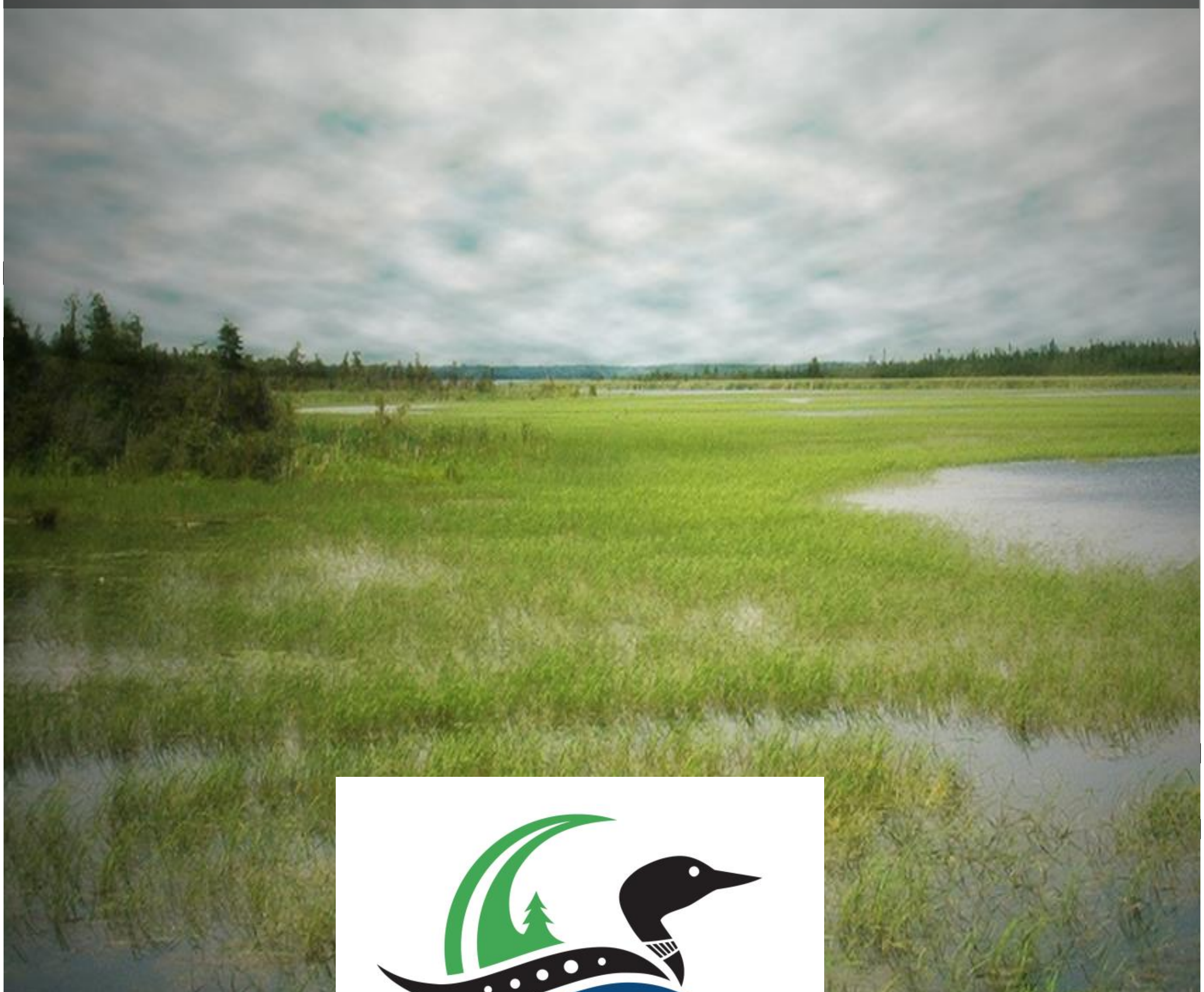
Balsam and Cameron Lakes Watershed Characterization Report

2015



KAWARTHA CONSERVATION

Discover · Protect · Restore

About Kawartha Conservation

A plentiful supply of clean water is a key component of our natural infrastructure. Our surface and groundwater resources supply our drinking water, maintain property values, sustain agricultural and support tourism.

Kawartha Conservation is the local environmental agency through which we protect our water and other natural resources. Our mandate is to ensure the conservation, restoration and responsible management of water, land and natural habitats. We do this through programs and services that balance human, environmental and economic needs.

We are a non-profit environmental organization, established in 1979 under the Ontario *Conservation Authorities Act* (1946). We are governed by the six municipalities that overlap the natural boundaries of our watershed and voted to form the Kawartha Region Conservation Authority. These municipalities are the City of Kawartha Lakes, Township of Scugog (Region of Durham), Township of Brock (Region of Durham), the Municipality of Clarington (Region of Durham), Cavan Monaghan, and the Municipality of Trent Lakes.

