North. Using these data, we study how the nutrient is transferred from land to water, detect areas of high phosphorus inputs, and evaluate the effectiveness of our remediation and stewardship strategies.

To date, results of the study have successfully reconstructed measured environmental conditions. The most successful environmental variables are: pH (r^2 = 0.53); alkalinity (r^2 = 0.66); nutrients (total phosphorus, r^2 = 0.50; total Kjehldahl nitrogen, r^2 = 0.60); specific conductance (r^2 = 0.79); and metal contamination (e.g. aluminum r^2 = 0.51). Further work includes fine tuning the species – variable calibration set, and using other biological indicators (e.g. thecamoebians [group of unicellular protozoa in the water that are sensitive to environmental changes], which are successful at reconstructing oxygen concentrations and detecting hypoxic / anoxic events which can result in fish kills).

Future work will be undertaken to narrow down what species give the most accurate results, so that eventually these samples can be used to determine what the changes are in the system. Once finalized, this type of sampling is faster and more economical than the multiple water chemistry samples currently taken today.

An analysis of the algae at the second site on the main branch downstream of the headwaters has also been completed. Again as these are the initial stages of the study, the focus was to see if the diatom-inferred values for several key environmental indicators were the same as instrument measured values. Analysis of diatom-inferred values showed a very good relationship with measured variables (Table 5-4). The diatom community is dominated by species typical of nutrient-rich flowing waters (*Achnanthes minutissima, Cocconeis placentula, Cyclotella meneghiana, Cymbella affinis, Fragilaria crotonensis, Nitzschia palea*) (Table 5-4).

Table 5-4: Comparison of diatom-inferred and recorded data for key environmental indicators at Hawkestone Creek, October 2011.

Variable	Diatom-inferred value	Measured value
pH	7.9	8.1
Temperature (°C)	19.5	17.9
Dissolved Oxygen (mg/L)	9.4	9.0
Total Phosphorus (mg/L)	0.02	0.02
Total Kjehldahl Nitrogen (mg/L)	0.71	0.60

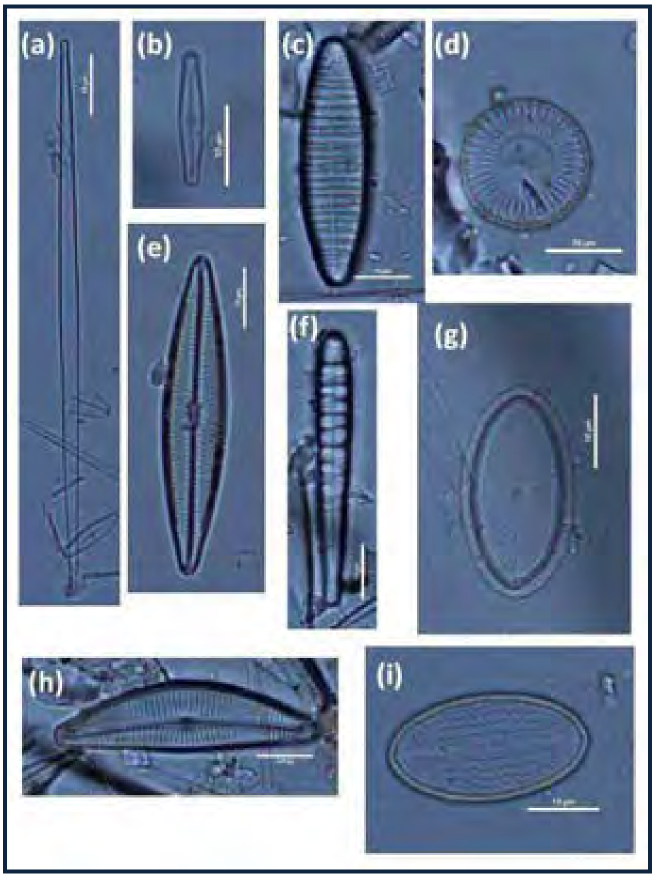


Figure 5-6: Photographs of key diatom taxa recorded from monitoring sites in Lover's Creek: (a) *Fragilaria sp.*, (b) *Achnanthes minutissima*, (c) *Diatoma vulgaris*, (d) *Cyclotella meneghaniana*, (e) *Navicula sp.*, (f) *Meridion circulare*, (g) *Cocconeis sp.*, (h) *Cymbella affinis*, (i) *Cocconeis sp*.

5.2.2 Overview of aquatic communities – Lake Nearshore

In addition to assessing the tributaries within the subwatersheds, the nearshore lake communities were also analyzed, as the nearshore zones are critical areas that are linked to both the terrestrial riparian area and to the tributaries and the aquatic communities within them. 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.

In May 2008, LSRCA carried out a survey of aquatic plants across Lake Simcoe to set a baseline for future change. While previous studies focused on Cook's Bay, an area of high plant biomass, this new study covered the entire lake, and identified five other areas of high biomass, one of which is the Oro shoreline at Carthew Bay [Figure 5-7 (a)]. While this area has a very small zone available for aquatic plant colonization due to the quick drop in depth, excess nutrient run-off into Lake Simcoe (the Oro Creeks North subwatershed contributes an estimated 2.6 tonnes[3] of phosphorus per year, while Oro Creeks South and Hawkestone contribute 0.4 and 0.3 tonnes[3] of phosphorus per year, respectively [values are based on modelled, three year average from 2007-2009] [LSRCA and MOE, 2013]), soft substrates, the sheltered nature of the Bay, 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 (*Dreissenia polymorpha*) clearing the water and creating ideal habitat for plant growth. The invasive species, eurasian watermilfoil (*Myriophyllum spicatum*), likely invaded this area and displaced any native species.

The second component being analyzed is the amount of phosphorus contained in lake sediments, which was poorly understood prior to the initiation of the LSRCA Lake Science Research and Monitoring Program. Monitoring of sediment phosphorus is undertaken because of the potential for phosphorus release under low dissolved oxygen concentrations in the water (less than 2 mg/L) and this is, thus far, an undetermined source of phosphorus loading. Along the Oro-Medonte shoreline, mean sediment nutrient concentrations are relatively high with total phosphorus (TP) ~0.8 mg/g, likely due to soft, muddy substrates which hold more nutrients than coarser grained sediments [Figure 5-7 (c)]. For comparison, concentrations range across the lake from TP ~0.35 mg/g in Cook's Bay to ~1.4 mg/g near Beaverton. For details on the total phosphorus within the tributaries please refer to **Chapter 3 - Water Quality**.

The last component of the LSRCA Lake Science Research and Monitoring Program is monitoring 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

[3] This total does not include septic systems

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, *Dreissenia polymorpha*; quagga mussel, *Dreissenia 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, with the only exception being just south of the study area along the Barrie shoreline, in Kempenfelt Bay, with dreissenids being found growing in clumps on softer substrates to a maximum depth of 31 m [Figure 5-7 (b)]. Further studies are being undertaken to determine a reason for this exception.

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).

In terms of rating the condition of the nearshore habitats, based on the three components above, the shoreline along these subwatersheds is considered to be in fair condition.

Lake nearshore habitat of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 5-7

Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Sampling Location

Lake Simcoe Region conservation authority

0 1 2 4 6 Kilometres

N E S W

A - Plants

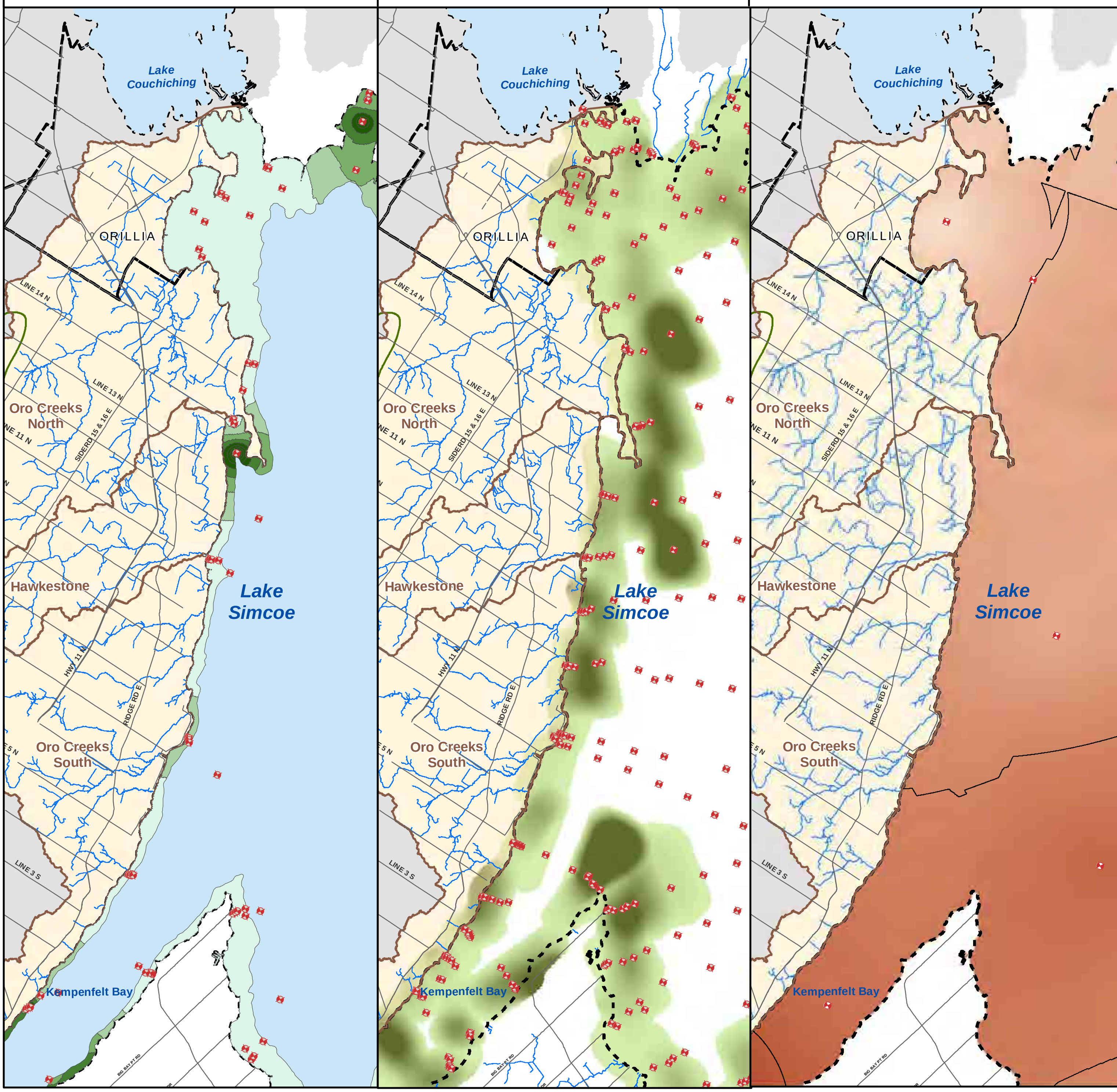
Total Biomass (g (dry wt) · m^{-2})
0 - <20
20 - <40
40 - <60
60 - <80
≥80

B - Zebra Mussels

Mussel Total dry wt. biomass ($g_{(dry)} \cdot m^{-2}$)
259.2
0.0

C - Sediment

Phosphorus Concentration (µg/g)
Phosphorus Concentration (µg/g)
1399 ($e^{7.24348}$)
391 ($e^{5.96875}$)



5.2.3 Rare and Endangered Species

There are no known aquatic Species at Risk in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

Key Points - Current Aquatic Natural Heritage Status:

- The aquatic habitat conditions in Oro Creeks North vary, with fisheries sampling on Bluff's Creek and Mill Creek showing healthy sites with coldwater species; and other sites displaying less healthy conditions with warm water species, particularly where they are affected by the presence of barriers, agricultural areas, and roads. These results are generally consistent with the benthic invertebrate sampling, which shows the healthiest sites in the headwaters of Mill Creek; somewhat less healthy conditions in Bluff's Creek, although this is likely due to substrate as much as habitat conditions; and sites ranging from Fair to Very Poor in the small tributaries that drain directly into the lake. This is likely due to lack of flow, poor substrates, and the cumulative impact of upstream land uses.
- Despite having high levels of natural cover, Hawkestone Creek only supports healthy coldwater fish communities, including brook and brown trout, in its extreme upper and lower reaches, with coldwater species absent in the middle reaches, likely due to the presence of a number of barriers. Benthic invertebrate samples generally show similar trends, although appear more healthy, likely due to good flow, rocky substrates, cool water, and a lack of inputs of organic pollution near these sites.
- Tributaries in the Oro Creeks South subwatersheds, including Lakeview Creek, Allingham Creek, Burls Creek, and Braden's Creek, are healthy enough to support coldwater fish species. Burl's Creek and Shelswell's Creek contain barriers that limit the movement of fish, likely limiting the extent of healthy fish populations in these tributaries. Benthic invertebrate samples show similar results to those of the fish samples, although Burl's Creek shows lower scores than would be expected given the high levels of natural cover, this is likely due to lack of flow during the summer months.
- While there are no specific studies on the spawning of species for these subwatersheds, there is evidence indicating that brook trout may be successfully spawning and surviving in Bluff's Creek, Burl's Creek, and Hawkestone Creek.
- A comparison of the historic and current presence of coldwater fish communities showed that, for the most part, fish communities have not changed significantly since sampling was first undertaken in the study area. There were five sites where coldwater species were not found historically, but are found in current samples; however this is likely more an indication of different sampling methods than a shift in the fish community.
- Sampling of the nearshore has found a high density of aquatic plants at Carthew Bay, due to relatively high phosphorus inputs, soft substrates, and increased water clarity due to zebra mussels; relatively high phosphorus concentrations in the sediment in the nearshore zone; and fairly high concentrations of zebra mussels. Based on these results, the nearshore area of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds were considered to be in fair condition

5.3 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,
- Enclosures,
- Flow diversion,
- Uncontrolled stormwater and impervious surfaces,
- Municipal drains,
- Removal of riparian vegetation,
- Water quality and thermal degradation,
- Loss of wetlands,
- Invasive species, and
- Climate change.

These factors are discussed in detail in the following sections.

5.3.1 Barriers

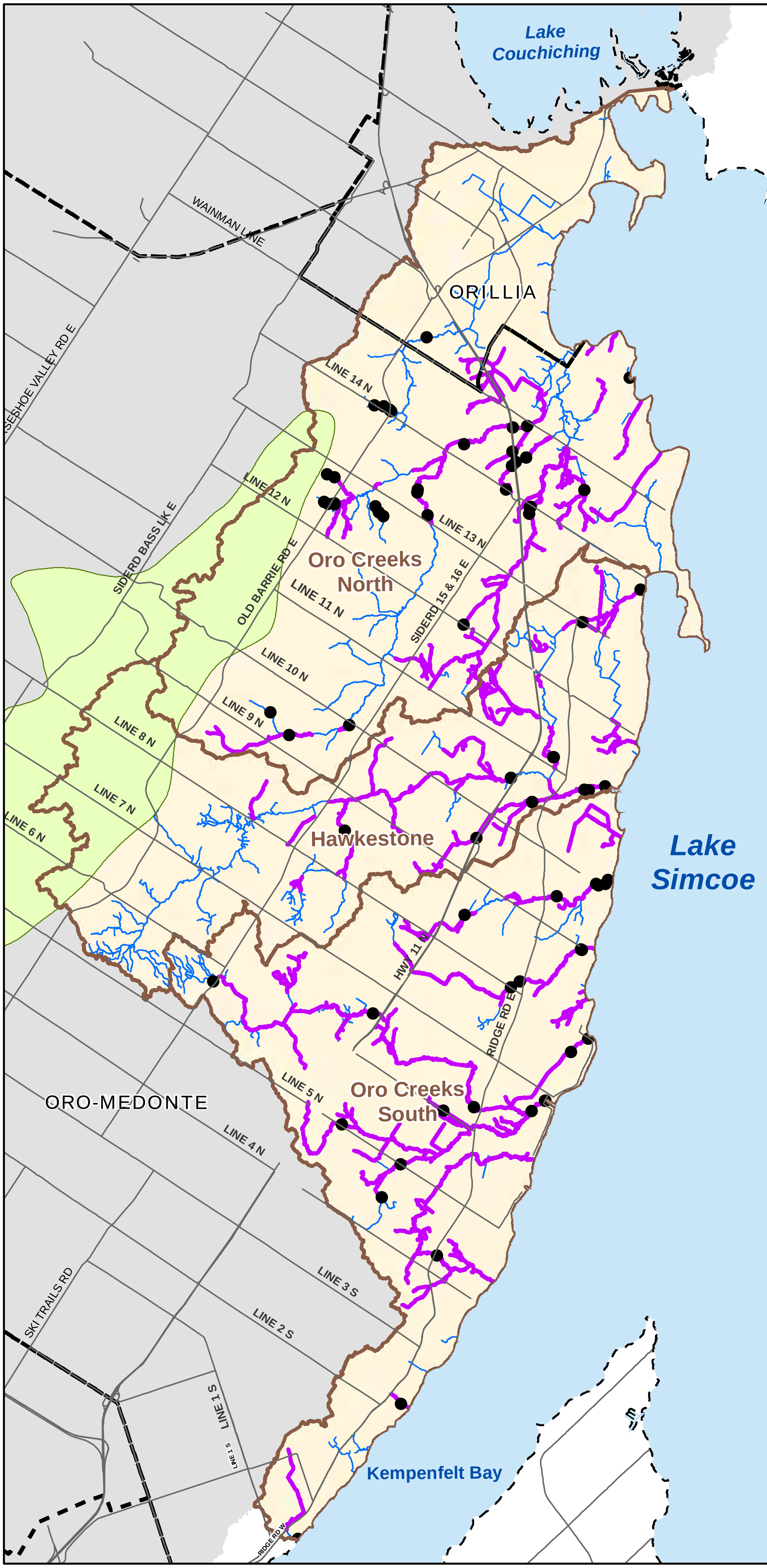
Barriers to fish movement in the form of dams, perched culverts, and enclosed watercourses serve to fragment the fish community by preventing fish from accessing important parts of their habitat. The impoundments created by dams serve to increase water temperatures, raise bacteria levels, and disrupt 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, 2009) looked at barriers to fish movement, which included dams, perched culverts, weirs, and other barriers, and sections of the bank that have been hardened or channelized. The BMP inventory covered 76%, 91%, and 48% of the watercourses in the Oro Creeks South, Hawkestone Creek, and Oro Creeks North subwatersheds, respectively.

The BMP Inventory has identified 37, 14, and 53 barriers to fish movement, respectively, in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds in the reaches surveyed thus far (Figure 5-8).

Barriers to fish movement in the Oro Creeks North, Hawkestone Creeks, and Oro Creeks South subwatersheds

Figure 5-8



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine
- BMP Watercourses Surveyed
- Barrier

0 0.5 1 2 3

Kilometres

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LSRCA GIS Services DRAFT dc created December 2013.

5.3.2 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 subject subwatersheds 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

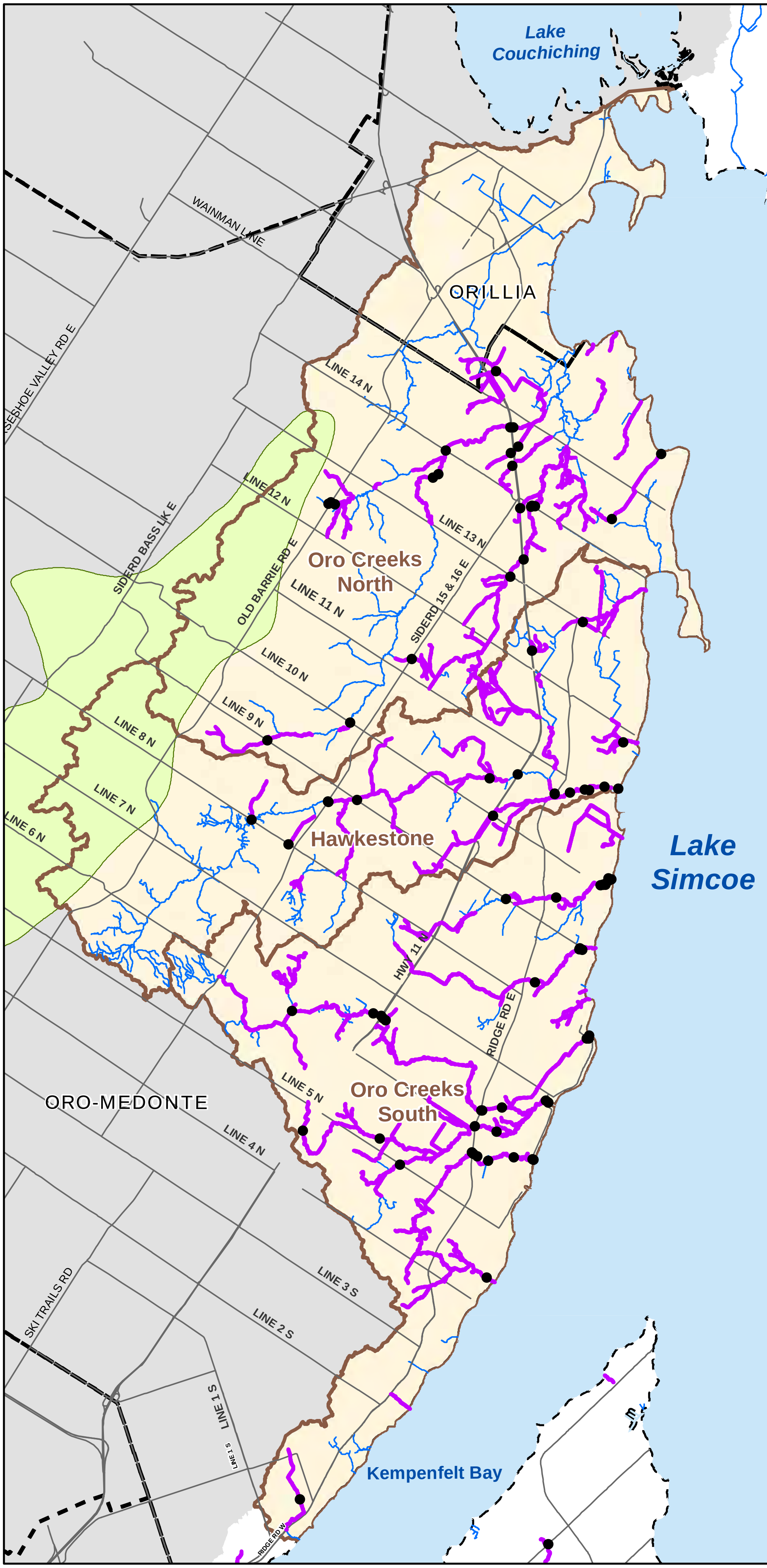
These effects result in the degradation of aquatic habitat. The riffle/pool sequences that occur in natural channels are lost in the channelized section as well as downstream. Much of the natural cover in the watercourse can be lost. Fluctuating flow levels can place stress on the aquatic biota, and 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 47, 18, and 23 hardened sections of stream identified in the Oro Creeks South, Hawkestone Creek, and Oro Creeks North subwatersheds, respectively, through the BMP Inventory. An additional 14 (Oro Creeks South), 6 (Hawkestone Creek), and 5 (Oro Creeks North) sites were identified to have been straightened. These are depicted in Figure 5-9. In Hawkestone Creek and Oro Creeks South, many of these sites fall on the lower reaches of the catchments, with a few scattered through the middle and upper reaches. In Oro Creeks North, most sites were in the headwaters and mid-reaches of Mill Creek, and spread along the length of Bluff's Creek. On Hawkestone Creek there are a few sites found through the mid- and upper reaches, but the majority of the sites were located just upstream of the mouth. In the Oro Creeks South, there is a concentration of hardened/channelized sites near the mouth of Allingham Creek; several along the length of Shelswell's Creek; and several found from the mouth upstream to Ridge Road on Lakeview Creek.

Of the sites identified with bank hardening, 12, 3, and 21 were failing in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, respectively. These failing sites should therefore be priorities for restoration activities, though the remaining sites are likely still having habitat impacts and should also be explored as resources allow. As this inventory was completed for the majority of the watercourses within the Hawkestone Creek subwatershed (91%), the total number of river sections identified as having channel hardening and straightening is relatively accurate, but could increase with the study of the sections of the watercourses that were not covered in the inventory. As both Oro Creeks South and Oro Creeks North had lower percentage of watercourses covered (76% and 48%, respectively), it is likely that the number of identified sites underestimates the actual number of sections of creek that have undergone hardening and straightening.