Acknowledgements

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Table of Contents

List of Tables

List of Figures

Abbreviations

CKL: City of Kawartha Lakes

CWQG: Canadian Water Quality Guideline

EC: Environment Canada

ELC: Ecological Land Classification

KLSA: Kawartha Lake Stewards Association

KPOW: Kawartha Protect Our Water

m.a.s.l.: Meters above sea level

MNR: Ontario Ministry of Natural Resources and Forestry

MOE: Ontario Ministry of the Environment and Climate Change

PGMN: Provincial Groundwater Monitoring Network

PWQMN: Provincial Water Quality Monitoring Network

PWQO: Provincial Water Quality Objectives

SLMP: Sturgeon Lake Management Plan

TKN: Total Kjeldahl Nitrogen

TP: Total Phosphorus

TSS: Total Suspended Solids

TSW: Trent Severn Waterway

WSC: Water Survey Canada

Executive Summary

The three-year monitoring and scientific studies undertaken in the Balsam and Cameron lakes watershed were designed to collect comprehensive and up-to-the-date hydrological, chemical, meteorological and biological data. Those data provide information necessary to define current and potential issues in the study area, and to make informed conclusions about the current state of both lakes and the corresponding watershed.

The physiographic regions surrounding Balsam and Cameron lakes include the Carden Plain, Dummer Moraine and Peterborough Drumlin Field. The north shore of Balsam Lake is represented as Carden Plain. This area can be characterized as an alvar, which are considered a provincially significant feature. The eastern part of the Cameron Lake subwatershed is represented by Dummer Moraine. The southern portion of the study area is occupied by Peterborough Drumlin Field.

The major soil types in the watershed include the sandy loams and loams represented by the Otonabee Loam and Dummer Loam. The Otonabee soils are found to the south and east of Balsam Lake, extending around Cameron Lake to just north of Fenelon Falls, while the Dummer soils are located in the northern part of the watershed.

The watershed is characterized by a good mix of different land uses. Agricultural lands occupy 42% of the watershed area. The majority of them are found in the southern portion of the watershed. With increasing farmland values and cash crop returns, there is a trend to clear more land for agriculture.

Only 0.33% of the watershed land area is occupied by urban development, but 49.7% of the Balsam Lake shoreline and 44.9% of the Cameron Lake shoreline is developed.

There is more natural cover (and it is in better condition) in the northern part of the Balsam and Cameron lakes watershed than in the southern portion of the study area. The northern part has less development and less agriculture in comparison with the southern part. Forests cover 22% of the study area, with that amount being below the recommended guideline of a minimum of 30%. However, if treed wetlands are included into forest cover category, it exceeds 30% guideline and reaches 38%. Interior forest and deep interior forest is below guidelines for the entire study area.

Wetlands and treed wetlands occupy 20% of the study area, double the recommended guideline of 10%. Wetlands alone occupy 4.3% of the watershed with the majority being swamp-type wetlands. Abundant wetlands provide significant benefits for the surface water, moderating stream flow, providing high and low flow mitigation and assisting in groundwater recharge.

The climate of the Balsam and Cameron lakes watershed is described as moist continental, mid-latitude. It is characterized by warm summers with occasional hot and humid spells, and cold winters with snowstorms, strong winds and cold air from Continental Polar or Arctic air masses. Precipitation is equally distributed throughout the year. Climate conditions are currently projected to change as a result of the global climate change process. Change in climate can bring changes to the lake ecosystems that require advance preparation and planning.

The water level regime of Balsam and Cameron lakes generally follows the natural pattern, but is regulated in accordance with the Trent-Severn Waterway management strategy.

The southern, unregulated tributaries of Balsam and Cameron lakes exhibit a natural flow regime with well-defined seasonal flow patterns. High flows typically occur in spring, associated with snowmelt, and throughout the year following high-volume precipitation events. Low flows are typically observed in the summer and winter months.

The Gull River, one of the two large northern tributaries, flows via numerous regulated lakes and is highly regulated for the purposes of the TSW navigation system. It still maintains a seasonal flow pattern with the highest flow in spring, and low flow periods during the summer and winter months. The Burnt River follows the same pattern.

Water quality monitoring determined that both Balsam and Cameron lakes can be characterized as oligotrophic water bodies with good water quality, but with room for improvement. Both lakes are currently on the verge between the oligotrophic and mesotrophic categories.