Bank hardening and/or channelization in the Oro Creeks North, Hawkestone Creeks, and Oro Creeks South subwatersheds

Figure 5-9



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine
- BMP Watercourses Surveyed
- Bank Hardening and or Channelization

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

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Figure 5-10: Examples of barriers, bank hardening, and channelization in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

5.3.3 Uncontrolled stormwater and impervious surfaces

Urban stormwater runoff occurs as rain or melting snow washes 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 to intercept and treat stormwater prior to its entering watercourses or waterbodies. However, in many older urban areas stormwater typically still reaches watercourses untreated

As the amount of impervious area increases, the natural water balance is disrupted. Evapotranspiration is decreased as there is little vegetation and the permeable soil surface is paved over; infiltration to groundwater is significantly reduced; and thus the runoff characteristics change. This results in increases in the frequency and magnitude of runoff events, a decrease in baseflow, and an increase in flow velocities and energy (further changes to the hydrologic regime are discussed in greater detail in **Chapter 4 - Water Quantity**). These changes further affect the form of the morphology of the stream, including channel widening, under cutting, sedimentation, and channel braiding.

One of the most significant impacts of stormwater runoff though, is to water quality (discussed in more depth in **Chapter 3 – Water Quality**). Problems with degraded water quality directly affect the aquatic ecosystem. This occurs 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 (MOE, 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 conditions (Figure 5-11).

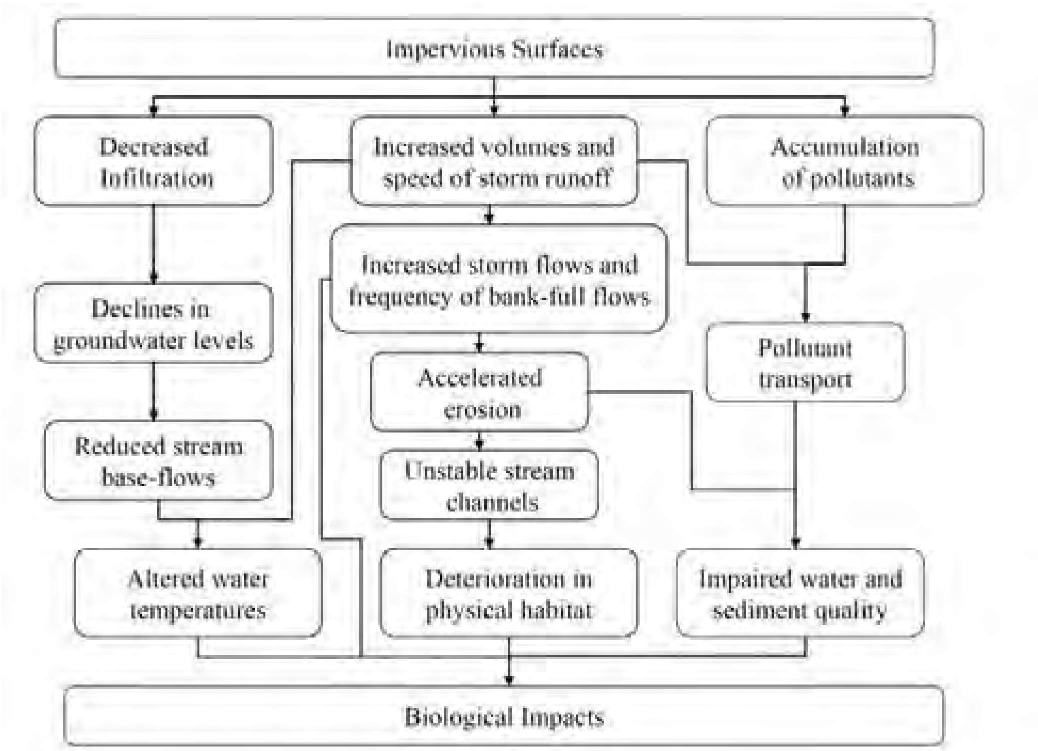


Figure 5-11: Pathways by which impervious surfaces may impact aquatic biological communities (ORMCP Technical Paper Series, #13).

5.3.4 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 may be 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. As there is often little to no riparian vegetation, water temperature can be increased and the drain can therefore become 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 alteration 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. Table 5-5 and Figure 5-12 illustrate the municipal drains that are found in the Oro Creeks North, Hawkestone, and Oro Creeks South subwatersheds, based on their drain type classification.

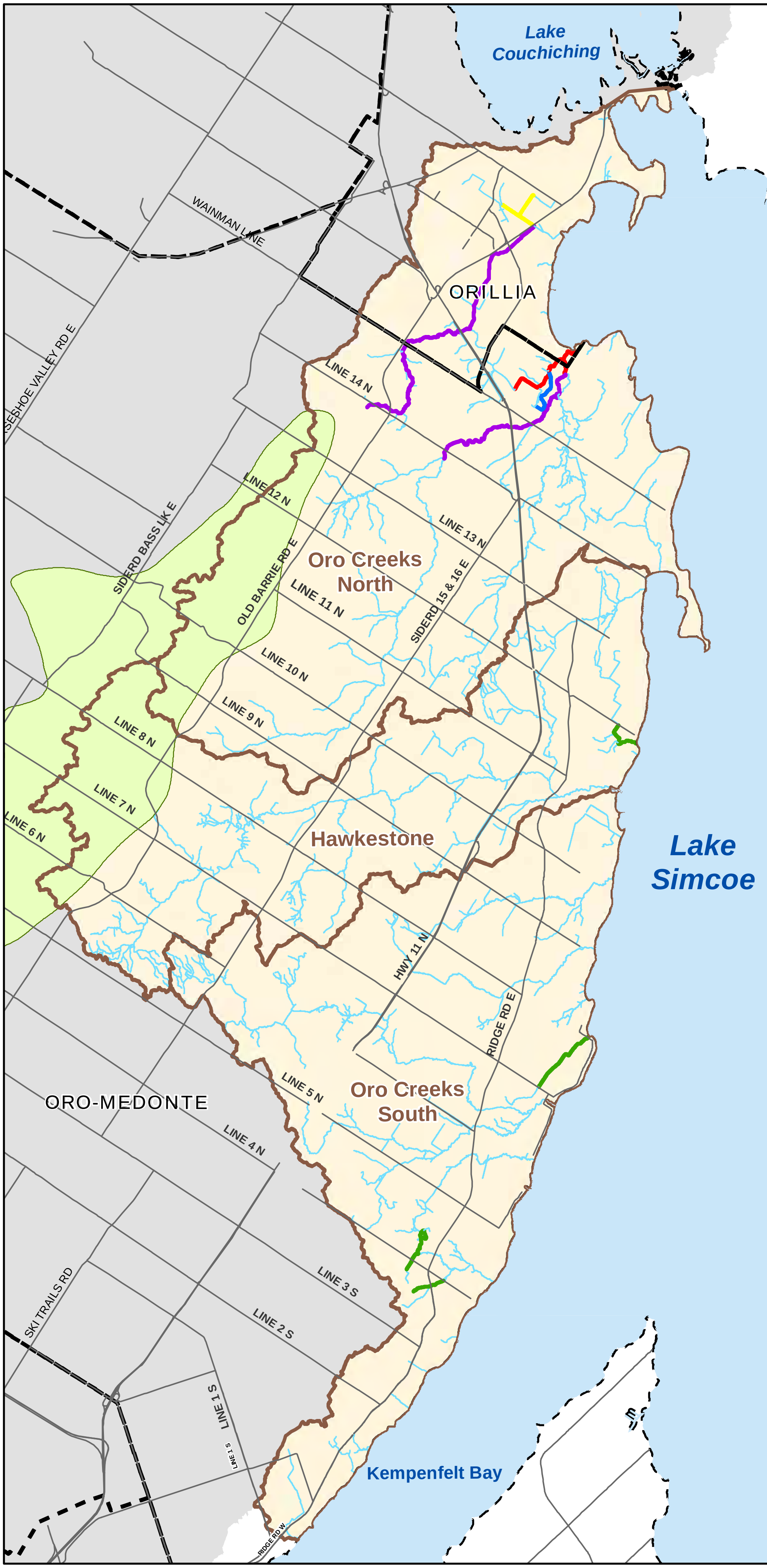
In the Mill Creek tributary of the Oro Creeks North, much of the southern branch is designated as a Type A municipal drain, and a portion of the northern branch in the City of Orillia is designated Type C. Bluff's Creek has sections of Type A, Type D, and Type E municipal drains, with the Type A section running approximately two concessions downstream from Line 14 N, and the Type D and E sections found downstream from Wainman Line to the outlet to Lake Simcoe.

In the Hawkestone Creeks subwatershed, the only catchment containing a municipal drain is 12^{th} Line Creek. The section of stream running between Line 12 N and the outlet into Lake Simcoe is classified at a Type F drain.

In the Oro Creeks South subwatershed, two of the catchments, Barillia Creek and Orolea Creek contain sections of municipal drain. The section of Barillia Creek from Line 7 N downstream to the outlet is designated as a municipal drain. Sections of two branches of Orolea Creek in the vicinity of Line 4 N are also designated as Type F municipal drains.

Table 5-5: Municipal drains located in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds

Subwatershed	Watercourse	Drain Class	Length of drain (m)	% of watercourse
Oro Creeks North	Bluff's Creek	A	4100.6	5.3
		D	1099.1	1.4
		E	2234.0	2.9
	Mill Creek	A	6938.2	43.3
		C	1321.2	8.2
Hawkestone Creek	Twelfth Line Creek	F	912.0	17.2
Oro Creeks South	Barillia Creek	F	1577.7	61
	Orolea Creek	F	1930.1	23.2



Municipal Drains in the Oro Creeks North, Hawkestone Creeks, and Oro creeks South subwatersheds

Figure 5-12

Legend

Road

Municipal Boundary

Watercourse

Subwatershed

Oro Moraine

Drain Class

A

B

C

D

E

F

0 0.5 1 2 3

Kilometres

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5.3.5 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 in suspension 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 many no longer be able to do so, and the community may shift to cool or warm water community containing less sensitive species.

In the subject subwatersheds, riparian cover is relatively high in comparison with many of Lake Simcoe's other subwatersheds. The Hawkestone Creek subwatershed has the highest level of natural vegetation of any Lake Simcoe subwatersheds, with 80% of the area within 30 m of the watercourses in natural cover. The Oro Creeks North and South subwatersheds are also relatively healthy in terms of vegetated cover in this area, with 78% and 76% of the riparian area containing natural vegetation, respectively.

5.3.6 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.

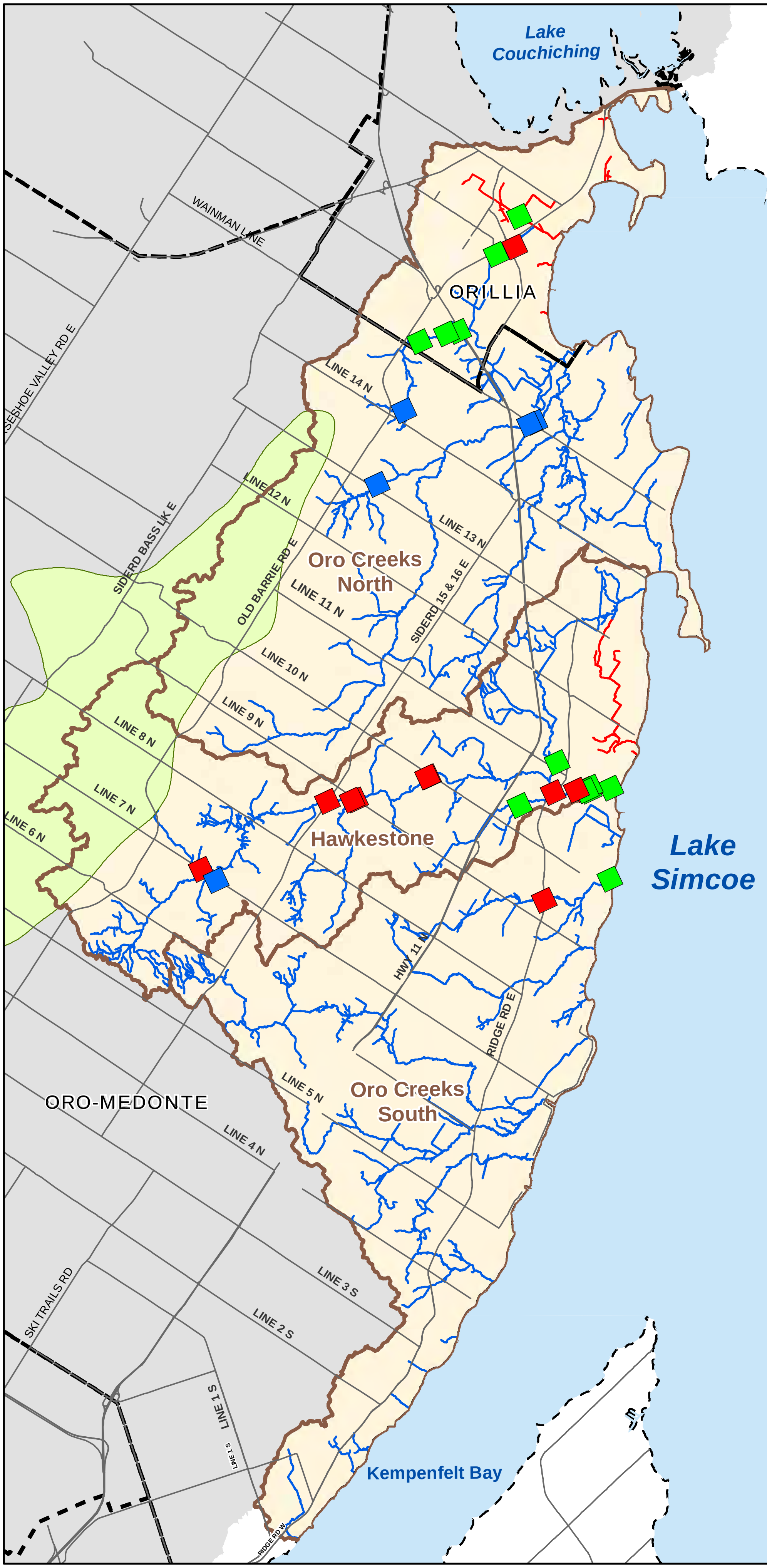
Specific information on water quality issues pertaining to these subwatersheds can be found in **Chapter 3 - Water Quality**.

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.

Figure 5-13 illustrates the OMNR approved temperature designation of the creeks (and the temperature at which they are managed at based on timing restrictions for in-water works) with current temperature ratings. Where the current ratings differ from OMNR designations (i.e. cool or warm water readings on cold water system) it indicates that the creek is experiencing thermal degradation.

Thermal degradation in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 5-13



Legend

Road
Municipal Boundary
Watercourse
Subwatershed
Oro Moraine

Timing Restrictions
October 1 to June 1
March 1 to June 30
April 1 to June 30

Current Temperature
Cold
Cool
Warm

Lake Simcoe Region conservation authority

0 0.5 1 2 3
Kilometres

N E S W

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5.3.7 Loss of wetlands

While the current status and stressors to wetlands are covered are in more detail in **Chapter 6 - Terrestrial Natural Heritage**, it is important to highlight the significant relationship they have with nearby aquatic systems. Wetlands are important to the aquatic natural heritage system as they store water and reduce flooding, prevent erosion along banks and are a source of groundwater recharge and discharge. They also improve the quality of water that filters through them into the creeks by removing sediments, pathogens, nutrients, and pesticides.

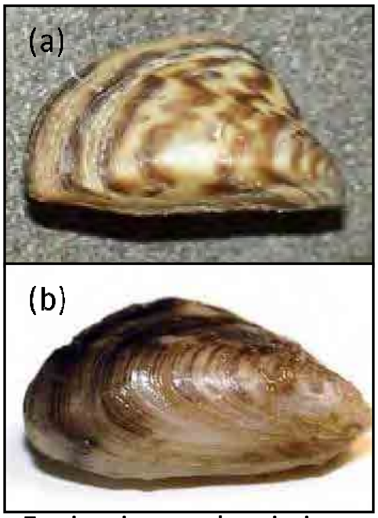
5.3.8 Invasive species

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 introduced 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.

As of 2012, the only aquatic invasive species found in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds was the common carp (*Cyprinus carpio*).

There have also been a number of invasive species indentified in Lake Simcoe that can impact the nearshore environments and the tributaries. These include:

- Eurasion watermilfoil (*Myriophyllum spicatum*),
- Curly-leaf pondweed (*Potamogeton crispus*,
- Common carp (*Cyprinus carpio*),
- Rainbow smelt (*Osmerus mordax*),
- Round goby (*Neogobius melanostomus*),
- Spiny waterflea (*Bythotrephes longimanus*),
- Rusty crayfish (*Orconectes rusticus*),
- Zebra mussel (*Dreissenia polymorpha*),
- Quagga mussel (*Dreissenia rostriformis bugensis*)



Two invasive mussel species in Lake Simcoe: (a) zebra mussel; (b) quagga mussel.

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 carps: The term “Asian carps” 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.

Invasive plant species on aquatic ‘watch list’: (a) fanwort, (b) European water chestnut, and (c) water soldier. (Photo credits: Ontario’s Invading Species Program)

5.3.9 Climate Change

Recent work from an MOE Vulnerability Report for Lake Simcoe watershed wetlands, streams and rivers (Chu, 2011) is suggesting that climate change over the next 90 years will increase stream temperatures 1.3°C above current conditions. This prediction essentially threatens most coldwater streams in the Lake Simcoe watershed. A model looked at the likelihood of the subwatersheds being able to retain cold water species in 2055 using maximum air temperatures and groundwater discharge potential (Table 5-6). Those with high groundwater discharge potential are likely still going to be able to provide thermal refuge for cold water species, despite increasing air temperatures. 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.

Table 5-6: Likelihood of watersheds to retain cold water species in 2055 using maximum air temperature projections from the Canadian Global Model 2 A2 scenario and groundwater discharge potential (Source: Chu *et al*., 2008).

	Likelihood to retain cold-water species		
	Low	Mid	High
Maximum air temperature (°C)	>29.34	28.49-29.34	<28.49
Baseflow index value	<0.36	0.36-0.54	>0.54

The information suggests that subwatersheds such as the Oro Creeks North, which has a higher baseflow index value (Table 5-7) and lower maximum air temperatures over the next 90 years, could offer thermal refuge for coldwater species. The Hawkestone Creek subwatershed has a lower baseflow index than Oro Creeks North, falling into the mid-range in terms of the influence of baseflow index on retaining coldwater species in Table 5-6, but the lower maximum air temperatures predicted for the subwatershed increase the likelihood that the watercourses will also be able to retain their coldwater species. The Oro Creeks South subwatershed; however, has a much lower baseflow index value, falling into the range for 'Low' likelihood to retain coldwater species on Table 5-3. Its maximum temperature range does fall into the 'High' likelihood to retain coldwater species range, suggesting that there may be some resilience to climate change, but this subwatershed would be less likely to retain its coldwater characteristics than would Oro Creeks North or Hawkestone Creek.

Table 5-7: Maximum air temperature and groundwater discharge potential characteristics of the subwatersheds that have cold-water stream fish species in the Lake Simcoe watershed. Base flow index values are measures of groundwater discharge potential, values close to 1 indicate high groundwater inflows (Source: Chu *et al*., 2008).

Subwatershed	Base flow index value	Maximum air temperature (°C)		
		2011-2040	2041-2070	2071-2100
Oro Creeks North	0.542	25.56	27.23	27.81
Hawkestone Creek	0.443	25.48	27.20	27.75
Oro Creeks South	0.329	25.67	27.44	28.02

Studies like this highlight the importance of protecting and building more resilience through 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. However, perhaps the most important way to address the risks of climate change is through the protection and maintenance of the current groundwater recharge-discharge system that supports these subwatersheds.

Key Points – Factors Impacting Aquatic Natural Heritage – stressors:

- There are a number of stressors on the aquatic natural heritage systems in these subwatersheds, the cumulative impacts of which can be seen in the health of aquatic communities
- The LSRCA conducted an inventory of best management practice opportunities in the watershed in 2008 and 2009, which covered 76% of the Oro Creeks South subwatershed, 91% of the Hawkestone Creek subwatershed, and 48% of the Oro Creeks North subwatershed
- Physical changes such as barriers, bank hardening, and channelization are some of the most significant stressors in these subwatersheds.
- Habitat quality and quantity are also impacted by changes in flow regime resulting from land use changes, water takings, stream alterations, municipal drains, loss of nearby wetlands (particularly in the headwaters), uncontrolled stormwater and an increase in impervious surface cover. Increased flow degrades habitat through processes such as bank erosion. Decreased flow can lead to a temporary or permanent reduction in the amount of aquatic habitat present. Poor water quality (indicated by poor benthic scores) and thermal degradation have also negatively impacted the aquatic communities
- No invasive aquatic species have been found in the subject subwatersheds. The round goby, an extremely invasive fish species has been caught in nearby subwatersheds, but has not yet been detected in the study area. If the watershed's invasive species expand into these subwatersheds, it is likely they will negatively affect native communities by occupying and/or destroying their habitat, consuming their eggs and young, 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 the Oro Creeks North and Hawkestone Creek subwatersheds may have enough resilience to maintain cold water attributes, but the Oro Creeks South subwatershed is at risk of losing its cold water fish communities.

5.4 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 Oro Creeks and Hawkestone Creek subwatersheds, as outlined below.

5.4.1 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 these subwatersheds. In Table 5-8 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 5-8: Summary of current 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)	Ontario Fisheries Regulations (1989)	LSRCA Watershed Development Policies (2008)	Simcoe County Official Plan (2007)	Township of Oro-Medonte Official Plan (2007)	City of Orillia Official Plan (2011)
Site alteration in wetlands	✓	✗	✓	✓ 4	✗	✗	✓	✓	✓	✓
Loss of riparian areas / shoreline development	✓ 1	✗	✓	✓ 4	✗	✗	✓	✓	✓ 10	✓ 7
Stream alteration (including enclosures and flow diversion)	✓ 1	✗	✓	✗	✗	✗	✓	✓ 9	✓ 12	✓
Instream barriers	✓	✗	✓	✗	✗	✗	✓	✓ 9	✗	✗
Bank hardening	✓ 1	✗	✓	✗	✗	✗	✓ 5	✓ 9	✗	✓ 7
Impervious surfaces	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗
Municipal drains	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓ 7
Uncontrolled stormwater	✓	✗	✓	✗	✗	✗	✓ 6	✓	✗	✓ 7
Interference with groundwater recharge / discharge	✓	✗	✓	✗	✗	✗	✓ 11	✓	✓	✓
Degradation of water quality (including thermal impacts)	✓ 2	✓	✓	✗	✓	✗	✓	✓	✓	✓
Introduction of invasive species	✓ 3	✗	✗	✗	✗	✓	✗	✗	✗	✓ 8
Climate change	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
✓ 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 stream alteration policies would cover this

[6] Stormwater controls required, application must demonstrate every effort made to achieve pre-development hydrologic conditions

[7] Consistent with LSPP

[8] States that preference for plantings should be given to native species, where appropriate

[9] References Fisheries Act (1985)

[10] Areas within 30 m of top of streambanks are protected; unspecified setback required for development along lake shore

[11] Within hydrologically defined Environmentally Significant Areas

[12] Only structural works required for flood and/or erosion or sediment control permitted within the zone defined by 30 m from top of bank

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 Lake Simcoe Protection Plan, establishes restrictions (outside of designated settlement areas) to development or site alteration within 100m of the Lake Simcoe shoreline (30m in already built-up areas, subject to a natural heritage evaluation) (policies 6.1 and 6.2), or within 30m of wetlands and watercourses, with natural heritage evaluations necessary for development proposed within 120m 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.

Some protection is also afforded through municipal Official Plans. The City of Orillia includes both Provincially Significant Wetlands and fish habitat as natural heritage features and areas under the Environmental Protection designation. Policy 3.5.3.3 identifies a very limited number of uses are permitted on these lands, including conservation uses, infrastructure, passive recreation opportunities not requiring site alterations, and buildings or structures necessary for flood or erosion control. In parts of the Environmental Protection Area where these types of development are permitted, or in adjacent areas, Environmental Impact Studies are required in order to ensure that there will be no negative impacts on the features or their functions. In the Township of Oro-Medonte Official Plan, sensitive surface water features and their related hydrological functions are protected by prohibiting most types of development within wetlands as well as any other areas that are determined to be environmentally significant as a result of a development review process. Fish spawning and nursery areas are included in the Environmental Protection Two designation, which generally discourages development within the features, and states that any development proposed within 30 metres that requires an amendment to the zoning by-law or to the Official Plan will be subject to the preparation of an Environmental Impact Study and a Management Plan that demonstrate that the proposed development can occur without having a negative impact on the significant natural features and ecological functions of the area.

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 MOE and MNR) to define and map ecologically significant groundwater recharge areas throughout the watershed. Ecologically significant groundwater recharge areas are those which are necessary to support coldwater fish habitat or 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. The process of identifying these areas for the Oro and Hawkestone Creeks subwatersheds is currently underway.

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*, and proposed new drains are subject to full review to ensure no harmful alteration occurs to fish habitat.

For infrastructure or other works occurring in water, the Ontario Ministry of Natural Resources 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.

5.4.2 Restoration and remediation

There is a range of programs operating in these subwatersheds to assist private landowners in improving the environmental health of its tributaries.

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 removing barriers from streams, adding bottom-draw structures to online ponds, and fencing and planting riparian areas, among others. Since 2004, in addition to projects focussed specifically on protecting water quality, LEAP has supported one tree planting project in the City of Orillia, and 116 projects in the Township of Oro-Medonte, including:

- Four manure storage projects,
- Nine well decommissionings,
- 13 wellhead protection projects,
- 70 septic system updgrades,
- Eight tree planting projects,
- Two milkhouse waste system upgrades, and
- Six stream erosion projects.

In 2008 and 2009, LSRCA field staff surveyed the 76%, 91%, and 48% of the watercourses in the Oro Creeks South, Hawkestone Creek and Oro Creeks North subwatersheds, respectively, documenting the range of potential stewardship projects that could be implemented to help improve water quality and fish habitat. The Lake Simcoe Basin Best Management Practice Inventory (LSRCA, 2009) found over 170 additional places in these three subwatersheds where additional riparian planting could be introduced, over 100 barriers that should be removed to improve fish passage, several locations along creeks that require additional fencing, and 113 locations where the creek channel had been hardened and/or straightened, which could be mitigated to improve fish habitat

The forthcoming shoreline management strategy, and wetland and riparian area prioritization exercise, will identify and prioritize stewardship opportunities in this subwatershed, specific to the shoreline and inland riparian and headwater areas, respectively.

These ongoing stewardship programs will soon be complemented by a forthcoming Voluntary Action Program. Initially, the Lake Simcoe Protection Plan proposed the development of a regulation to prohibit activities that would adversely affect the ecological health of the Lake Simcoe watershed (policy 6.16). Feedback during the initial rounds of consultation in development of this regulation raised concerns about its enforceability, and the need to educate the public on best management practices before taking a regulatory approach. As a result, the MOE reframed the Shoreline Regulation as a Shoreline Voluntary Action Program.

The Shoreline Voluntary Action Program is intended to increase the extent of native vegetation along shorelines, and reduce the use of phosphate-containing fertilizer in the watershed, through a combination of surveys which are aimed at understanding the current range of public knowledge, attitudes, and practices, and outreach to summer camps, landowners, and garden centres.

This voluntary action program is being run as a two year pilot program, with ongoing monitoring to determine the rate of uptake, impacts on phosphorus levels, and impacts on native vegetation along the shoreline. After the pilot program is complete, these results will be reviewed to determine if a voluntary program is sufficient, or if a regulatory approach is necessary.

5.4.3 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 MNR and the LSRCA, and periodic research studies conducted by academics, are contributing to our understanding of these values.

The Ministry of Natural Resources 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 (monitoring sites in these three watersheds are displayed in Figure 5-3 and Figure 5-5). In the study area, Hawkestone Creek, Mill Creek, and Burl's Creek are the only systems on which consistent fisheries studies have been conducted.

More recently, the LSRCA began a nearshore monitoring program in the lake, to better understand the connection between watershed landuse 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, some results of which are shown in Figure 5-7.

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 MNR, MOE, 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).

5.5 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.

5.5.1 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, Ministry of the Environment, Ministry of Agriculture, Food and Rural Affairs, Ontario Federation of Agriculture, Ontario Soil and Crop Improvement Association, Lake Simcoe Region Conservation Authority, representatives from local stewardship and watershed municipalities.

Recommendation 5-1 – That MNR, MOE, OMAFRA, and LSRCA continue to implement stewardship projects in these subwatersheds, and encourage other interested organizations in doing the same.

Recommendation 5-2 – 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 5-3 – That MOE, MNR, LSRCA and other members of the Lake Simcoe Stewardship Network 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 the have completed and encourage others to do the same.

Recommendation 5-4 – 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 5-5 – The MOE, MNR, OMAFRA, LSRCA and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, 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 5-6 – The MOE, MNR, OMAFRA and LSRCA 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.

5.5.2 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 barriers, bank hardening, and areas of insufficient riparian cover as some of the most important factors impacting instream habitat. Analogous to terrestrial natural heritage stewardship requirements, a tool is needed to help prioritize stewardship projects. Ideally a single prioritization tool, addressing both aquatic and terrestrial stewardship activities, should be developed.

Recommendation 5-7 – The LSRCA, in collaboration with MNR and MOE, should develop a spatially-explicit prioritization tool to assist in targeting stewardship aquatic habitat projects in the Lake Simcoe watershed. In the context of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, this prioritization tool should take into account:

- The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover and on-line ponds;
- Use of best available datasets to identify potential restoration sites, including LSRCA BMP inventory and riparian assessment;
- Expected improvements to aquatic habitat and therefore fish and benthic community condition, including improved water temperature, increase connectivity for movement within and between tributaries, and shelter.
- The relative cost of implementing projects in urban, urbanizing and agricultural areas, particularly with respect to the cost of implementing retrofit projects in the relatively heavily urbanized City of Orillia

Recommendation 5-8 – Prioritized restoration areas be integrated 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 5-1 through 5-6.

5.5.3 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, including both high or peak flows, and low flow condition. While water quantity and associated recommendations are discussed in detailed within Chapter 4, the following recommendations are specific to aquatic habitat:

> **Recommendation 5-9** –That the MOE, with the assistance of MNR and LSRCA, determine if the Oro Creeks South, Oro Creeks North, or Hawkestone Creeks subwatershed are water quantity stressed and require the development of in-stream flow targets.

> **Recommendation 5-10** –That LSRCA work with the municipalities and OMAF to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using the principles of natural channel design. Look for opportunities to abandon drains when there no longer is a need for a municipally managed drainage system. These projects would need to ensure that there are no consequences for neighbouring properties on the same drain, or that any potential issues could be mitigated.

5.5.4 Water Quality and Water Temperature

Based on the benthic invertebrate community scores in some areas in these subwatersheds, water quality can be considered degraded in some areas. Similarly, the assessment of fish Index of Biotic Integrity and water temperature indicate that the thermal regime of the creeks is being affected by factors such as loss of riparian cover, increased impervious surfaces and barriers. Recommendations addressing water quality are presented in Chapter 3, and recommendations pertaining to increased water temperature are described above, e.g. Recommendations 5 and 7.

5.5.5 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 brook trout spawning (redd) 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 5-11** – That LSRCA, with support from Municipalities, the Province, and local volunteers, undertake a baseline assessment of brook trout spawning areas and from this develop an annual monitoring program to continually assess the LSPP aquatic habitat indicator of natural reproduction and survival of aquatic communities.

Recommendation 5-12 – That LSRCA explore potential reasons for the decline in brook trout populations, particularly in Hawkestone Creek. This will include an investigation of the areas offshore of the mouths of the subject subwatersheds, particularly the shoal off of Hawkestone Creek, to determine how these areas are being used and whether changing conditions in these areas are affecting these uses.

Recommendation 5-13 – That LSRCA, with support from Municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

6 Terrestrial Natural Heritage

6.1 Introduction

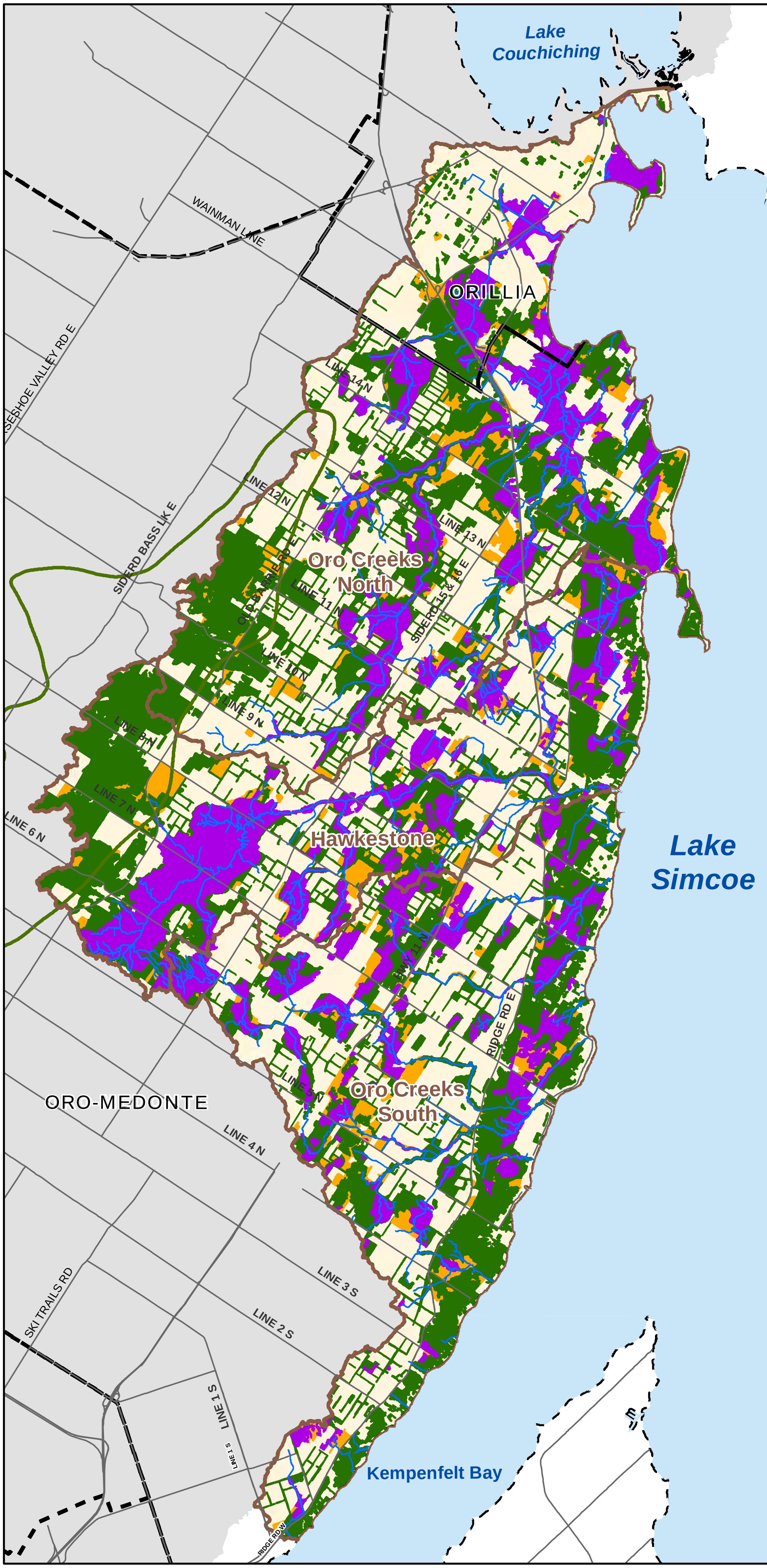
Terrestrial natural heritage features are extremely important components of subwatershed health, as they not only provide habitat for many of the species residing in the subwatershed, but also influence subwatershed hydrology and water quality. They are among the most important parts of the ecosystem, 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 Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds' terrestrial system interacts with other hydrological and human systems, and serves as habitat for flora and fauna throughout the subwatersheds. 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 subwatersheds can tell us a great deal about its health. Figure 6-1 details the distribution of natural features in the subwatersheds.

Currently, natural heritage features account for 45.5% of the Oro Creeks North subwatershed (composed of 13.5% wetland, 27.3% upland forest, and 4.6% grassland), 46.5% of the Oro Creeks South subwatershed (composed of 12.1% wetland, 28.9% upland forest, and 5.4% grassland), and 57.1% of the Hawkestone Creek subwatershed (composed of 21.3% wetland, 29.7% upland forest, and 6% grassland).

Terrestrial natural heritage features in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 6-1



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine
- Grassland
- Wetland
- Woodland

Lake Simcoe Region conservation authority

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LSRCA GIS Services DRAFT dc created December 2013.

6.2 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 Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds can be described, relative to these targets, where data permits.

At 45.5%, 46.5% and 57.1% respectively, the total natural cover in the Oro Creeks North, Oro Creeks South and Hawkestone Creek subwatersheds are some of the highest in the Lake Simcoe watershed as a whole. All exceed the target of 40% natural areas for the entire Lake Simcoe watershed set by the Lake Simcoe Protection Plan, although it is not yet known if all of these natural areas would be considered 'high quality' as is the goal of the LSPP. All three subwatersheds have fairly high levels of agriculture, with between 34 and 38 percent of the subwatershed areas being occupied by this land use. Other, less prevalent land uses include urban, industrial, and institutional land uses, as well as rural development and aggregate extraction operations (Figures 2-2, 2-3, and 2-4).

6.2.1 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

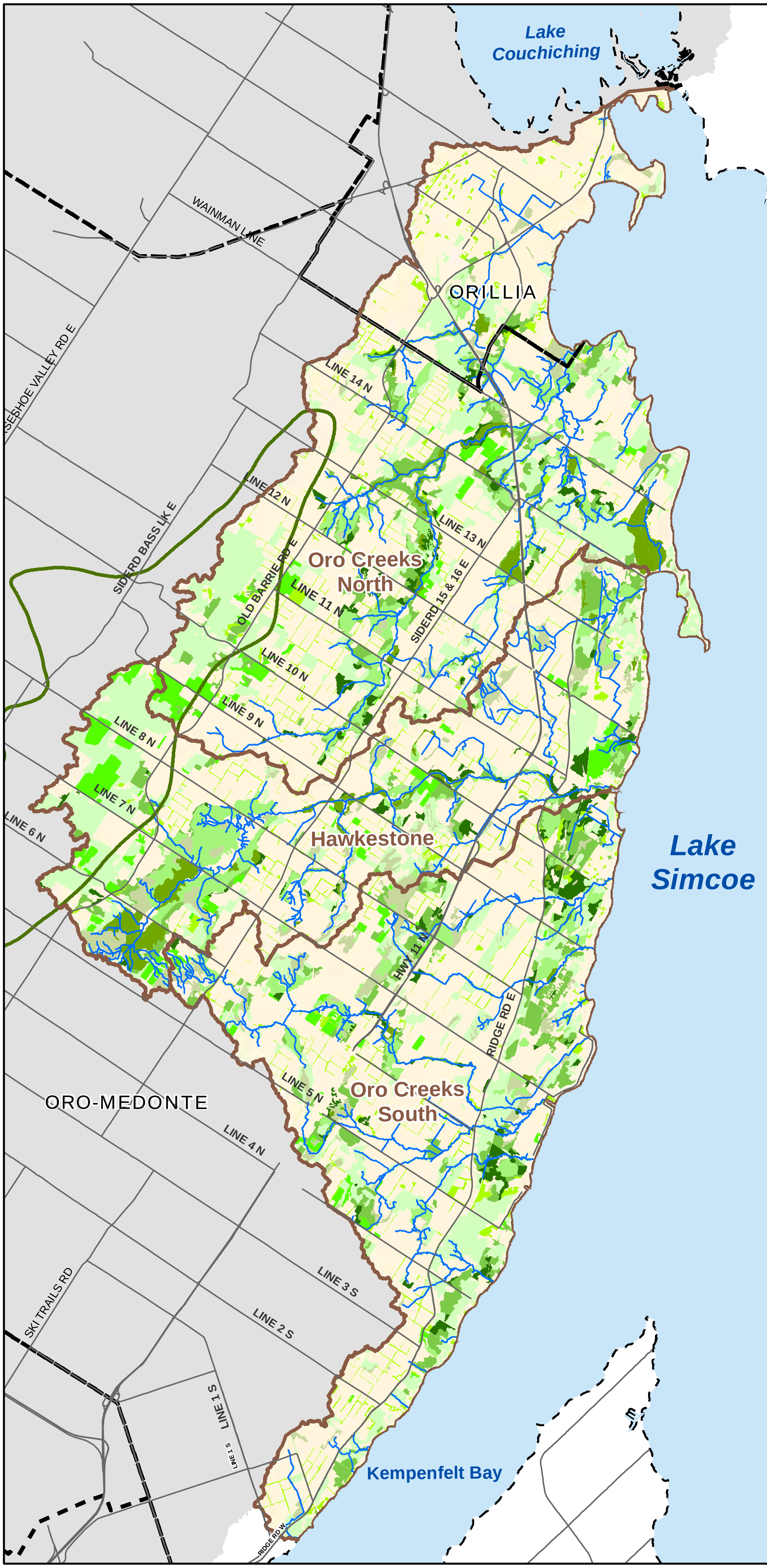
Woodlands include all treed communities, whether upland or wetland. The Ecological Land Classification (ELC) communities that were considered to represent woodlands are forest, swamp, plantation, and cultural woodland (the breakdown of these woodland types is displayed in Table 6-1 and Figure 6-2). Some 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).

Prior to European settlement the dominant land cover type of Southern Ontario was woodland. Estimates of total pre-settlement woodland cover in Simcoe County was 83%. By 1955 this had decreased to 32.4%, then increased to 40.2% by 1978 across the county (Larson *et al*., 1999), with areas being cleared for agriculture and urban development. Woodland cover in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds is 36%, 37%, and 45%, respectively (Table 6-1); these are slightly lower than the average for the County in Oro Creeks North and Oro Creeks South, but slightly higher in Hawkestone Creek.

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; however the forest cover alone in the Hawkestone Creek subwatershed exceeds this target without considering the other ecosystem types, and the Oro Creeks North and Oro Creeks South subwatersheds also come close to meeting this target with only forest 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. Existing forest cover in the three subject subwatersheds exceeds this lower target.



Woodland types in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 6-2

Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Woodland Type

- Coniferous Forest
- Coniferous Swamp
- Cultural Plantation
- Cultural Woodland
- Deciduous Forest
- Deciduous Swamp
- Mixed Forest
- Mixed Swamp

Lake Simcoe Region conservation authority

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Table 6-1 Woodland cover types in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds

Woodland Type		Woodland Cover					
		Oro Creeks North		Oro Creeks South		Hawkestone Creek	
		Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Upland forest	Cultural Plantation (CUP)	161.6	2.1	81.3	1.4	229.0	4.8
	Cultural Woodland (CUW)	270.1	3.6	181.1	3.2	122.0	2.5
	Conifer Forest (FOC)	112.0	1.5	164.1	2.9	79.5	1.7
	Deciduous Forest (FOD)	1089.3	14.5	809.6	14.1	750.6	15.7
	Mixed Forest (FOM)	418.5	5.6	423.0	7.4	238.3	5.0
Swamp forest	Conifer Swamp (SWC)	150.6	2.0	18.3	0.3	168.1	3.5
	Deciduous Swamp (SWD)	144.5	1.9	241.0	4.2	259.2	5.4
	Mixed Swamp (SWM)	334.5	4.4	233.3	4.1	325.8	6.8
Total upland forest		**2051.4**	**27.3**	**1659.1**	**28.9**	**1419.4**	**29.7**
Total forest		**2680.9**	**35.6**	**2151.6**	**37.5**	**2172.4**	**45.4**
Target (LSPP)[1]		**3010.5**	**40**	**2295.5**	**40**	**1913.5**	**40**
Target (LSRCA IWMP)[2]		**1881.6**	**25**	**1434.7**	**25**	**1196.0**	**25**

The most common forest types in the Oro and Hawkestone Creeks subwatersheds are deciduous forest, which is defined as a natural community with greater than 60% canopy cover and greater than 75% deciduous composition, and mixed forests, which also have greater than 60% canopy cover, and neither the deciduous nor the coniferous composition is less than 25%. (Table 6-1).

Relatively uncommon in these subwatersheds are coniferous woodlands (including forests, swamps, and plantations), which account for only 16.6% of the total woodland. These relatively rare forest types 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).

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

[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

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 MNR (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 6-3). 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 has a wide range of forest patch sizes, ranging from less than 0.5 hectares to over 200 ha (Figure 6-3). Approximately 40% of the patches are less than 0.5 ha in size; however, these account for only 1.6% of the forest area. While the number of larger patches is relatively lower, these patches account for a significant portion of forest area, with half of the study area's forest being comprised of patches larger than 50 ha in size.

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 100m or greater for the rate of predation on nesting birds (Burke and Nol, 2000). Although this research has typically been interpreted such that 100m 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 300m into woodlots.

It can be seen from Figure 6-3 that there is a large number of the 100 m forest interior or "core" areas within the study area; a number of these being a fairly substantial size, including three of these areas that are larger than 100 ha. These are likely very productive habitat for forest-dwelling birds. In addition, 200 m "deep forest core" areas were calculated for the study area, with 21 patches of deep forest being identified. Two of these patches were over 65 ha in size, and could potentially support some of the most sensitive species, with fewer edge effects being felt.

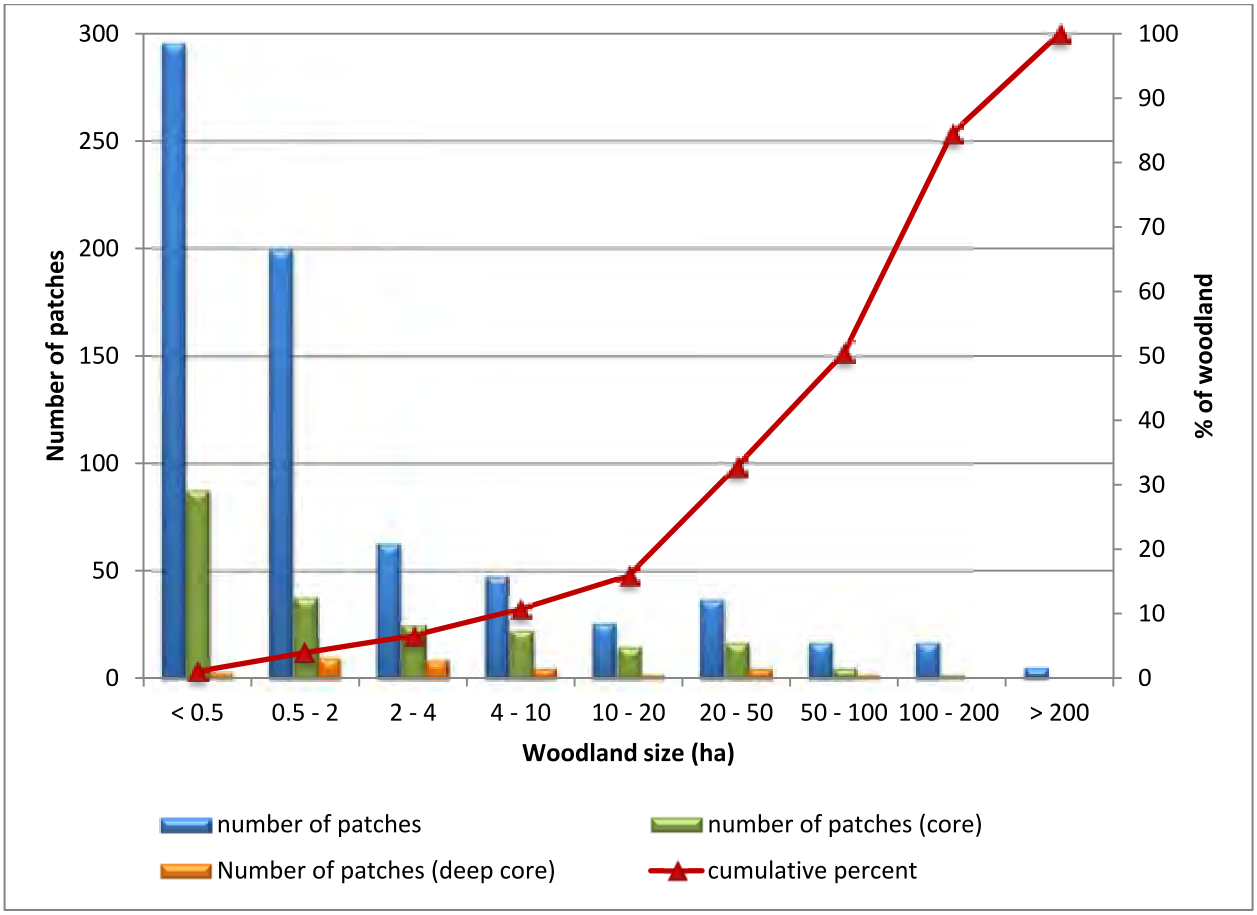


Figure 6-3 Woodland patch size distribution in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

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.

6.2.2 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.