While average phosphorus concentrations in Cameron Lake are around 0.01 mg/L, in summer months the lake has occasionally elevated phosphorus levels. These can exceed the Provincial Water Quality Objective (0.01 mg/L) and reach as high as 0.024-0.031 mg/L. At these levels, blue-green algae blooms and excessive aquatic plant growth can be stimulated. Average phosphorus concentrations in Balsam Lake are usually around 0.007-0.009 mg/L, while the highest observed readings are 0.011-0.014 mg/L. Nitrogen concentrations in the water of both lakes fluctuate within a lower range, mostly below 0.5 mg/L.

Pearns Creek, Martin Creek South and Staples River, small southern tributaries, quite often have elevated phosphorus levels as a result of human activities in the corresponding subwatersheds. Pearns Creek exhibited the highest levels of phosphorus throughout the monitoring period.

Nitrogen concentrations were also occasionally elevated in the southern tributaries. While nitrate concentrations in these streams are very low and far below the guideline, levels of total Kjeldahl nitrogen (and as a result, total nitrogen concentrations) are sometimes quite high during summer. For example, total nitrogen concentrations observed in Martin Creek South were measured at 1.76 mg/L in June 2013.

E.coli monitoring results have revealed that monitored streams in the watershed quite often have E.coli levels above the Provincial Water Quality Objective (100 cfu/100 mL). The number of exceedences can be up to 25-43% of all samples collected annually. The Staples River has had elevated E.coli concentrations the most often.

Elevated E.coli levels in excess of the provincial objective have been often observed at the Bond Street beach in Fenelon Falls and at the Lions Park beach in Coboconk. As a result, these two beaches have been frequently posted every year since 2011.

The phosphorus and nitrogen balances were separately calculated for Balsam Lake and Cameron Lake for three hydrological years (2011-2012, 2012-2013 and 2013-2014). The average total annual phosphorus input into Balsam Lake is 8,303 kg. The average annual total phosphorus (TP) amount retained in the lake (net loading) is 2,635 kg. The average total annual phosphorus input into Cameron Lake is 16,368 kg. The average annual TP amount retained in the lake is 2,151 kg.

The most significant anthropogenic sources of phosphorus found in Balsam and Cameron lakes include urban runoff (Fenelon Falls and small urban areas along the shoreline) and septic systems around the lakes. Phosphorus loading from septic systems within 75 m around the lakes was estimated at 1,214 kg annually (851 kg into Balsam Lake and 363 kg into Cameron Lake). Septic systems generate 6.1 % of total phosphorus load, but account for 42.5% of phosphorus that is entering the lakes from local sources. The average annual urban TP loading into both lakes was 374 kg or 1.9% of total load (222 kg into Balsam Lake and 152 kg into Cameron Lake) over the three-year period.

The average annual nitrogen input into Balsam Lake is 299,365 kg and into Cameron Lake it is 527,960 kg. The majority of nitrogen is entering the lakes with the river flow from outside the watershed: 297,453 kg (46.9%) from the Burnt River, 218,991 kg (34.5%) from the Gull River and 8,031 kg (1.3%) from Corben Creek.

Cameron Lake's average annual nitrogen export into Sturgeon Lake is 485,644 kg. The average annual nitrogen net loading in Balsam Lake is 76,401 kg or 26% of the total loading, and in Cameron Lake it is 42,316 kg or 8% of the total loading.

Balsam and Cameron lakes support diverse, cool/warm water fish communities. Thirty fish species have been documented within the lakes, and 22 fish species have been documented in lake tributaries. Most of these fish species are common throughout the warm/cool waters of the Kawartha Lakes. Over the years, the fish community structure in the lakes has become increasingly complex due to intentional stocking, range extensions, unintentional introductions and non-native species invasions. A coldwater fish species, lake herring, has been documented in the past in the deep basins of both lakes. There are no known fish species of conservation concern.

Tributaries draining directly into the lakes provide spawning habitat for important migratory lake-dwelling fish species such as walleye, muskellunge, and white sucker. The lower reaches of the Staples River, Pearns Creek, Martin Creek South and Hannivan's Creek are known to provide significant spawning habitat for lake-resident muskellunge. The dams located at Rosedale, Coboconk and Fenelon Falls act as physical barriers that limit migratory routes and other ecological pathways. The lock and canal system, however, does facilitate the movement of aquatic life between lakes.

Nearshore areas provide important habitat for lake-dwelling fishes. Shallow nearshore areas (<3 meters in depth) are extremely productive for fishes, and are utilized by many fish including important top predator species such as muskellunge and walleye for spawning and feeding. Balsam Lake and Cameron Lake have a relatively narrow width of nearshore area compared to most other Kawartha Lakes, the majority of which are located adjacent to shorelines and in the bays at the outlets of major tributaries. The low natural productivity of Balsam Lake and Cameron Lake makes these nearshore areas especially important in supporting the aquatic ecosystem.