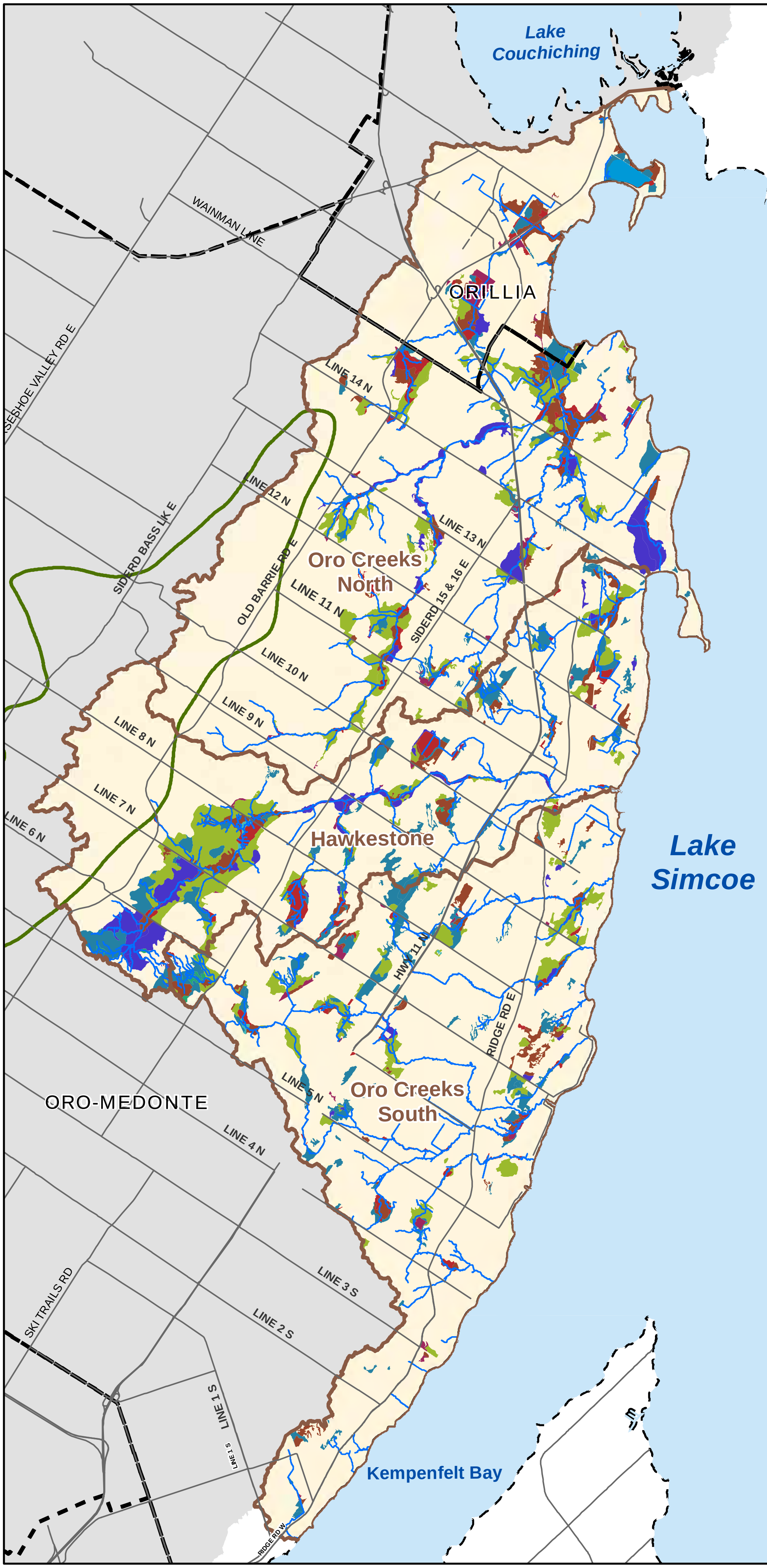
Wetlands provide numerous functions for an ecosystem. These include (OMNR, 2010):

- **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 (2013), Environment Canada recommends that at least 10% of a watershed be in wetland cover, and that these wetlands should be well dispersed through the area. 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.

Wetland types in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 6-5



Legend

- Road
- Municipal Boundary
- Watercourse
- Subwatershed
- Oro Moraine

Wetland Type

- Coniferous Swamp
- Deciduous Swamp
- Floating-leaved Shallow Aquatic
- Meadow Marsh
- Mixed Shallow Aquatic
- Mixed Swamp
- Shallow Marsh
- Shrub Bog
- Submerged Shallow Aquatic
- Thicket Swamp

Lake Simcoe Region conservation authority

0 0.5 1 2 3
Kilometres

N E S W

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LSRCA GIS Services DRAFT dc created December 2013.

In a study undertaken by Ducks Unlimited Canada in 2010, it was estimated that, prior to European settlement, 11.8% of Oro (the study treated Oro and Medonte separately; this plan only looks at the statistics for Oro) and 17.1% of Orillia were wetlands (DUC, 2010). Wetlands were lost as settlement occurred, reducing their relative cover to 8.1% and 8.7% of Oro and Orillia, respectively by 1967. Wetland levels have been fairly steady since 1967; both municipalities showed slight increases in the 1982 data, but this may have been due to improved mapping and analysis; and in the 2002 numbers, both have 7.8% wetland cover, evidence of some small losses (DUC, 2010). It should be noted that the Ducks Unlimited study derives its estimates of wetland distribution from soil maps, and underestimates the current extent of wetlands in these subwatersheds. Thus, they may also underestimate the amount of wetland lost since the time of settlement (pre-settlement maps may provide a better estimate).

According to data available from the MNR and LSRCA (current as of 2009), there are 1018 ha, 697 ha and 1020 ha of wetland remaining in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds, respectively (Figure 6-4, Table 6-2).

Table 6-2 Distribution of wetland types in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds

Wetland type	Wetland Cover					
	Oro Creeks North		Oro Creeks South		Hawkestone Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Meadow marsh (MAM)	61.4	0.8	23.7	0.4	9.7	0.2
Shallow marsh (MAS)	96.5	1.3	50.0	0.9	89.8	1.9
Floating leaved shallow aquatic (SAF)	0	0	1.5	0.0	0	0.0
Mixed shallow aquatic (SAM)	0	0	8.4	0.1	10.7	0.2
Submerged shallow aquatic (SAS)	5.5	0.1	4.8	0.1	14.0	0.3
Coniferous swamp (SWC)	150.6	2.0	18.3	0.3	168.1	3.5
Deciduous swamp (SWD)	144.5	1.9	241.0	4.2	259.2	5.4
Mixed swamp (SWM)	334.5	4.4	233.3	4.1	325.8	6.8
Thicket swamp (SWT)	199.1	2.6	116.2	2.0	142.7	3.0
Shrub bog (BOS)	26.3	0.3	0	0	0	0
Total marsh	**163.5**	**2.2**	**88.4**	**1.5**	**124.2**	**2.6**
Total swamp	**828.7**	**11.0**	**608.7**	**10.6**	**895.7**	**18.7**
Total bog	**26.3**	**0.3**	**0**	**0**	**0**	**0**
TOTAL	**1018.5**	**13.5**	**697.1**	**12.1**	**1019.9**	**21.3**

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 graphs 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.

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."*

There are approximately 1018 ha of wetland in the Oro Creeks North subwatershed, which is approximately 13.5% of the landscape (Table 6-2), with a number of small, mainly riparian wetland patches along most of the subwatershed's headwaters, and several larger areas in the lower reaches of a number of watercourses. These include the Provincially Significant Bluff's Creek East Wetland, the Victoria Point wetland at the outlet of Lake Simcoe into Lake Couchiching, and the Carthew Bay Wetland in the south of the subwatershed. There are also a number of locally significant wetlands, such as the small areas along Mill Creek referred to as the Orillia Filtration Swamp and the Bluff's Creek West wetland along the upper and mid-reaches of Bluff's Creek (Figure 6-4). The remainder of the wetlands have been identified by LSRCA in their natural heritage system mapping, but have never been evaluated under the Provincial system.

There are approximately 1019.9 ha of wetland in the Hawkestone Creek subwatershed, which is approximately 21.3% of the landscape (Table 6-2). Wetlands in this subwatershed are dominated by the Hawkestone Creek Provincially Significant wetland complex, which consists of a very large patch in the headwaters, supplemented by a scattering of other smaller, primarily riparian wetlands along the main branch of Hawkestone Creek and a number of its tributaries (Figure 6-4).

Wetlands account for 697.1 hectares of the Oro Creeks South subwatershed, or 12.1 percent of the landscape (Table 6-2). The wetland area consists of a large patch in the headwaters considered to be a portion of the Hawkestone Creek wetland complex, and a series of smaller wetland patches, mainly found along watercourses, which are found throughout the subwatershed (Figure 6-4). None of these patches is considered to be of provincial significance.

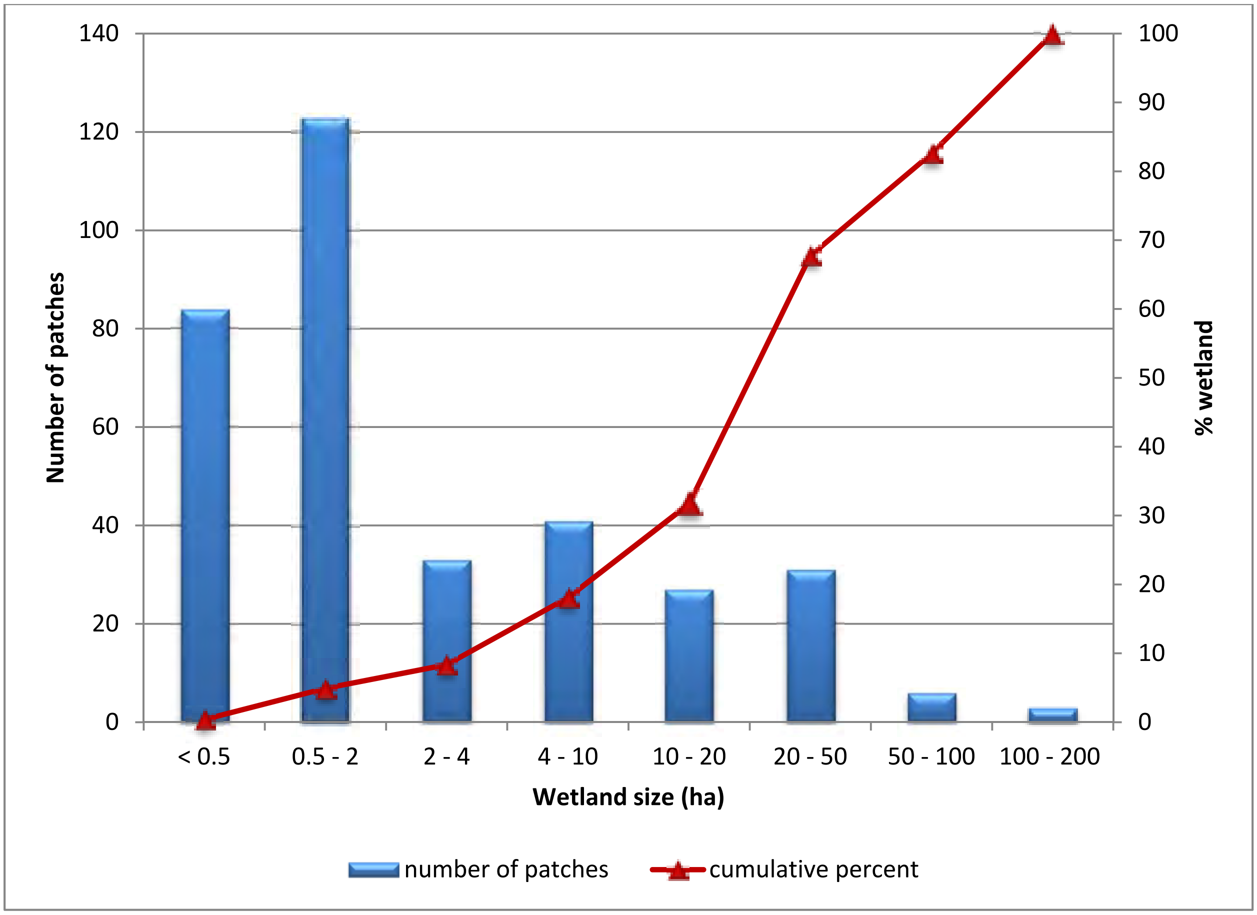


Figure 6-5 Wetland patch size distribution in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

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 of these subwatersheds requires both habitat types, as well as physical connectivity between them, be protected.

6.2.3 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

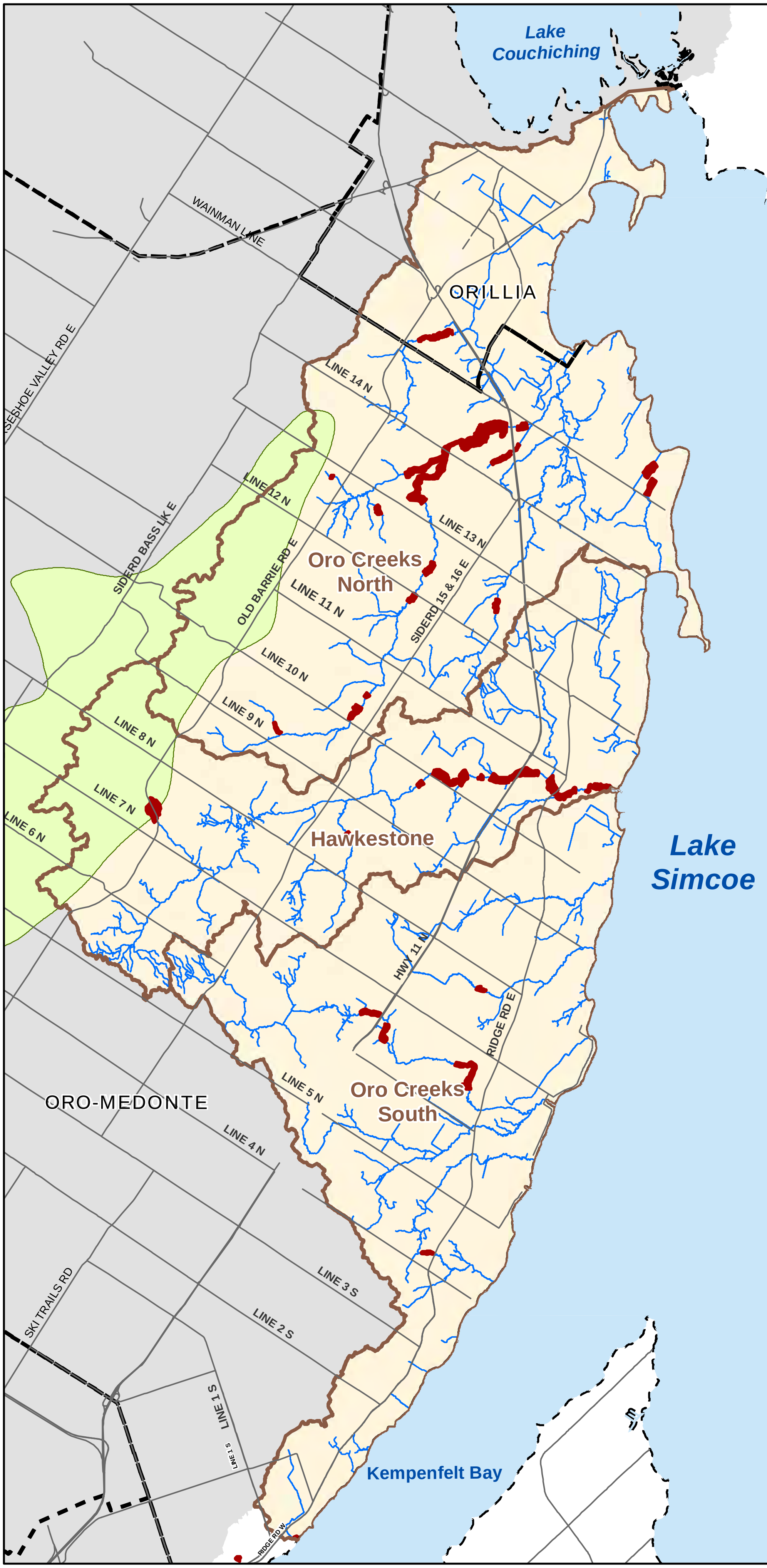
In the Oro Creeks North, there are approximately 76 ha of key valleyland features. Much of this is located along the middle reaches of Bluffs Creek, with small patches in the upper reaches; and other small areas located in the upper reaches of Mill Creek, and on Cedarmount Creek and Carthew Creek.

Significant valleylands occupy 41 ha of the Hawkestone Creek subwatershed, with much of this found along the middle and lower reaches, and a very small area in the headwaters.

Finally, there are 15 ha of significant valleylands in the Oro Creeks South subwatershed, mostly located along Shelswells Creek, with small areas on Burls Creek and Orolea Creek.

Key valleyland features in the Oro creeks North, Hawkestone Creek, and Oro creeks South subwatersheds

Figure 6-6



Legend

- Road
- Municipal Boundary
- Subwatershed
- Oro Moraine
- Valleyland

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

6.2.4 Riparian and shoreline habitat

The term riparian refers to the area of land adjacent to a stream, river, or lake. These areas provide services to aquatic habitats as a buffer between the aquatic and terrestrial ecosystems, and contribute resources to the aquatic system such as woody structure, nutrients, and shade. They also provide habitat for terrestrial organisms (Environment Canada, 2013).

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

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 30m width along watercourses and the Lake Simcoe shoreline.

All three subwatersheds have high levels of natural cover within the 30m riparian buffer; the Oro Creeks South has the lowest level, with 75% natural cover, while Oro North and Hawkestone Creeks both contain around 80% (Table 6-3, Figure 6-10).

Land use with the 30 m buffer for the Oro Creeks North subwatershed is mainly natural heritage, at close to 80% of its area, with agriculture at just over 10% and high and low intensity development at 5% and 2.5%, respectively. The level of natural cover decreases with increasing distance from the watercourses, with the majority of the corresponding increases in agriculture, as well as smaller increases in low intensity development. High intensity development remains fairly consistent at all distances analyzed (Figure 6-7).

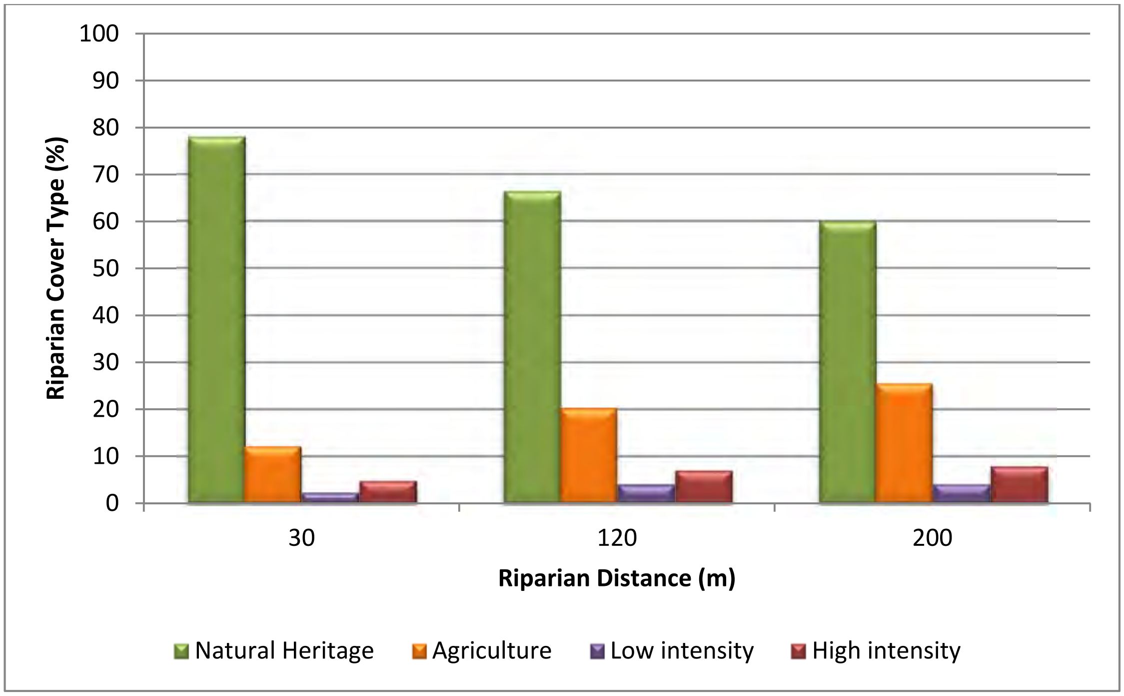


Figure 6-7: Riparian cover percentage per buffer distance for Oro Creeks North.

The 30 m riparian area in the Hawkestone Creek subwatershed also contains high levels of natural heritage cover, at 80%. Agriculture occupies close to 15%, while high intensity development and low intensity development account for less than 3% combined. As the distance from the watercourse increases, the level of natural heritage decreases, to just over 60% in the 200 m buffer. The majority of these losses correspond to increases in the level of agriculture, with very small increases in developed area (low and high intensity development account for just 5% of the area in the 200 m buffer area) (Figure 6-8).

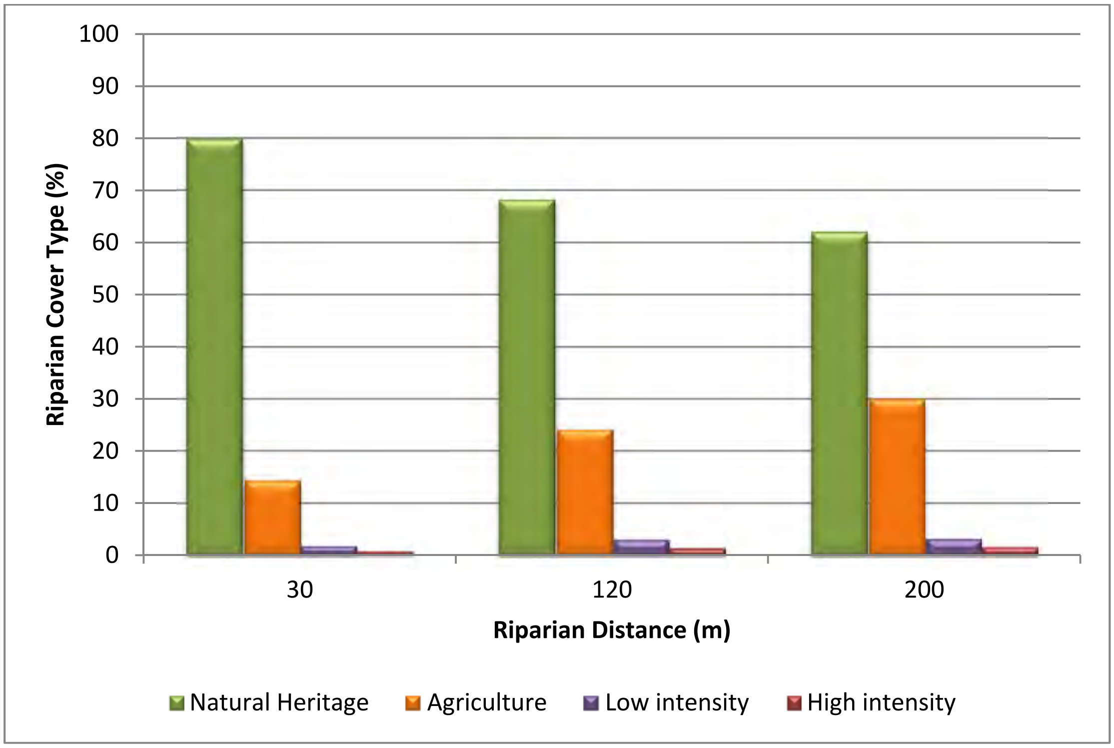


Figure 6-8: Riparian cover percentage per buffer distance for Hawkestone Creek.

The primary land use in the 30 m riparian buffer for the Oro Creeks South subwatershed is natural heritage cover, at just over 75%. This is followed by agriculture, at approximately 17% cover, and high and low intensity development represent close to 6% of the buffer area. As in the rest of the study area, natural heritage cover decreases with increasing distance from the watercourse, with approximately 20% less of the 200 m buffer in natural heritage cover. The majority of this loss corresponds to an increase in agricultural cover, and there are also small increases in both high and low intensity urban development (Figure 6-9).

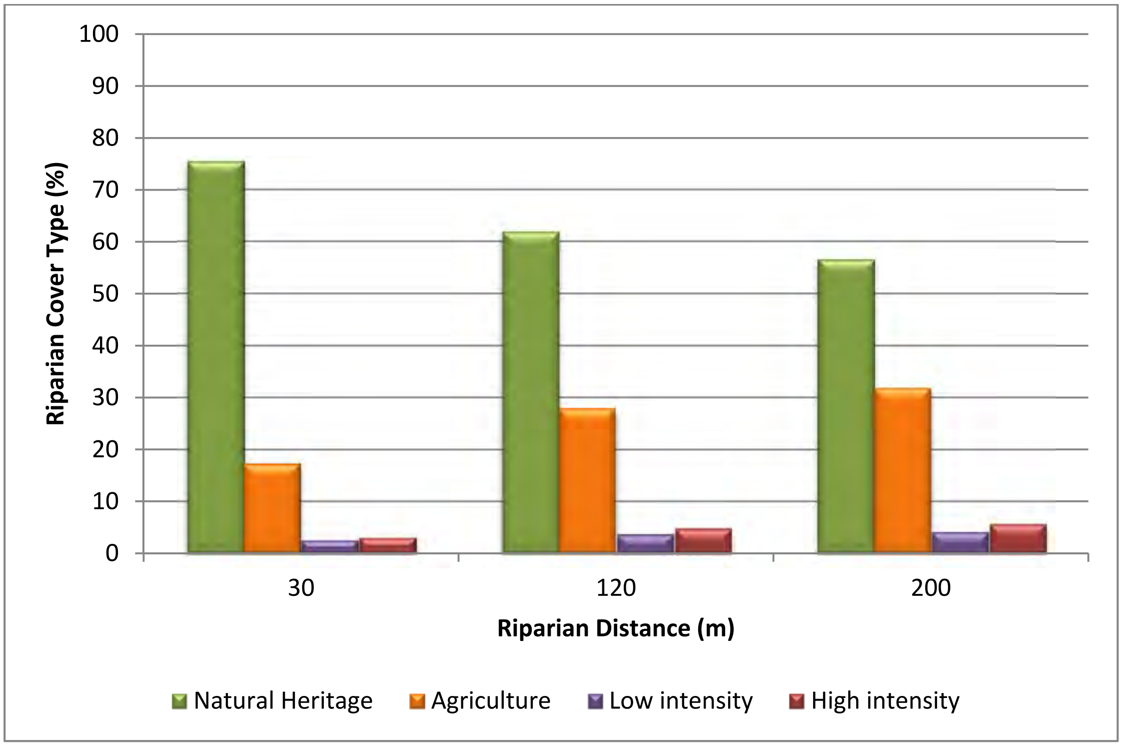
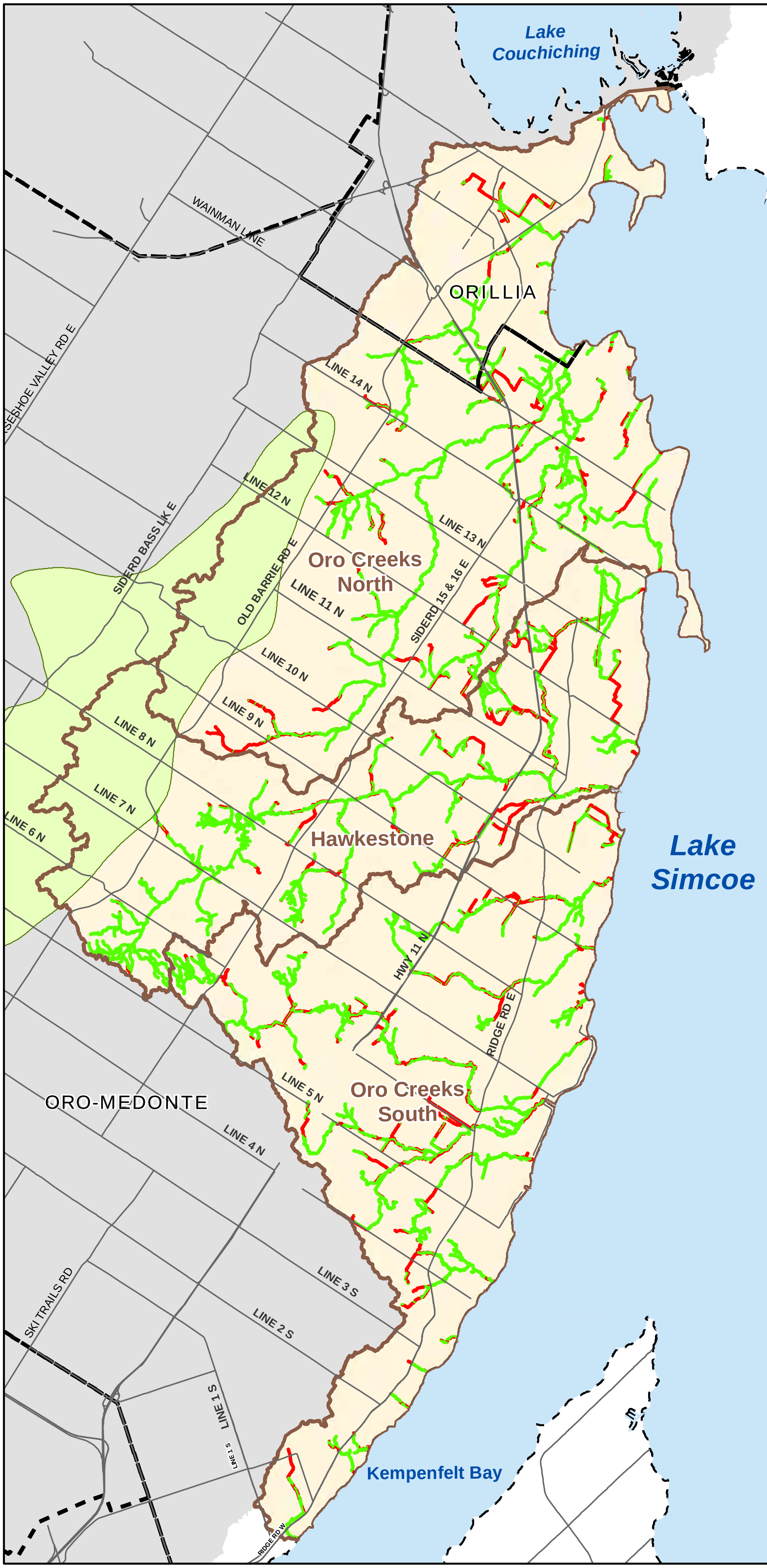


Figure 6-9: Riparian cover percentage per buffer distance for Oro Creeks South.



Riparian and shoreline habitiat in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 6-10

Legend

- Road
- Municipal Boundary
- Subwatershed
- Oro Moraine

Riparian

- Natural Vegetation
- No Vegetation

0 0.5 1 2 3 Kilometres

N E S W

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 December 2013.

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 of the study area have experienced heavy development pressures, particularly the short shoreline of the Hawkestone Creek subwatershed, which has only retained 9% of the natural cover along the shoreline. The more extensive shorelines of the Oro Creeks North and Oro Creeks South subwatershed have retained relatively more of their natural cover, with 29% and 20% natural cover remaining, respectively; however these are fairly low levels considering the high proportion of natural cover in the riparian buffers of these subwatersheds’ watercourses.

Table 6-3 Extent of natural vegetation along riparian areas in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

	Natural vegetation in riparian zone		
	Oro Creeks North (%)	**Hawkestone Creek (%)**	**Oro Creeks South (%)**
Stream banks (30 m buffer)	78	80	76
Lake Simcoe shoreline	29	9	20
Both	**72**	**78**	**69**

6.2.5 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 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 MNR 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.

Two ANSIs fall within the boundaries of these subwatersheds; a portion of the Rugby West Life Science ANSI is found within the Oro Creeks North subwatershed, and a part of the Martin Farm South Life Science ANSI falls within the Hawkestone Creek subwatershed. The Rugby West ANSI has been described as offering the best example of relatively undisturbed kame hills with upland semi-mature woods in its ecosite (District 6-6) (Hanna, 1984), which is why it is of provincial significance. The Martin Farm South ANSI is desribed as having gently to moderately rolling kame hills with immature to semi-mature sugar maple-ash-beech with sugar maple understory (Hanna, 1984). Both of these ANSIs are found on the Oro Moraine, a feature considered to be important to the Township of Oro-Medonte, with much of it afforded protections under the municipal official plan. Because it is considered to be of provincial significance, the Rugby West ANSI is included under the designation of Oro Moraine – Natural Core/Corridor in the Oro-Medonte Official Plan. This designation affords it the highest level of protection in the township, with very few activities permitted. The official plan stipulates that there is to be no development in a provincially significant ANSI, and any development proposed within 50 m of an ANSI will be subject to the completion of an Environmental Impact Study and Management Plan to ensure that there will be no negative impacts on the feature or its functions. As a regionally significant ANSI, the Martin Farm South area is subject to less rigorous restrictions, but development is discouraged, and requires either a zoning amendment or an amendment to the official plan, with the potential requirement for an EIS or Management Plan for development proposed within 50 m of an ANSI. In addition, the Oro-Medonte Official plan identifies some of the land within this ANSI as being part of the Natural Core/ Corridor designation, thus affording these areas the same protection as a provincially significant ANSI.

Table 6-4 ANSIs found in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds

ANSI Name	Significance Level	Status	Life Science/ Earth Science	Total Area (ha)	Watershed (area in watershed)
Rugby West	Provincial	Confirmed	Life	185.4	Oro Creeks North (103.5 ha)
Martin Farm South	Regional	Confirmed	Life	108.6	Hawkestone Creek (76.2 ha)

6.2.6 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 in the Oro Creeks North subwatershed include:

- Blanding's Turtle, *Emydoidea blandingii*; S3; Threatened)
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- Eastern ribbon snake (*Thamnophis sauritis*; S3; Special Concern)
- Black tern (*Chlidonias niger*; S3B, Special Concern)
- Bobolink (*Dolichonyx oryzivorus*, Threatened) which nest in hayfields and other grasslands;
- The aerial insectivores common nighthawk (*Chordeiles minor*, Threatened) and whip-poor-will (*Caprimulgus vociferus*, Threatened)
- Chimney swift (*Chaetura pelagica*; Threatened)
- Canada warbler (*Wilsonia canadensis*; Special Concern)
- Red-headed woodpecker (*Melanerpes erythrocephalus*; Special Concern)

Species of conservation concern in the Hawkestone Creek subwatershed include:

- American ginseng (*Panax quinquiefloius*; S2, Endangered)
- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- Bobolink (*Dolichonyx oryzivorus*, Threatened) which nest in hayfields and other grasslands;
- Canada warbler (*Wilsonia canadensis*; Special Concern)
- Chimney swift (*Chaetura pelagica*; Threatened)
- The aerial insectivores common nighthawk (*Chordeiles minor*, Threatened) and whip-poor-will (*Caprimulgus vociferus*, Threatened)
- Red-headed woodpecker (*Melanerpes erythrocephalus*; Special Concern)
- Olive-sided flycatcher (*Contopus cooperi*; Special Concern)

Species of conservation concern in the Hawkestone Creek subwatershed include:

- Snapping turtles (*Chelydra serpentina*; S3; Special Concern) which inhabit large wetlands;
- Bobolink (*Dolichonyx oryzivorus*, Threatened) which nest in hayfields and other grasslands;
- Chimney swift (*Chaetura pelagica*; Threatened)
- The aerial insectivores common nighthawk (*Chordeiles minor*, Threatened) and whip-poor-will (*Caprimulgus vociferus*, Threatened)
- Golden-winged warbler (*Vermivora chysoptera*; Special Concern)
- Olive-sided flycatcher (*Contopus cooperi*; Special Concern)
- Red-headed woodpecker (*Melanerpes erythrocephalus*; Special Concern)

6.2.7 Grasslands

In addition to these rare and at-risk species, are rare ecosystems. There are a few documented remnants of pre-settlement tallgrass praire ecosystems in the Lake Simcoe watershed. These small relict ecosystems are dominated by big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). Historic records provide a more detailed plant list of these remnants, including 17 plant species which are rare in the Lake Simcoe watershed (Reznicek, 1983).

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, 2005). There are scattered grasslands throughout these three subwatersheds, primarily on the margins of woodlands, swamps, and agricultural areas including a fairly large one in the lower end of the Hawkestone Creek subwatershed (Figure 6-1, Table 6-5).

Table 6-5 Distribution of grassland types in the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds

Grassland type	Grassland Cover					
	Oro Creeks North		Oro Creeks South		Hawkestone Creek	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Cultural meadow (CUM)	196.4	2.6	83.0	1.4	125.3	2.6
Cultural thicket (CUT)	151.6	2.0	229.1	4.0	162.8	3.4
Total	**348.0**	**4.6**	**312.1**	**5.4**	**288.1**	**6.0**

Key Points - Current Terrestrial Natural Heritage Status:

- The Oro Creeks North subwatershed contains 45% natural heritage cover, with 13.5% wetland, 27.3% upland forest, and 4.6% grassland. This subwatershed is extremely healthy with respect to riparian buffers, with 80% of the area within a 30m buffer along its watercourses consisting of natural heritage cover.
- The Hawkestone Creek subwatershed is among the least affected by land use change in the Lake Simcoe watershed, with 57% of its natural cover remaining. This consists of 21.3% wetland, 29.7% upland forest, and 6% grassland. The level of natural cover in the riparian buffer is also high, at 80%.
- Oro Creeks South contains 46% natural heritage cover, including 12.1% wetland, 28.9% upland forest, and 5.4% grassland. Approximately 75% of the riparian buffer in this subwatershed consists of natural heritage features.
- There is a wide range of forest and wetland patch sizes, with many large patches of both forest and wetland. This includes several patches that include forest interior habitat, which supports a number of sensitive bird species, as well as several patches of deep forest interior, greater than 200 m from the forest edge.
- Several Species of Conservation Concern are also found in these subwatersheds, including Blanding's turtle, bobolink, chimney swift, and American ginseng.
- The natural heritage component of the assessments of these subwatersheds is relatively data-poor, particularly as it relates to the distribution of flora and fauna throughout the subwatershed
- 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.

6.3 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.

6.3.1 Land use change

Prior to European settlement, the Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds were almost entirely covered by upland and wetland forest (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 these subwatersheds.

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. Natural habitat remains in just less than half (45%) of the Oro Creeks North subwatershed, with the majority of the rest of the subwatershed being converted to agricultural and urban land uses (Figure 2-2). The Hawkestone Creek subwatershed is the least affected of the three, with 57% of the natural cover remaining. The majority of the land use change in this subwatershed has been to agriculture, with a relatively small percentage being converted to urban (Figure 2-3). Similar to the Oro Creeks North subwatershed, Oro Creeks South has retained close to half of its natural cover (46%), with close to 40% being changed to accommodate agriculture, and much of the remainder in urban development (Figure 2-4).

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 these subwatersheds will be a shift from agricultural land uses to more intensive landuses including residential, commercial, and 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 habitat 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. In those cases, stormwater ponds can act to suppress amphibian populations beyond the suppression caused by wetland habitat loss alone (Hamer and McDonnell, 2008).

Both the City of Orillia and the Township of Oro-Medonte are slated to grow under the Provincial Growth Plan for the Greater Golden Horseshoe (OMPIR, 2006). They have been designated to receive an increase in population of 10,500 (34%) and 6,000 (28%) respectively by 2031. As this development proceeds, the stresses associated with the loss and fragmentation of natural habitat will only continue.

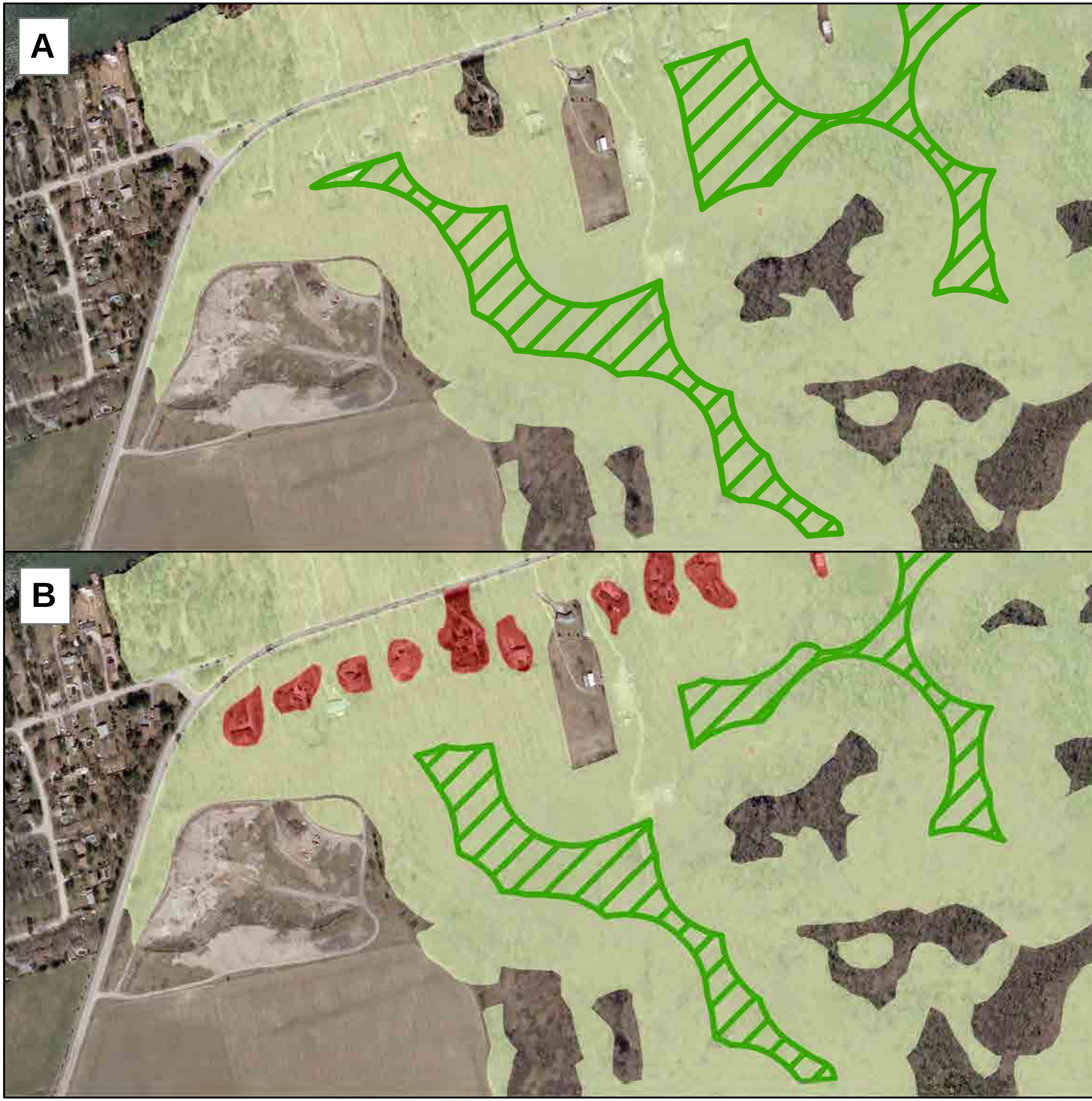
6.3.2 Habitat fragmentation

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 6-11, 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 (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).

Example loss of forest interior resulting from estate residential development

Figure 6-11



Legend

- Estate Residential
- Woodlands
- Interior Forest

Lake Simcoe Region conservation authority

0 50 100 200 300 Metres

N S W E

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This map has been produced for illustrative purposes only.
LSRCA GIS Services DRAFT DC created December 2013.

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). These impacts are much less pronounced in these subwatersheds though, with estate residential occupying only 0.3% in both the Oro Creeks North and Oro Creeks South subwatersheds, and 0.2% in the Hawkestone Creek subwatershed.

6.3.3 Shoreline development

The Lake Simcoe shoreline has 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 6) 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 in all three of the study subwatersheds have been subject to significant urban development. Currently, only 29%, 20%, and 9% of the shoreline in the Oro Creeks North, Oro Creeks South, and Hawkestone Creeks subwatersheds remain under natural cover, respectively. Much of the shoreline area that has been changed from natural cover is defined as urban, with houses being built along the lakeshore. There are also some manicured parklands, as well as low levels of commercial and agriculture.

6.3.4 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.

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, continued development in the subwatersheds will increase the number of natural areas vulnerable to these effects.

6.3.5 Changes to hydrologic regime

Although the current status of, and stressors on, surface water hydrology are dealt with more fully in **Chapter 4 – 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 4.

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, the water table drops. 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 with relatively high levels of residential development, including some areas in these subwatersheds, many of the plants which colonize rapidly changing areas such as this are non-natives.

The most significant instance of a municipal drain potentially impacting a natural heritage feature in these subwatersheds is in the lower reaches of Bluff’s Creek in the Oro Creeks North subwatershed. A number of branches of Bluff’s Creek flowing through the Bluff’s Creek East wetland are designated as municipal drains, and have the potential to impact this provincially significant wetland.

6.3.6 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).

There is little documentation of which terrestrial invasive species are present in these subwatersheds; however this is no doubt reflective more of a lack of documentation than a lack of invasive species. 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, oak wilt, and white nose syndrome in bats.

Within five years of the release of the LSPP (i.e. 2014), the MNR is to develop response plans to address invasive species in the watershed, and those on the watch list.

Figure 6-12: 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, MNR)

6.3.7 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).

6.3.8 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.

As these subwatersheds develop, these types of impacts will no doubt increase, as the combination of larger populations 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.

6.3.9 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*), red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), and eastern hemlock (*Tsuga canadensis*) will all exhibit slight decreases in their occurrence in the forests of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. 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*), 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 proto-typically Canadian. Both sugar maple (*Acer saccharum*) (Canada's national symbol), and white pine (*Pinus strobus*) (Ontario's provincial tree) are predicted to experience severe declines in the Oro Creeks North and Oro Creeks South subwatersheds; however, it appears that the Hawkestone Creek subwatershed will provide a refuge for white pine (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 ground water 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, and a net loss of tree species diversity; although the high levels of natural cover in these areas may help them 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 black maple [*Acer nigrum]*) 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, 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 these subwatersheds however, as the interacting effects of climate change, landscape fragmentation, and urbanization 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 these subwatersheds, many of which interact.
- Over the short term, the greatest impact to natural heritage values is expected to be due to changes in land use. These impacts can only be expected to increase as the population in these subwatersheds increases.
- In addition to the direct loss of natural areas, development is typically associated with an increase in 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 heavily 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.

6.4 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 Oro Creeks North, Oro Creeks South, and Hawkestone Creek subwatersheds, as outlined below.

6.4.1 Protection and policy

6.4.1.1 Land use planning and policy

Several acts, regulations, policies, and plans have shaped the identification and protection of the terrestrial natural heritage of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. Those having most impact on natural heritage features are summarized in Table 6-6. 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 6-6 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 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 6-6 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 Watershed Development Policies (2008)	Simcoe County Official Plan (2007)	Township of Oro-Medonte Official Plan (2007)	City of Orillia Official Plan (2011)
Site alteration in upland natural heritage features	1,4			6		2,4	4	2
Site alteration in wetlands	1,4			6	4	4	4	4
Shoreline development	4			6				
Loss of connectivity between natural heritage features								
Impervious areas						7	10	10
Climate change								
Introduction of invasive species	3						11	13
Protection of species of conservation concern			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] "Species of conservation concern" identified as an indicator, but not defined or regulated
[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] Within the Oro Moraine Planning Area
[10] Impervious not mentioned directly, but has policies around maintaining flow regimes and interconnectivity with groundwater resources (Oro)/ensuring that proposed development will not cause adverse effects on groundwater supply and protecting Significant Groundwater Recharge Areas (Orillia)
[11] Mentions preparation of a Natural Environment Stewardship Manual for shoreline developments, which would cover items including the value of native vegetation
[13] Gives preference to the use of native species in the Downtown area, and for stormwater pond plantings

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 100m 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 120m of the feature.

Draft definitions of Key Natural Heritage Features protected by the LSPP include all areas that meet the definition of wetland provided by either the Ontario Wetland Evaluation System or the Ecological Land Classification manual, all woodlands larger than 10 ha in size (or larger than 4 ha in size if they contain late successional tree species more than 100 years old, or are near other Key Natural Heritage Features) and all valleylands that meet specific dimensional requirements.

The Official Plan for the City of Orillia contains an Environmental Protection Area designation, which includes Provincially Significant Wetlands and other wetlands >0.5 ha in size; significant woodlands >2 ha in size; significant valleylands; significant wildlife habitat; significant habitat of threatened and/or endangered species; significant ANSIs; and fish habitat. There is no development or site alteration permitted within Provincially Significant Wetlands or significant habitat of endangered or threatened species; development on other features under the Environmental Protection Area designation will only be permitted if an EIS demonstrates that there will be no negative impact on the feature or its ecological function. The Official Plan also requires the completion of an EIS for developments proposed on lands adjacent to Environmental Protection Area features (the width of this adjacent area depends on the type of feature); this must also demonstrate that there will be no negative impacts.

The Township of Oro-Medone identifies areas as Environmental Protection One in its Official Plan; this designation is intended to include the following significant features: all wetlands;

provincially significant Areas of Natural and Scientific Interest; and significant wildlife habitat areas. Few uses are permitted in these areas, as well as in adjacent areas, and those developments/site alterations that are permitted require the completion of an Environmental Impact Study and a Management Plan that will demonstrate that there will not be negative impacts to the feature or its ecological functions, as well as addressing how the development will protect, maintain, or restore the significant natural features and ecological functions of the natural heritage system. The Official Plan also has an Environmental Protection Two overlay designation, which includes woodlands, regionally significant Areas of Natural and Scientific Interest; other wildlife habitat areas, and fish spawning and nursery areas. Development in these areas is limited to the underlying designation; and if a proposal requires an amendment to the zoning by-law or to the Official Plan, an Environmental Impact Statement is required.

The LSRCA is assisting 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, 1999), 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.

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.

6.4.2 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 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 Oro-Medonte Wetlands, and contains up to three significant ecological features including the Hawkestone Wetland Complex (PSW), the Martin Farm South ANSI (Life Science - Regional), Significant Waterfowl Habitat and interior forest area. This target area is approximately 1,300 hectares in size. The provincially significant wetland complex is 843 ha and is made up of eleven individual wetlands, composed of swamp and marsh. The ANSI is comprised of 130 hectares of gently to moderately rolling kame hills. 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.

Similarly, Simcoe County has a land acquisition program intended to increase the amount of County Forest holdings. Priority acquisition of land for the County Forest program is given to properties adjacent to existing county forests, and that contribute to both forestry and natural heritage purposes.

The Township of Oro-Medonte and the City of Orillia also have parkland dedication targets in their Official Plans. These targets are intended to ensure that as the population grows, opportunities for outdoor recreation grow as well. Although parkland targets are 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.

6.4.3 Restoration and remediation

There are a range of programs operating in these subwatersheds to assist 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 1999 and 2004, in addition to projects focussed specifically on protecting water quality, LEAP supported 1 streambank erosion project in Oro-Medonte. Between 2004 and 2012, LEAP supported two upland tree planting projects in Or Creeks North, and six in Oro Creeks South, as well as one streambank erosion project in Oro Creeks North, two in Hawkestone Creeks, and two in Oro Creeks South.

The Ontario Ministries of Natural Resources, Environment, and Agriculture, Food and Rural Affairs provide the Lake Simcoe Community Stewardship Program for non-farm rural landowners in the Lake Simcoe watershed. This program is intended to provide non-farm rural residents with financial and technical assistance in implementing projects such as shoreline stabilization, septic system upgrades, wetland creation, and forest management, among others. The Lake Simcoe Community Stewardship Program has implemented 16 shoreline improvement projects and three wetland improvement projects in the Oro Creeks North subwatershed, eight shoreline improvement projects in the Hawkestone Creek subwatershed, and 16 shoreline improvement and tree planting projects in the Oro Creeks South subwatershed thus far.

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, no projects that would directly improve terrestrial natural heritage have been completed in the City of Orillia, while in the Township of Oro-Medonte less than five have been implemented.

In 2008 and 2009, LSRCA field staff surveyed the majority of the watercourses in these subwatersheds 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. This survey found over 150 additional places in these three subwatersheds where additional riparian planting could be introduced.

The forthcoming shoreline management strategy, and wetland and riparian area prioritization exercise will identify and prioritize stewardship opportunities in this subwatershed, specific to the shoreline and inland riparian and headwater areas respectively.

These ongoing stewardship programs will soon be complemented by a forthcoming Voluntary Action Program. Initially, the Lake Simcoe Protection Plan proposed the development of a regulation to prohibit activities that would adversely affect the ecological health of the Lake Simcoe watershed (policy 6.16). Feedback during the initial rounds of consultation in development of this regulation raised concerns about its enforceability, and the need to educate the public on best management practices before taking a regulatory approach. As a result, the MOE reframed the Shoreline Regulation as a Shoreline Voluntary Action Program.

The Shoreline Voluntary Action Program is intended to increase the extent of native vegetation along shorelines, and reduce the use of phosphate-containing fertilizer in the watershed, through a combination of surveys which are aimed at understanding the current range of public knowledge, attitudes, and practices, and outreach to summer camps, landowners, and garden centres.

This voluntary action program is being run as a two year pilot program, with ongoing monitoring to determine the rate of uptake, impacts on phosphorus levels, and impacts on native vegetation along the shoreline. After the pilot program is complete, these results will be reviewed to determine if a voluntary program is sufficient, or if a regulatory approach is necessary.

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 MNR 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds for wetland and linkage/corridor restoration can be found in Figure 6-8 below.

Table 6-7 – 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)
Oro Creeks North	313	1461	5604	934
Hawkestone Creek	188	1255	3262	687
Oro Creeks South	211	917	5691	467

6.4.4 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 MNR 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 MNR, LSRCA and MOE 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 6.2). 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. Unfortunately, neither of these programs have established routes in the Oro Creeks North, Hawkestone Creek, or Oro Creeks South subwatersheds.

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 these subwatersheds. Exceptions include grasslands and some small isolated forests.
- Wetlands are effectively protected in these 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 municipal official plans
- The Ministry of Natural Resources, Lake Simcoe Region Conservation Authority, and South Simcoe Streams Network provide programs 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 programs, uptake has been limited in these subwatersheds. The forthcoming Shoreline Voluntary Action Program may help increase uptake, by increasing public awareness of the value of shoreline ecosystems, increasing public awareness of the existence of funding and technical assistance programs, and by conducting surveys to determine barriers to public uptake
- The definition of Key Natural Heritage features for the LSPP has just been released for review, therefore it is not known at this point the extent to which the study area's natural features will be protected

6.5 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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.

6.5.1 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 6-1** - That the LSRCA, and relevant provincial agencies assist subwatershed municipalities in ensuring official plans are consistent with the recommendations presented in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatershed plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with municipalities, 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).*

6.5.2 Revisions in Key Natural Heritage Protection Policies

Policy 6.50 of the LSPP requires the MNR. MOE 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 6-2** – That the MNR, MOE, 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.

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 6-3 - That LSRCA, 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.

6.5.3 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), including the remnant listed above, in the Lake Simcoe watershed. These features are each less than 25 ha in size, and together are less than 30ha in total size. Features this small 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 these subwatersheds related to the preservation of habitat for grassland-dependent wildlife is one that is widespread throughout the Province. Within the past year, 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 6-4 – That the MNR, MAFRA, LSRCA, subwatershed municipalities, and interested members of the agricultural community review the results of the studies being conducted on methods and policy tools to protect grassland dependent wildlife on active agricultural land as they become available, to determine if they provide solutions for the conservation of grassland habitat which would be applicable for these subwatersheds.

Recommendation 6-5 – That the City of Orillia and Township of Oro-Medonte, with the assistance of the MNR and LSRCA, give consideration to including policies in their respective Official Plans to contribute to the protection of grassland habitats, as necessary, based on the results of Recommendation #6-4, and recognize the need for balance in the approach to development in urban areas.

6.5.4 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 6-6 – 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 6-7 – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, MTO, LSRCA and MOE (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 wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

6.5.5 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 Oro Medonte Wetlands, which were identified by the LSRCA as a priority area for securement.

Recommendation 6-8 – 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.

Recommendation 6-9 – That the LSRCA and subwatershed municipalities, with the assistance of the MNR, 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 6-10 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to support securement of notable natural areas.

6.5.6 Stewardship implementation – increasing uptake

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, Ministry of the Environment, 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. Despite this range of players, the uptake of proffered stewardship programs is limited by the number of private landowners who voluntarily participate.

Recommendation 6-11 – That the MNR, MOE, MAF, and LSRCA 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.

Recommendation 6-12 – 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 6-13 – 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 6-14 – That MOE, MNR, LSRCA and other members of the Lake Simcoe Stewardship Network 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 the have completed and encourage others to do the same.

Recommendation 6-15 – That the MOE, MNR, MAF, LSRCA, and other interested members of the Lake Simcoe Stewardship Network support research to determine public motivations and barriers limiting uptake of stewardship programs in these subwatersheds 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 6-16 – The MOE, MNR, OMAFRA and LSRCA 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.

6.5.7 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 natural heritage and hydrological priorities, and an assessment of barriers to uptake as listed above, would allow improved targeting of programs to areas of relatively high need.

Recommendation 6-17 – That the MNR, with the assistance of the MOE and LSRCA, use their draft ‘Delineation of Priority Areas for Restoration’ report to develop a spatially-explicit decision support tool to assist in targeting terrestrial stewardship projects in the Lake Simcoe watershed. In the context of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, this decision tool should take into account factors including:

- The need to increase the extent of natural shoreline Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds
- Protecting and restoring significant groundwater recharge areas and ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- The need to protect and restore grassland habitat, particularly rare native grasslands
- Opportunities to enhance resilience to climate change
- The need to reduce phosphorus loadings to the tributaries in these subwatersheds.

Recommendation 6-18 – 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.

6.5.8 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South 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 6-19 – That the County of Simcoe, City of Orillia, and Township of Oro-Medonte, with assistance of MNR and LSRCA, conduct natural heritage inventories, and develop and implement management plans for publicly accessible natural areas that they own, to mitigate potential threats related to invasive species and increased recreation pressure.

Recommendation 6-20 – That the MNR and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-21 – That the City of Orillia, the Township of Oro-Medonte and the County of Simcoe, with support from LSRCA, 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 6-22 – That the City of Orillia and Township of Oro-Medonte give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands, recognizing that Orillia does give such preference in the policies for their Downtown planning designation.

6.5.9 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 MNR, LSRCA, and MOE 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 6-23 – That the MNR, with the assistance of LSRCA and MOE, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 6-24 – That the MNR, LSRCA, and MAFRA continue to maintain an up-to-date seamless land cover map for the watershed, as defined by the LSPP, with natural heritage features classified using Ecological Land Classification, managed in such a way as to allow change analysis.

Recommendation 6-25 – That the MNR 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 6-26 – That the MNR, 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.

6.5.10 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 6-27 – That the MNR, LSRCA, and MOE 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.

6.5.11 Terrestrial Natural Heritage Research Needs

The Lake Simcoe watershed, including areas in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, is one of the most rapidly urbanizing watersheds in Ontario. Although there is a substantial suite of policies in place to protect existing natural heritage features from development and site alteration, the effects on those features resulting from intensified development in the surrounding landscape is less well understood.

Recommendation 6-28 – That the Lake Simcoe Science Committee, other levels of government, and academia support research to better understand the stresses to wildlife and wildlife habitat associated with urban development, to allow management responses to be refined. Important questions of interest include: the use of stormwater ponds as amphibian breeding habitat, the importance of remnant natural areas to quality of life for local residents, the indirect impacts of roads on resident and migratory wildlife, and the impacts of high density and low density development on wildlife communities in natural areas. This research may include literature reviews, analysis of data available through the monitoring program, or original, innovative, peer-reviewed research.

7 Integration and Implementation

7.1 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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds. 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 3 to 6 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).

7.2 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 7-1) (Earthfx, 2013a). In the case of the the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, the Oro Moraine, an important glacial feature that lies along the western boundary of the study area, provides significant groundwater recharge (Figure 4-2) and feeds the headwaters of numerous streams that drain to Lake Simcoe, and also to its neighbouring watersheds to the north and west. When 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 these subwatersheds generally follows surface water flow, from the heights of the Oro Moraine to the lows associated with major stream channels and Lake Simcoe. In their 2013 study of the area, Earthfx found that significant quantities of groundwater flow discharging to some significant features in the study area, particularly in the headwaters of Hawkestone Creek, are originating from outside of the watershed through lateral groundwater inflow. Much of this groundwater flows in either the upper Oro Moraine aquifer composed of sand and gravel and deposited by glaciers to form the Oro Moraine, the near-surface aquifer (composed of sand and gravel and deposited along the shores of glacial Lake Algonquin), an intermediate regional aquifer (consisting of gravel, sand and silty sand), a lower aquifer comprised of sand and silty sand, or a deep thin basal gravel aquifer associated with the underlying weathered bedrock.

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 discharge to the headwater reaches represents a significant portion of the total baseflow. Hawkestone Creek appears to be the subwatershed that is most well connected to the groundwater system in the study area.

Based on modelling results, the Oro Moraine provides flow primarily to the headwater streams and to the wetlands at the base of the moraine. Groundwater discharge to these 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. In fact, the Oro Moraine also provides flow to features located at greater distances from the moraine such as near the Bluffs Creek East Wetland. This illustrates the deeper flow systems that exist beneath the till confining units. There is also some cross-watershed boundary flow, where recharge occurring within the study area discharges beyond the study area limits; and recharge from outside the study area feeds features within the study area.

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 the main contributor to flow during times of limited rainfall. Evidence of the importance of this groundwater source is seen in a number of watercourses along the lakeshore 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, 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, in some cases maintaining it below the critical temperature needed for healthy reproduction of sensitive species such as brook trout and mottled sculpin. When temperatures exceed their critical maximums, it causes physiological stress to these species, and may make them more susceptible to being outcompeted by more generalist species such as suckers, minnows, and brown trout. Even when groundwater discharge is not able to decrease the overall water temperature of the creek below that threshold, it may create small 'refugia' habitats in the discharge zone, providing sensitive species a small area of cold water where they can take shelter during the hottest days of the year. This refuge habitat may explain the continued presence of coldwater species in the lower reaches of Hawkestone Creek and some of the Oro Creeks South tributaries, where they persist despite the water temperature appearing to be too high to meet their habitat requirements. With brook trout particularly, groundwater discharge is thought to be a critical habitat factor.

Brook trout will only spawn in areas in which they can lay their eggs on gravelly substrate that is continually flushed by groundwater (Figure 7-1). As such, the preservation of groundwater recharge and discharge, even at relatively large distances from creeks, is critical to preserving breeding populations of brook trout.

In areas that have become urbanized, this groundwater relationship can be interrupted (Figure 7-1). 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 all three subwatersheds is expected to be reduced by less than one percent of the current conditions (Earthfx, 2013a). The Earthfx report (2013a) 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, all of the subwatersheds were 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, total streamflow and stage in the wetlands across the subwatersheds. The results of both analyses found some reduction in groundwater levels, but municipal pumping wells did not go dry, and some impacts to streamflow, particularly in headwater areas, though these effects were relatively minor (Tables 4-20 and 4-21).

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, providing habitat for coldwater fish species. Once identified, the Lake Simcoe Protection Plan directs municipalities to develop policies in their Official Plans to protect, improve, or restore these features.

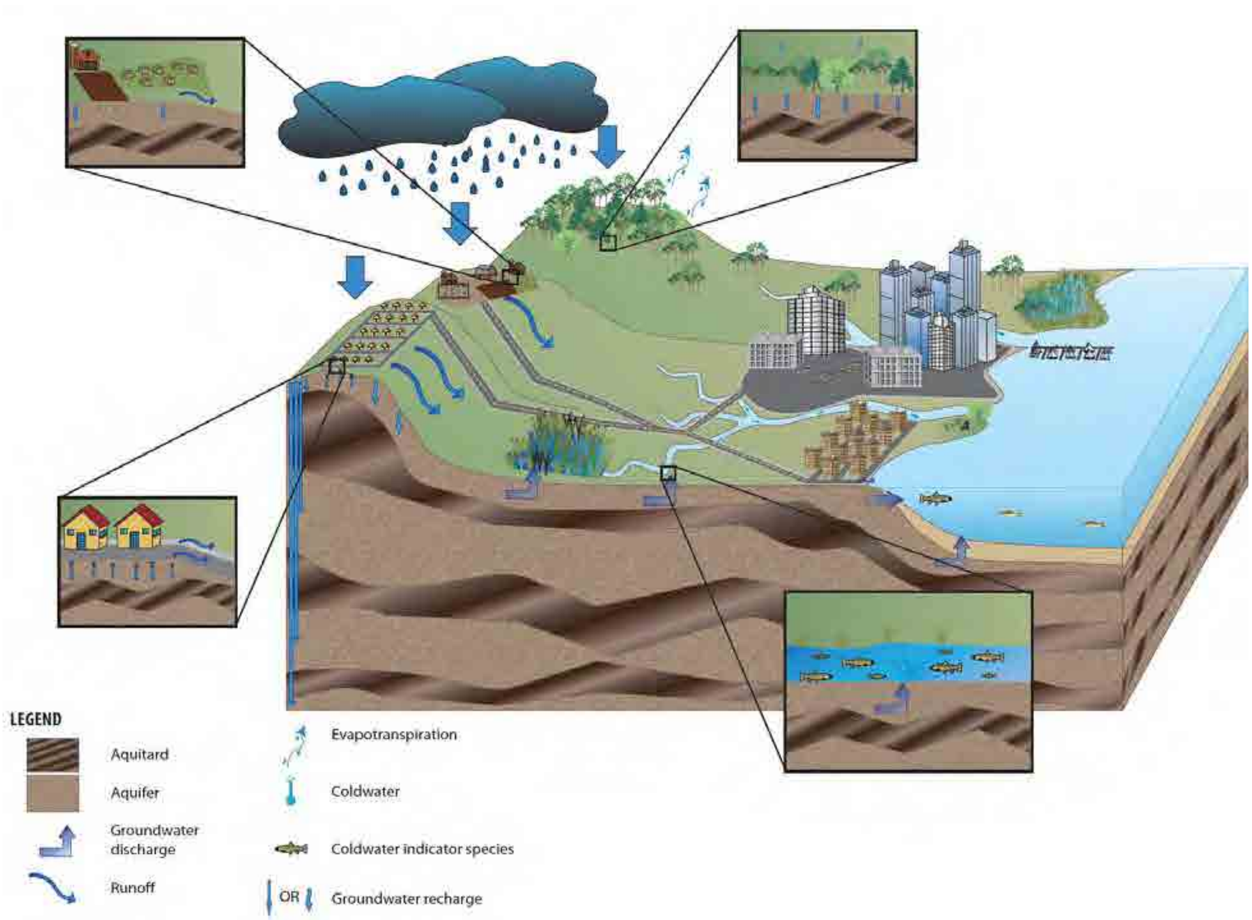


Figure 7-1: Groundwater interactions in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds.

7.3 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 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 fertilizer (Figure 7-2). 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 one of the major land uses in each of the study area's subwatersheds, and modelling has estimated that it contributes close to one third of the phosphorus load in both the Hawkestone Creek and Oro Creeks North subwatersheds (Louis Berger Group, Inc., 2010). 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 for species such as brook trout, mottled sculpin, white sucker, and others. 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 7-2).

An issue specific to the management of agricultural watersheds is agricultural drains. 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. For example, the conversion of a large portion of Mill Creek in the Oro Creeks North subwatershed, and the loss in water storage and habitat quality that would result from this change, may be contributing to the absence of coldwater fish species from many of these reaches, in spite of coldwater temperatures at these stations. (Figure 5-2, Figure 5-4, Figure 5-13). In cases where these drains bisect wetlands, as they do in some of the lower reaches of Bluffs Creek, 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 7-2).

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 7-2).

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 7-2). As an example, inputs from malfunctioning septic systems near the lake were found to be the most significant contributor to phosphorus loads in the Hawkestone

Creek subwatershed under the modelling completed by Berger and Associates in their 2010 report (Table 3-8).

Fortunately, the reasonably high levels of natural vegetation along many of the watercourses flowing through agricultural land in these subwatersheds (Figure 6-10) 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, 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 7-3). In spite of the relatively healthy levels of riparian cover in these subwatersheds, there are a number of areas within the study area where riparian buffers are lacking, including some of the middle reaches of the Hawkestone Creek subwatershed and a number of other reaches in the Oro Creeks North and Oro Creeks South subwatersheds (Figure 6-10). 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.

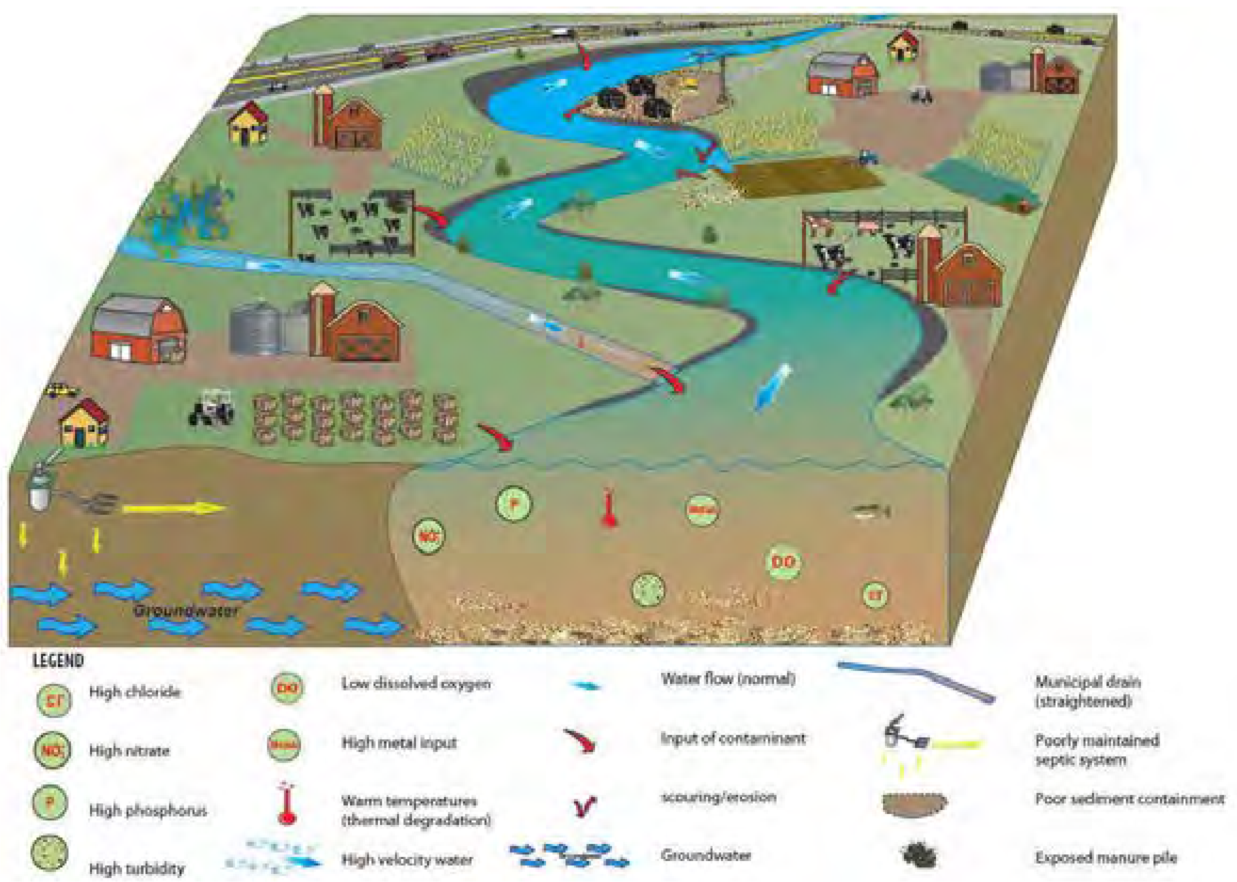


Figure 7-2: Influences of rural and agricultural land use on subwatershed health.

The release of sediment and phosphorus from farm fields can also be reduced through the use of cover crops, by minimizing 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 7-3).

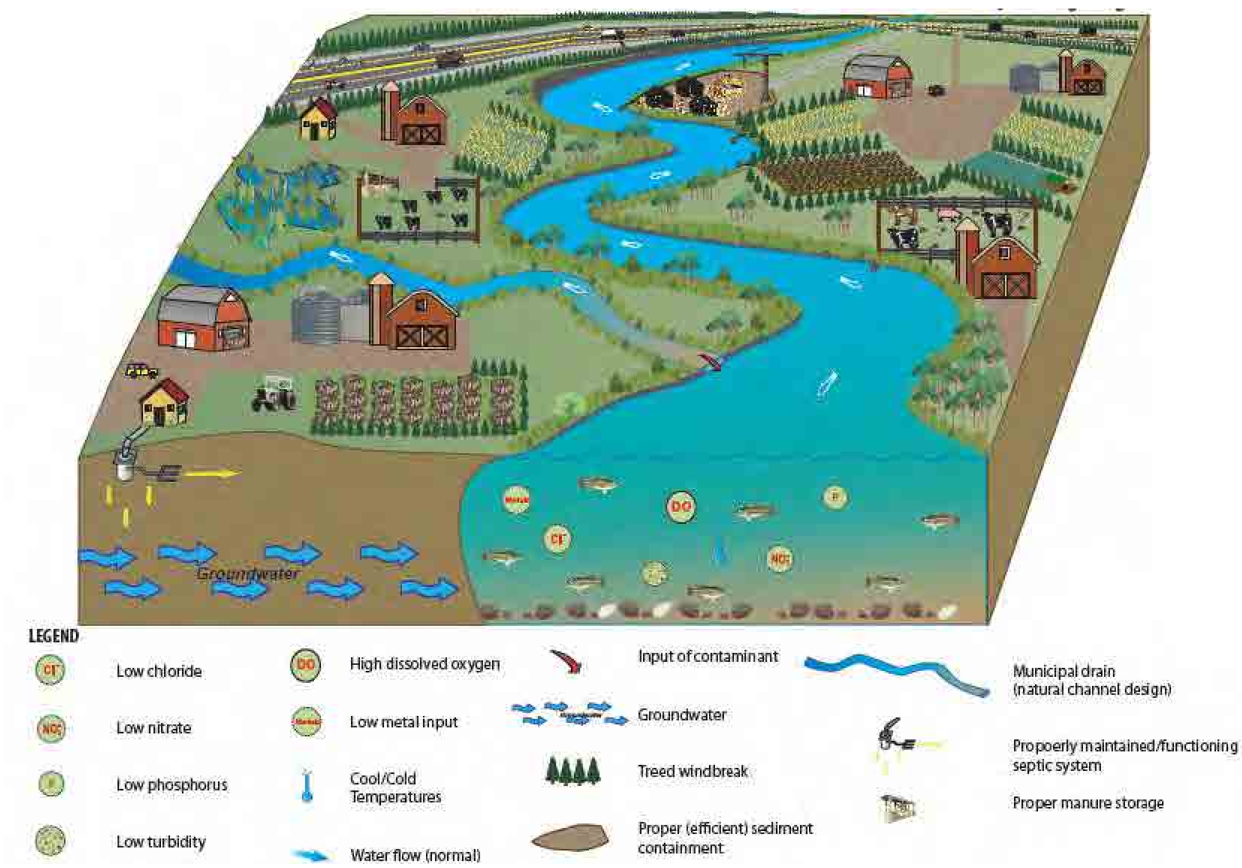


Figure 7-3: An agricultural landscape with appropriate best management practices implemented to protect subwatershed health

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, Ontario Soil and Crop Improvement Association, and their partners have implemented extensive projects in the agricultural areas of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, primarily related to stream bank fencing, repairs to failing septic systems, establishment of riparian buffers, and improved management of manure and milkhouse waste (Figure 7-4, Figure 7-5, Figure 7-6).

Despite this effort, many more opportunities to increase the amount of stream bank vegetation, reduce barnyard runoff, and restrict livestock access still remain in these subwatersheds, and there are many more septic systems which will require repairs or upgrades to prevent them from contributing phosphorus to ground and surface water as they age (Figure 7-4, Figure 7-5, Figure 7-6, Figure 7-7).

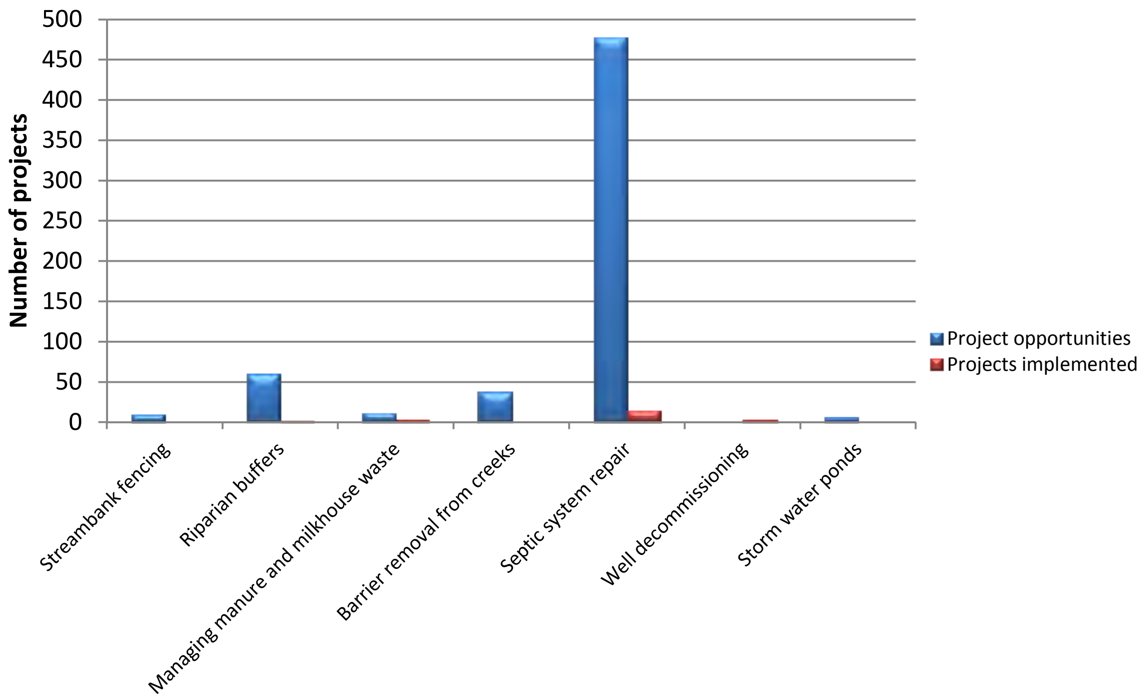


Figure 7-4: Approximate number of stewardship projects (completed by the LSRCA) and stewardship opportunities in the Oro Creeks North subwatershed.

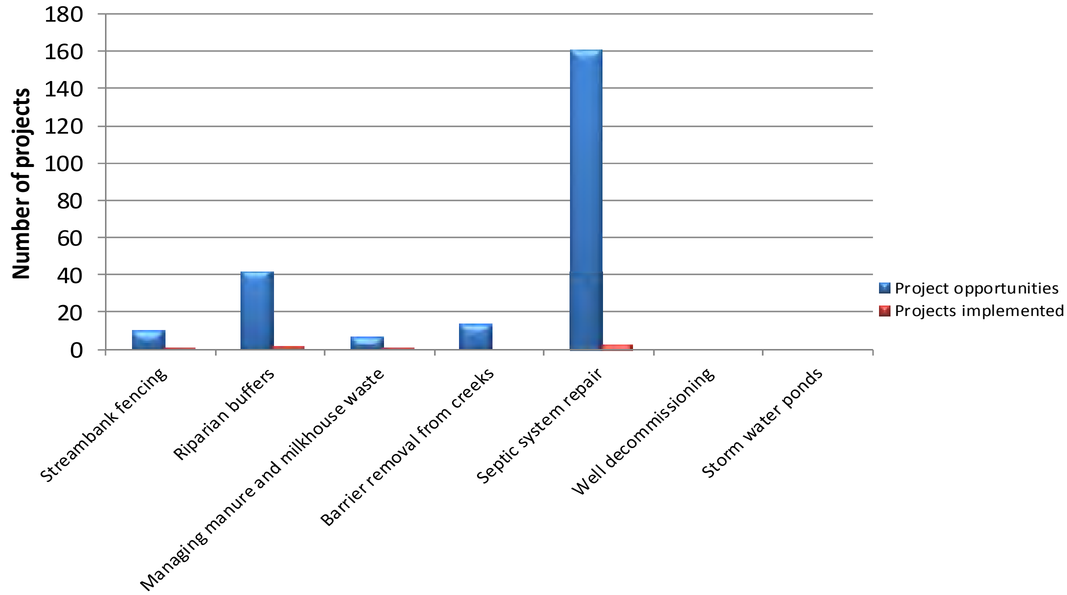


Figure 7-5: Approximate number of stewardship projects (completed by the LSRCA) and stewardship opportunities in the Hawkestone Creek subwatershed.

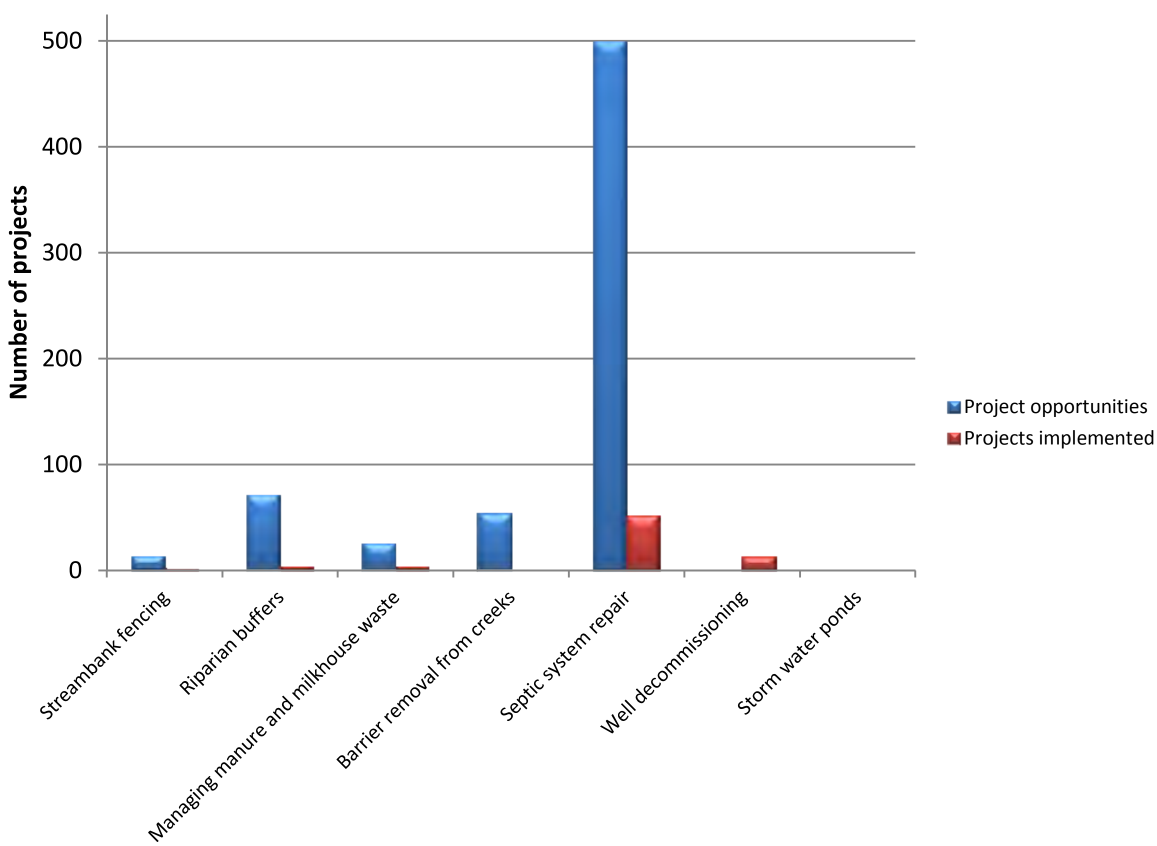
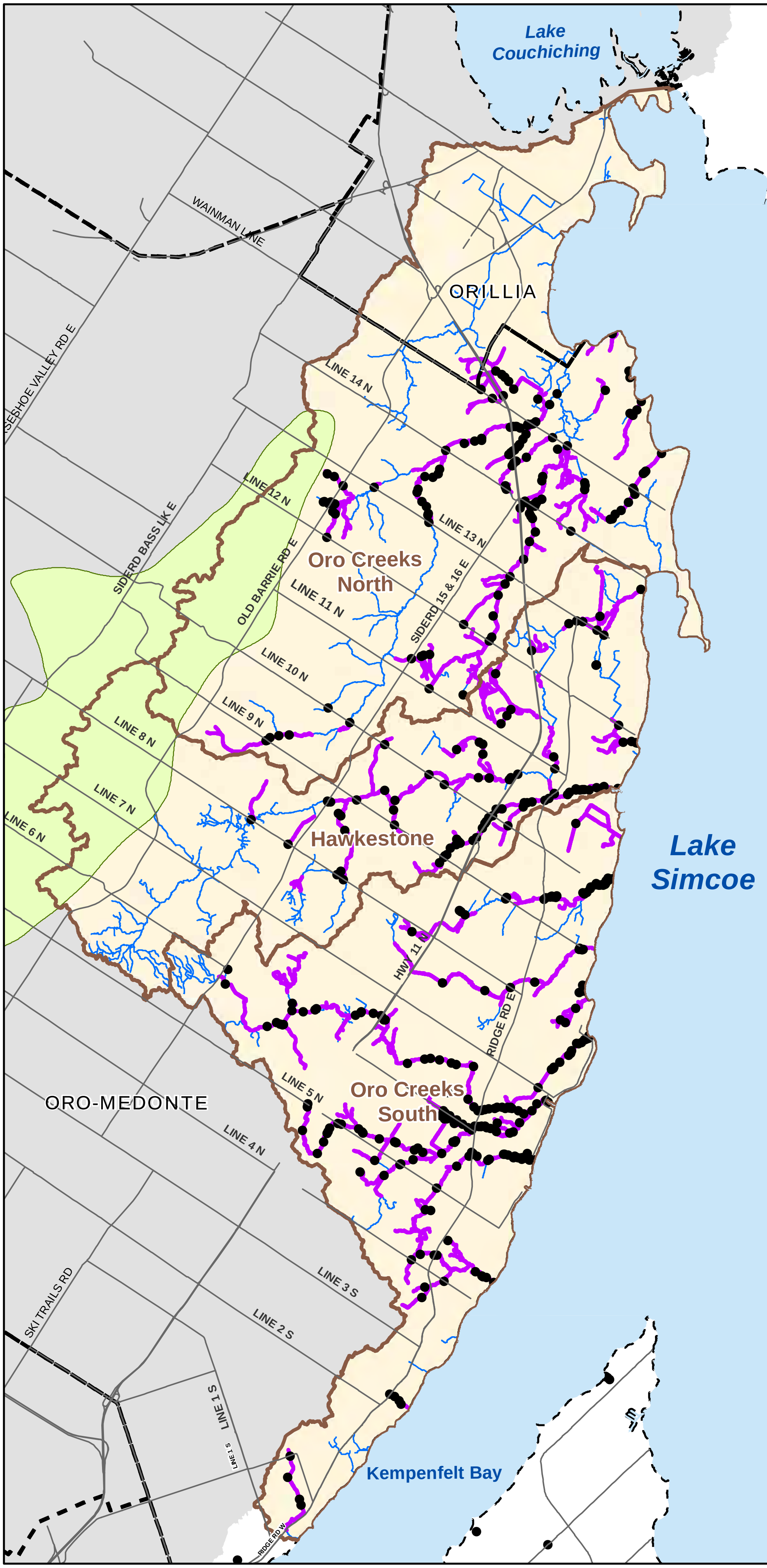


Figure 7-6: Approximate number of stewardship projects (completed by the LSRCA) and stewardship opportunities in the Oro Creeks South subwatershed.



Best Management Practices project opportunities in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds

Figure 7-4

Legend

- BMP Opportunities
- Road
- Municipal Boundary
- Watercourse
- BMP Watercourse Surveyed
- Subwatershed
- Oro Moraine

Lake Simcoe Region conservation authority

0 0.5 1 2 3 Kilometres

N E S W

7.4 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 7-8). Urban areas can generally be found in small pockets of development throughout the study area, with the largest area being the City of Orillia in the Oro Creeks North subwatershed. Urban areas, and the stormwater associated with them, have been found to be significant contributors to the phosphorus load in Lake Simcoe. The most recent phosphorus loading calculations have found the Oro Creeks North subwatershed to be the fifth largest per-hectare contributor of phosphorus to the Lake Simcoe watershed (Figure 3-10), with urban areas being thought to contribute a significant portion of this load due to the results of previous modelling works (Table 3-7).

A fair amount of urban development is expected in the City of Orillia, as well as in small pockets in the Township of Oro-Medonte; 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 an 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 7-8). 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 urban area of Orillia 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.

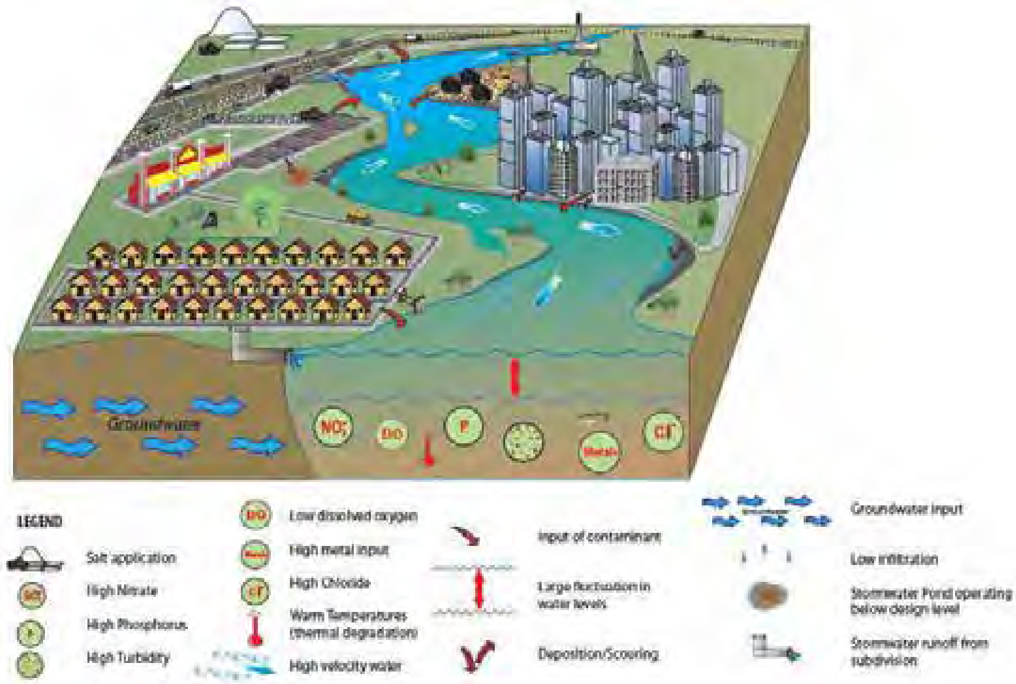


Figure 7-8: Influences of urban land use on subwatershed health

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 7-8). 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 on Hawkestone Creek and Bluffs Creek generally fall well below the guideline for chronic exposure and the Hawkestone Creek station is showing no trend in the short-term data for chloride, and the period of record for the Bluffs Creek station is not long enough to determine trends. 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 these these stations are not necessarily representative of the entire study area, due to their locations. These stations are located away from large roadways and urban areas, and may not be showing the influence of these types of land uses. For example, while salt application rates reported by the City of Orillia are generally quite low, high concentrations were detected in the City through the monitoring conducted as part of the Certificate of Approval for the Kitchener Street Waste Diversion site. A number of stations around the waste diversion site, including stations both upstream and adjacent to the site, showed high chloride concentrations; these were often attributed to highways and commercial parking lots (Golder, 2012). Additional monitoring around the study area, in a wider varity of land use type, would give us a better understanding of chloride concentrations in these subwatersheds, and could potentially identify chloride 'hot spots' that should be targeted for chloride reduction activities.

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 cold water species like brook trout (Figure 7-8).

While it is difficult to identify a particular source of nutrient enrichment, the area of dense plant growth in Carthew Bay and high sediment phosphorus levels along the Oro-Medonte shoreline (Figure 5-7) 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 7-9). 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 7-9).

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.

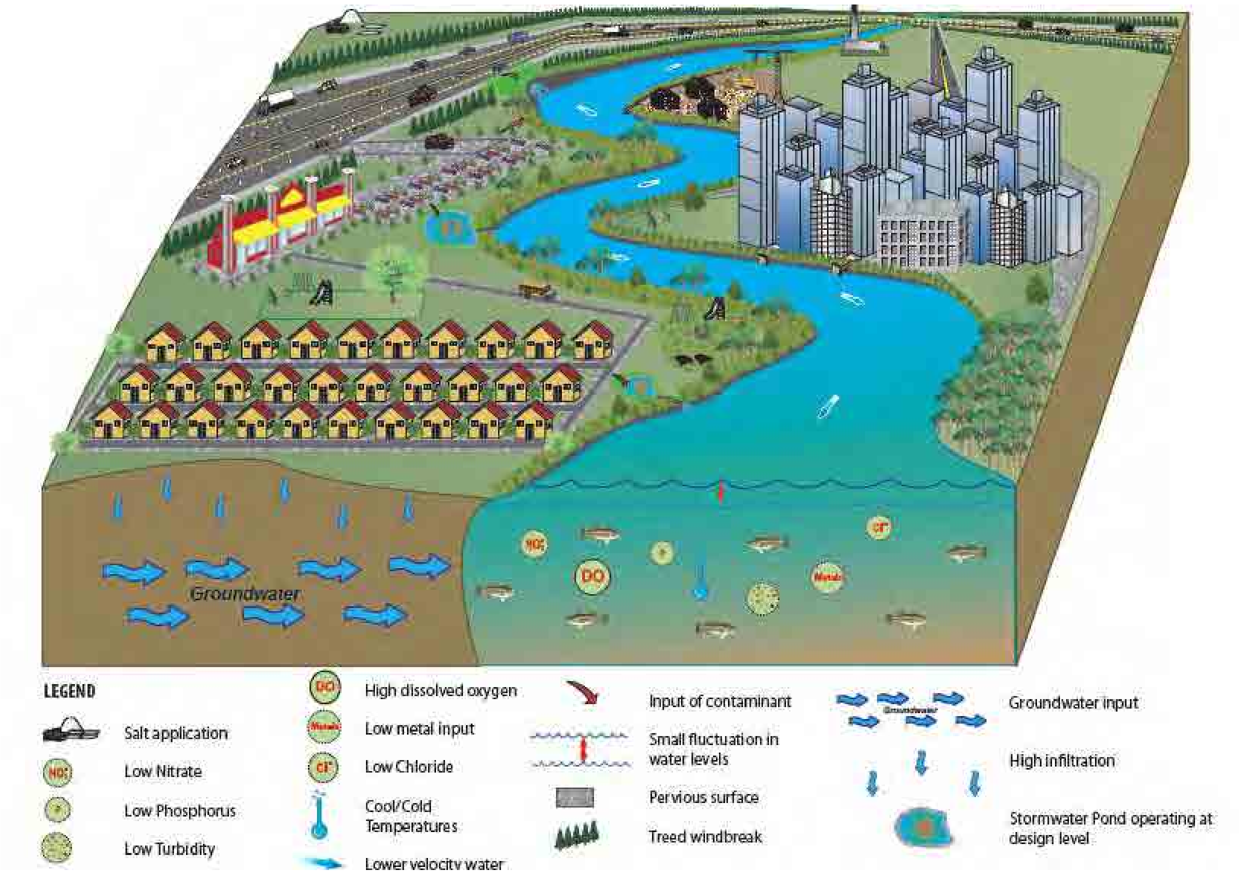


Figure 7-9: An urban landscape with appropriate best practices implemented to protect subwatershed health

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 well below their designed efficiency, and can contain sediments which have high concentrations of phosphorus, chloride, heavy metals, and petrochemicals. A survey completed in a number of the watershe'd urban areas in 2010 found that more than half of the stormwater ponds were operating below their designed efficiency, capturing less phosphorous and sediment from stormwater than intended (Figure 3-19, Figure 3-20, Figure 3-21). 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 7-8).

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 7-9). 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 these subwatershed, but there are also many opportunities to improve conditions in the urban areas, such as increasing the extent of riparian buffers and upgrading and/or retrofitting stormwater ponds (Figure 7-4, Figure 7-5, Figure 7-6, Figure 7-7, Figure 3-18).

7.5 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 preservation of 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 shading provided by vegetation along the banks, particularly for small streams like many of the tributaries in these three subwatersheds, plays an important role in reducing water temperature in mid-summer, which is a particularly important factor in providing habitat for species such as brook trout or mottled sculpin. 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 these subwatersheds, 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. These impacts can be exacerbated when the removal of vegetation is accompanied by other more extreme interventions such as bank hardening, stream channelization, 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 7-10). 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 while maintenance is occurring.

Figure 7-10: 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 7-10). It is likely the result of in-stream activities such as these, particularly the establishment of barriers along the streams, that brook trout can no longer be found throughout much of the Hawkestone Creek subwatershed. Septic systems, which support many of the rural residences in these subwatersheds, 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 on Burls Creek in recent years to improve fish habitat, reduce temperatures, and reduce phosphorus loading. Many more opportunities to remove barriers from creeks, naturalize creeks which have been channelized, or even enclosed in pipes, remain in these subwatersheds (Figure 7-4, Figure 7-5, Figure 7-6, Figure 7-7, Figure 7-11).

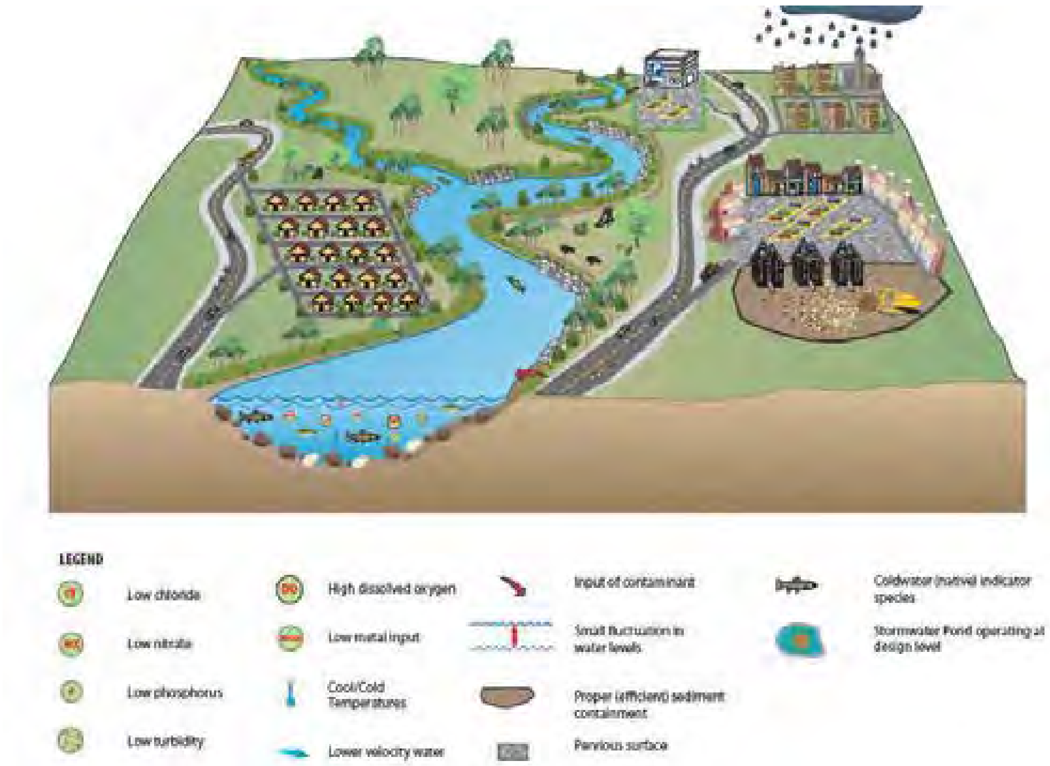


Figure 7-11: Riparian area with appropriate best practices implemented to protect subwatershed health

7.6 Shoreline interactions - activities in and near the lakeshore, water quality, and aquatic wildlife

Of particular importance to these subwatersheds is the role played by the Lake Simcoe shoreline. The shoreline along the Township of Oro-Medonte and the City of Orillia has 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 7-12). A large proportion of the the native vegetation has been removed from the shoreline in these subwatersheds, 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, this loss of vegetation is often exacerbated with 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 7-12).

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 Oro Creeks North, Hawkestone Creek, and Oro Creeks South shoreline, which represents close to 18% of the total lakeshore, has already had 77% of its length developed 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 7-13). Financial and technical support for these types of projects is provided by the MNR and LSRCA.

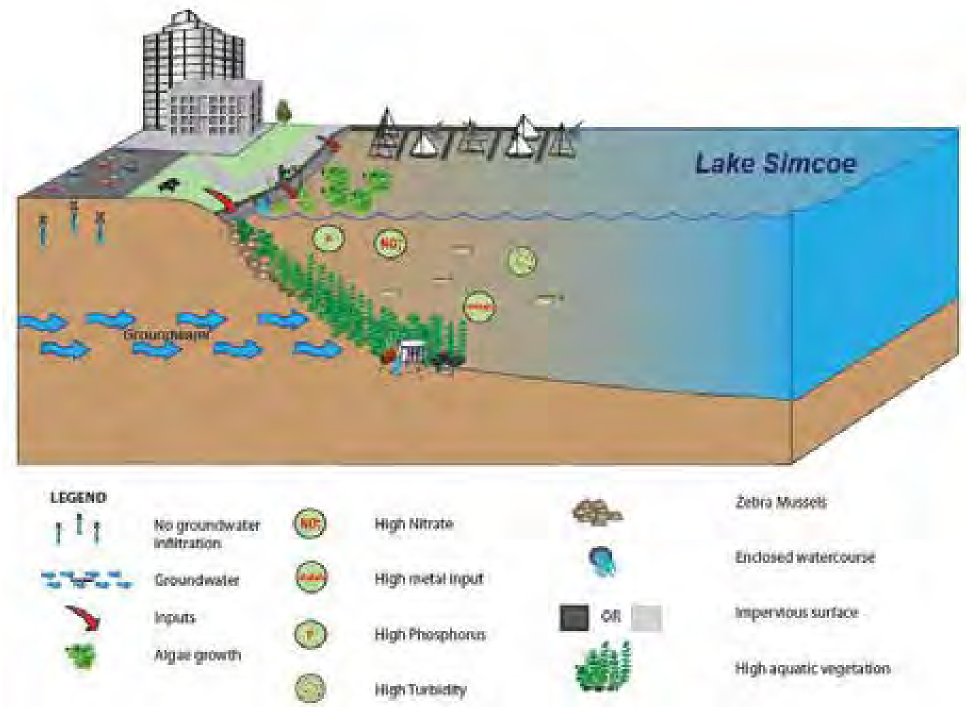


Figure 7-12: Influences of shoreline land use on subwatershed health

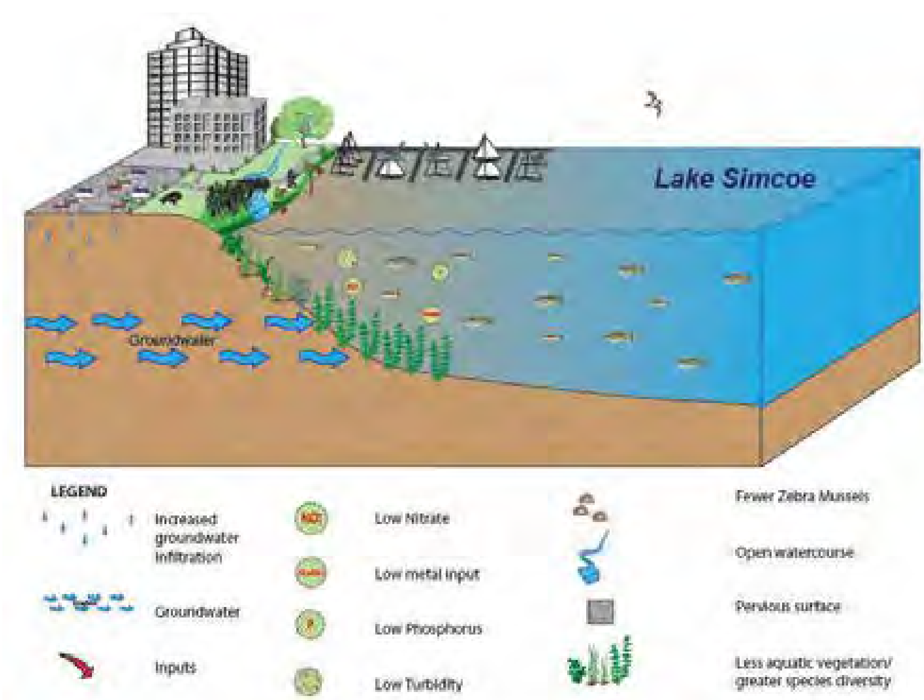


Figure 7-13: Shoreline area with appropriate best practices implemented to protect subwatershed health

7.7 Developing an implementation plan

The Oro and Hawkestone Creeks Subwatershed Plan includes an assessment of the current state of the environment in that 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 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 has been 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, which will be made up of the Township of Oro-Medonte, City of Orillia, County of Simcoe, provincial Ministries of the Environment, Natural Resources, and Agriculture and Food, as well as the Lake Simcoe Region Conservation Authority, and other relevant stakeholders. These groups, who are the primary lead agencies on the recommendations developed in this plan, 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.

8.1 Protection and Policy

8.1.1 Official Plan consistency

Recommendation 6-1 - That the LSRCA, and relevant provincial agencies assist subwatershed municipalities in ensuring official plans are consistent with the recommendations presented in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatershed plan, as approved by the LSRCA Board of Directors. This approval will be subsequent to consultation with municipalities, 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).*

8.1.2 The adaptive watershed planning process

Recommendation 8-1 – That the LSRCA 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 8-2 (3-21) - That the LSRCA, MNR and MOE analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs regularly, and that the information be used to update the LSRCA Watershed Report Card. 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 8-3 – That the LSRCA, 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 8-4 – Within five years of the completion of this subwatershed plan, that the LSRCA, in collaboration with MOE, MNR, subwatershed municipalities, and other interested and relevant stakeholders, review and update this subwatershed plan.

8.1.3 Protecting Natural Heritage

Recommendation 6-2 – That the MNR, MOE, 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 6-3 - That LSRCA, 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 6-4 – That the MNR, MAFRA, LSRCA, subwatershed municipalities, and interested members of the agricultural community review the results of the studies being conducted on methods and policy tools to protect grassland dependent wildlife on active agricultural land as they become available, to determine if they provide solutions for the conservation of grassland habitat which would be applicable for these subwatersheds.

Recommendation 6-5 – That the City of Orillia and Township of Oro-Medonte, with the assistance of the MNR and LSRCA, give consideration to including policies in their respective Official Plans to contribute to the protection of grassland habitats, as necessary, based on the results of Recommendation #6-4, and recognize the need for balance in the approach to development in urban areas.

8.1.4 Reducing impact of land use – groundwater recharge and discharge

Recommendation 4-6 – Where not already noted in their Official Plans, municipalities should generally direct development and incompatible land uses away from Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas.

Recommendation 4-7 – Where avoidance is not possible, municipalities shall only permit new development or redevelopment in significant recharge areas, where it can be demonstrated through the submission of a hydrogeological study and water balance, that the existing groundwater recharge will be maintained (i.e. there will be no net reduction in recharge).

Recommendation 4-8 - Municipalities should amend their planning documents to require the treatment of all contaminated runoff, prior to it being infiltrated. The treated runoff must meet the enhanced water quality criteria outlined in the MOE Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-9 - That municipalities incorporate the requirement for the re-use or diversion of roof top runoff (clean water diversion) from all new development in significant recharge areas away from storm sewers and infiltrated to maintain the pre-development water balance (except in locations where a hydrogeological assessment indicates that local water table is too high to support such infiltration) in their municipal engineering standards.

Recommendation 4-10 – That MOE, in the context of LSPP Policy 6.37-SA, consider adopting the 'Guidance for the protection and restoration of significant groundwater recharge area in Lake Simcoe' document, following its completion. Further, that subwatershed municipalities utilize this document to incorporate policies around significant groundwater recharge areas into their official plans, as per LSPP Policy 6.38-DP.

Recommendation 4-11 – That the MOE, in partnership with LSRCA, promote stormwater management technologies that maintain pre-development groundwater recharge conditions.

Recommendation 4-12 – That the MOE consider amending the Environmental Compliance Approvals application form and Guide to recognize the importance of protecting Ecologically Significant Groundwater Recharge Areas and Significant Groundwater Recharge Areas.

Recommendation 4-13 – Municipalities, in collaboration with the Lake Simcoe Region Conservation Authority, shall undertake an education and outreach program focusing on the importance of significant recharge areas, and the actions residents and businesses can take to maximize infiltration from impervious surfaces while minimizing contamination such as salt. Activities could include website postings, newsletter inserts in municipal mail-outs, or school outreach. Education of municipal staff in all applicable departments should also be undertaken to ensure consistent messaging within the municipality.

Recommendation 4-14 - The Lake Simcoe Region Conservation Authority should create eligibility for infiltration projects and stormwater management system retrofits under the LEAP, giving priority to those in significant groundwater recharge areas where possible.

Recommendation 4-15 - Municipalities shall collaborate with the Lake Simcoe Region Conservation Authority to promote infiltration of clean water in significant recharge areas, and prioritize stormwater retrofits utilizing water quality controls, and ultimately infiltration devices for treated stormwater runoff.

Recommendation 4-16 - The Federal and Provincial governments should consider extending programs like Lake Simcoe Clean Up Fund and Showcasing Water Innovation that make investments into stormwater management facility retrofits and infiltration projects within recharge areas.

Recommendation 4-17 – The LSRCA and other stewardship groups should undertake works to increase natural cover in SGRAs/ESGRAs.

Recommendation 4-18 – Local and county municipalities and MTO should include significant recharge areas in their assessment of areas vulnerable to road salt, and modify their Salt Management Plans and snow disposal plans as necessary. The work currently being completed by LSRCA on identifying salt vulnerable areas should be considered in these assessments.

8.1.5 Incorporating LSPP objectives in Environmental Assessments

Recommendation 6-6 – 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 6-7 – That reviewers of Environmental Assessments for municipal infrastructure in the Lake Simcoe watershed, including subwatershed municipalities, and LSRCA and MOE (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 wildlife crossing structures, and/or the use of traffic calming measures in critical locations.

8.1.6 Promoting Low Impact Development

Recommendation 3-1 - That the LSRCA work with MOE to develop an action plan to address barriers to the implementation of LID technologies in the subwatershed, using the previously developed LID discussion paper.

8.1.7 Improving stormwater management

Recommendation 3-2 - That the subwatershed municipalities, with the assistance of the LSRCA, promote the increased use of innovative solutions to address stormwater management and retrofits, particularly in areas lacking adequate stormwater controls, and lacking conventional retrofit opportunities, such as:

- the use of soakaway pits, infiltration galleries, permeable pavement (where appropriate), and other LID solutions, where conditions permit;
- enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls;
- improving or restoring vegetation in riparian areas;
- installation of rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways; and
- the on-going inventory, installation, and proper maintenance of oil grit/hydrodynamic separators combined with the use of technologies to enhance their effectiveness where appropriate.

Recommendation 3-6 - That Official Plans be amended to contain policies that would help minimize impervious surface cover in the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds through requirements such as using low impact development solutions, limiting impervious surface areas on new development, and/or providing stormwater rates rebates and incentives to residential and non-residential property owners demonstrating best practices for managing stormwater.

Recommendation 3-7 - That the Township of Oro-Medonte manage ditch run-off from the municipal roads that end at the Lake Simcoe shoreline 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 lake.

8.1.8 Managing thermal degradation

Recommendation 3-17 – That, as new or retrofit stormwater facilities are constructed, LSRCA work with subwatershed municipalities to reduce potential thermal impacts of those stormwater ponds and to recognize the importance of LID uptake in relation to maintaining stream temperature.

8.1.9 Improving construction practices

Recommendation 3-8 - That the LSRCA and watershed municipalities promote and encourage the adoption of best management practices to address sediment 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 3-9 - That subwatershed municipalities 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 3-10 – That the municipalities undertake a review of current tree cutting by-laws to ensure that they conform with 'good forestry practices' as described in the Ontario Woodlot Association's by-law template.

8.1.10 Land securement by public agencies

Recommendation 6-8 – 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.

Recommendation 6-9 – That the LSRCA and subwatershed municipalities, with the assistance of the MNR, 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 6-10 – That the Federal, Provincial, and Municipal governments provide consistent and sustainable funding to support securement of notable natural areas.

8.2 Restoration and remediation

8.2.1 Improving stormwater management

Recommendation 3-3 - That the Province of Ontario, through the implementation of initiatives including the stormwater policies contained in the LSPP, Showcasing Water Innovation, and the Great Lakes Protection Act, be encouraged to support, through financial or other measures, municipalities and/or the LSRCA to design, maintain (where appropriate), and /or retrofit stormwater facilities as identified by the LSRCA Stormwater Rehabilitation program.

Recommendation 3-4 - Given the high rate of phosphorus loading per hectare in the Oro Creeks North subwatershed, that the MNR, MOE, and LSRCA make the Oro Creeks North subwatershed a priority for stewardship projects intended to reduce phosphorus loading. Further, that the

City of Orillia make stormwater retrofits and the use of LID solutions in the Oro Creeks North subwatershed a priority, due to their significant potential to reduce phosphorus loading.

Recommendation 3-5 - That the subwatershed municipalities routinely monitor and maintain the design level of stormwater facilities. In addition to maintaining design level, criteria for maintenance should also include frequency and exposure to spills and other contaminant sources.

8.2.2 Managing agricultural impacts

Recommendation 3-15 - That the subwatershed municipalities, through the LSRCA, create a roundtable made up of municipalities, LSRCA, MOE, MNR, MAF, agricultural groups, NGOs, and related landowner representatives, or through the expansion of existing frameworks such as the Lake Simcoe Stewardship Network or the Water Quality Trading Working Group, to determine co-operative ways of implementing phosphorus reduction and improved water quality measures in Oro North, Hawkestone, and Oro South Creeks, and to develop an 'action plan' for their implementation within the agricultural and rural communities.

Recommendation 5-10 – That LSRCA work with the municipalities and OMAF to examine innovative forms of municipal drain maintenance, or opportunities to create new drains using principles of natural channel design. Look for opportunities to decommission when the land use changes, removing the need for their use. These projects would need to ensure that there are no consequences for neighbouring properties on the same drain, or that any potential issues could be mitigated.

8.2.3 Dealing with indirect impacts to natural areas

Recommendation 6-19 – That the County of Simcoe, City of Orillia, and Township of Oro-Medonte, with assistance of MNR and LSRCA, conduct natural heritage inventories, and develop and implement management plans for publicly accessible natural areas that they own, to mitigate potential threats related to invasive species and increased recreation pressure.

Recommendation 6-20 – That the MNR and its partners provide outreach to garden centres, landscapers, and garden clubs regarding the danger of using invasive species in ornamental gardens.

Recommendation 6-21 – That the City of Orillia, the Township of Oro-Medonte and the County of Simcoe, with support from LSRCA, 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 6-22 – That the City of Orillia and Township of Oro-Medonte give preference to native species when selecting trees to be planted in boulevards, parks, and other municipal lands, recognizing that Orillia does give such preference in the policies for their Downtown planning designation.

8.2.4 Increasing uptake of stewardship programs

Recommendation 5-1 (6-11) – That the MNR, MOE, MAFRA, and LSRCA 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.

Recommendation 5-2 (6-12) – 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 5-3 (6-14) – That MOE, MNR, LSRCA and other members of the Lake Simcoe Stewardship Network 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 the have completed and encourage others to do the same.

Recommendation 5-4 (6-13) – 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 5-5 (6-15) – The MOE, MNR, OMAFRA, LSRCA and other interested members of the Lake Simcoe Stewardship Network support research to determine barriers limiting uptake of stewardship programs in these subwatersheds, 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 5-6 (6-16) – The MOE, MNR, OMAFRA and LSRCA 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.

8.2.5 Prioritizing stewardship projects

Recommendation 6-17 – That the MNR, with the assistance of the MOE and LSRCA, use their draft 'Delineation of Priority Areas for Restoration' report to develop a spatially-explicit decision support tool to assist in targeting terrestrial stewardship projects in the Lake Simcoe watershed. In the context of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, this decision tool should take into account factors including:

- The need to increase the extent of natural shoreline Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds
- Protecting and restoring significant groundwater recharge areas and ecologically significant groundwater recharge areas, to help mitigate the expected impacts of climate change
- The need to protect and restore grassland habitat, particularly rare native grasslands
- Opportunities to enhance resilience to climate change
- The need to reduce phosphorus loadings to the tributaries in these subwatersheds.

Recommendation 5-7 – The LSRCA, in collaboration with MNR and MOE, should develop a spatially-explicit prioritization tool to assist in targeting stewardship aquatic habitat projects in the Lake Simcoe watershed. In the context of the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds, this prioritization tool should take into account:

- The need to incorporate each major type of aquatic habitat stressor including bank hardening, barriers, riparian cover and on-line ponds;
- Use of best available datasets to identify potential restoration sites, including LSRCA BMP inventory and riparian assessment;
- Expected improvements to aquatic habitat and therefore fish and benthic community condition, including improved water temperature, increase connectivity for movement within and between tributaries, and shelter.
- The relative cost of implementing projects in urban, urbanizing and agricultural areas, particularly with respect to the cost of implementing retrofit projects in the relatively heavily urbanized City of Orillia

Recommendation 5-8 – Prioritized restoration areas be integrated 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 5-1 through 5-6.

Recommendation 3-16 - That the spatially-explicit tool described in Recommendations 5-7 and 5-8 (**Chapter 5 – Aquatic Habitat**) and the terrestrial prioritization tool described in Recommendation 6-17, be used to prioritize allocation of 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.

8.2.6 Reducing salt use

Recommendation 3-13 - That the LSRCA, in collaboration with subwatershed municipalities, deliver a salt education and certification program, to increase awareness and understanding of the importance of salt management by snow removal contractors, property managers, and the general public.

Recommendation 3-14 - Recognizing that increasing concentrations of chloride in watercourses is an emerging issue shared by all municipalities in the Lake Simcoe watershed, that the watershed municipalities, academia, LSRCA, MOE, MTO and MNR form a Salt Working Group, or utilize an existing group such as the Simcoe County Road Superintendents, as a mechanism to share information on best practices for salt application, methods of increasing public awareness of the environmental impacts of road salt, and the effectiveness of municipal Salt Management Plans.

8.3 Applied science

8.3.1 Reducing salt use

Recommendation 3-11 - That the LSRCA, with the support of subwatershed municipalities, develop a program to determine relative contribution of chloride from road salt application (e.g. how much is coming from roads vs. parking lots, etc.), establish baseline indicators, and examine the effectiveness of current protocols on salt storage, application, and disposal, as outlined in their respective Salt Management Plans, adapting them as necessary.

Recommendation 3-12 - That the LSRCA, with the support of subwatershed municipalities, identify areas within the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds which are vulnerable to road salt, such as Lake Simcoe and the watercourses flowing through the study area's urban areas (as outlined by Environment Canada). 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, once identified.

8.3.2 Establishing instream flow targets

Recommendation 4-2 - That the MNR and MOE, in partnership with LSRCA, develop a more detailed surface water budget for the Oro Creeks North, Hawkestone Creek, and Oro Creeks South subwatersheds that will provide the basis of actions needed to determine ecological (instream) flow targets.

Recommendation 4-3 (5-9) – That the MOE, with the assistance of MNR and LSRCA, determine if the Oro Creeks South, Oro Creeks North, and Hawkestone Creeks subwatershed are water quantity stressed and require the development of in-stream flow targets.

Recommendation 4-4 – That the MOE Director consider sensitive hydrogeologic and hydrologic features (e.g. SGRAs, and ESGRAs that support wetlands and coldwater reaches) identified in the Oro and Hawkestone Creeks subwatershed plan, in the review of Permit to Take Water applications.

Recommendation 4-5 – That the issue of 'mobile' water takers (e.g. water trucks) be assessed and that the MOE, in order to minimize the potential impact of these activities on aquatic biota, ensure that permits are being obtained, where required; that permit limits are being adhered to; and finally that permitted takings from individual watercourses are sustainable.

8.3.3 Increasing our understanding of climate change

Recommendation 3-18 (4-21) – That the LSRCA work with its 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 other BMP implementation in conjunction with the protection of current hydrologic functions and water conservation initiatives and practices.

Recommendation 6-18 – 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 4-19 – That the LSRCA, in collaboration with the MNR and MOE, utilize the recently developed, fully integrated groundwater and surface water model to predict how stream flow volumes will respond to the seasonal and ecological impacts of climate change, in terms of increased peak flows, reduced baseflows, and increased water demand. This information will be used in the development of in-stream flow targets and the development of management strategies to address climate change impacts.

8.3.4 Monitoring and assessment

Recommendation 3-19 - That the LSRCA enhance the existing monitoring network, through the comprehensive monitoring strategy, to address identified limitations and gaps of the current monitoring program. Review of potential enhancements should consider:

- 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
- Establishing new monitoring stations
- Monitoring additional parameters that are key indicators of ecosystem health and restoration progress such as brook trout spawning.

Recommendation 3-22 - That the LSRCA, in collaboration with MNR, MOE, and MAF, 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 6-23 – That the MNR, with the assistance of LSRCA and MOE, complement the proposed monitoring strategy with standardized surveys of the distribution and abundance of terrestrial species at risk throughout the Lake Simcoe watershed.

Recommendation 6-24 – That the MNR, LSRCA, and MAFRA continue to maintain an up-to-date seamless land cover map for the watershed, as defined by the LSPP, with natural heritage features classified using Ecological Land Classification, managed in such a way as to allow change analysis.

Recommendation 6-25 – That the MNR 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 6-26 – That the MNR, 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.

8.3.5 Improving data management

Recommendation 4-1 - That the MOE be encouraged to 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 6-27 (3-20) – That the MNR, LSRCA, and MOE 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.

8.3.6 Additional research needs

Recommendation 5-11 – That LSRCA, with support from Municipalities, the Province, and local volunteers, undertake a baseline assessment of brook trout spawning areas and from this develop an annual monitoring program to continually assess the LSPP aquatic habitat indicator of natural reproduction and survival of aquatic communities.

Recommendation 5-12 – That LSRCA explore potential reasons for the decline in brook trout populations, particularly in Hawkestone Creek. This will include an investigation of the areas offshore of the mouths of the subject subwatersheds, particularly the shoal off of Hawkestone Creek, to determine how these areas are being used and whether changing conditions in these areas are affecting these uses.

Recommendation 5-13 – That LSRCA, with support from Municipalities and the Province, aim for improved spatial and temporal resolution in annual monitoring of aquatic habitat, including water quality, fish and benthic indicators.

Recommendation 6-28 – That the Lake Simcoe Science Committee, other levels of government, and academia support research to better understand the stresses to wildlife and wildlife habitat associated with urban development, to allow management responses to be refined. Important questions of interest include: the use of stormwater ponds as amphibian breeding habitat, the importance of remnant natural areas to quality of life for local residents, the indirect impacts of roads on resident and migratory wildlife, and the impacts of high density and low density development on wildlife communities in natural areas. This research may include literature reviews, analysis of data available through the monitoring program, or original, innovative, peer-reviewed research.

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