Balsam and Cameron lakes have been exposed to a variety of non-native aquatic species, including common carp, bluegill, black crappie, zebra mussels and eurasian watermilfoil. The recreational corridor of the Trent-Severn Waterway facilitates the expansion of these species throughout the system. There are other non-native species that are at immediate risk of becoming established, for example, yellow flag iris or round goby. The non-native northern pike in particular have been proliferating recently, most likely to the detriment of native muskellunge.

Approximately half of the shoreline on both lakes has been developed within a 30 m distance from shore. Much of this area has been hardened with concrete, armour stone and other non-natural materials, which reduce aquatic habitat potential and isolate land from water.

In most small-to-medium sized lake tributaries, existing natural riparian land cover (72%) is close to minimum recommended guidelines of 75% to maintain ecological integrity. Studies of existing benthic macroinvertebrate communities indicate a certain degree of stream habitat degradation, as almost half of all sampled sites show biological impairment. Riparian cover loss is largely due to conversion of lands with natural cover for agricultural activities.

In many of the Kawartha Lakes, the walleye population has shown a considerable decline since 1998. This was largely attributed to changes to their aquatic ecosystem that have favoured other fish species (e.g., bass).

Walleye populations within Balsam Lake and Cameron Lake have remained relatively stable during this same time period.

In conclusion, it can be said that the results of the research and monitoring programs undertaken during the 2011-2014 period revealed that Cameron Lake’s water quality, environmental health and ecological state are generally in good condition. The lake, nevertheless, needs a long-term management strategy to address current issues, prevent potential ones and maintain/improve the environmental sustainability of the lake’s aquatic ecosystem. A considerable amount of phosphorus and nitrogen is retained in the lake every year that contributes to the process of eutrophication. In order to decrease phosphorus accumulation in the lake, it is necessary to reduce phosphorus loading from several major sources of primarily human origin.

Water quality in Balsam Lake is even better than in Cameron Lake. The lake also has healthy aquatic life and sizeable areas of natural cover across the watershed. Although there are currently no issues with phosphorus or nitrogen concentrations and loading amounts in the lake, the development and implementation of a comprehensive lake management plan is necessary to ensure long-term sustainability of the lake’s water quality as increasing development along the lake shoreline can result in future impacts for the lake’s aquatic ecosystem.

In addition to phosphorus and nitrogen, several other issues require attention as priorities during the Balsam and Cameron Lake Management Plan implementation. They include elevated E.coli concentrations at public beaches, modified and hardened shorelines, lack of vegetated buffers along streams and shorelines, presence of exotic species in the lakes, and increasing shoreline and back lot development.

1.0 Introduction

1.1 Project History

Balsam Lake is one of the jewels of the Kawartha Region and its growing tourism industry. For most of the 20th century, the lake served as a vacation destination for residents of southern Ontario and the Greater Toronto Area (GTA). The same can be said about Cameron Lake, which is a much smaller water body located between Balsam Lake (upstream) and Sturgeon Lake (downstream). Over time, these lakes have transitioned from seasonal havens into year-round residential areas. Currently, Balsam and Cameron lakes support many aspects of the local economy in the City of Kawartha Lakes. For example, the shoreline residences and small lakeside communities support many local businesses including landscaping, home renovation and property management, as well as commercial enterprises in the Fenelon Falls, Rosedale and Coboconk areas.

Balsam and Cameron lakes currently have good water quality and environmental conditions. This state should be preserved and maintained. In order to create the framework for the continuous management of the lakes, Kawartha Conservation and the City of Kawartha Lakes initiated the development of the Balsam and Cameron Lake Management Plan (BCLMP) as the second phase of the watershed-wide lake management initiative.

The first phase of watershed-wide lake management planning in the City of Kawartha Lakes was initiated in 2010. That year, Kawartha Conservation and the City of Kawartha Lakes, recognizing the importance of the environmental health of Sturgeon Lake, and with support from multiple citizen groups and partner organizations, commenced the Sturgeon Lake Management Plan (SLMP).

During the first three years of developing a plan, the study team identifies sources of contamination, measures the amounts of phosphorus and nitrogen entering lakes, and determines other ecological problems and issues in the watersheds. Based on the results, a practical program is established, with community input, to implement rehabilitation measures intended to maintain and improve water quality and watershed health.

The Balsam and Cameron lakes watershed is comprised of the entire area of land around the lakes that is drained by their tributaries. It includes small streams such as Pearns Creek and Staples River, and large rivers such as the Burnt River and Gull River. The watersheds of the Burnt River and Gull River cover a significant area extending well to the north, far beyond Kawartha Conservation's jurisdiction. This Watershed Characterization Report is therefore an overview of the current state of the aquatic and terrestrial ecosystems within the Balsam and Cameron lakes core watershed area that falls under the jurisdiction of Kawartha Conservation. It includes information on geology and physiography, climate and hydrology, terrestrial and aquatic ecology, land use and economic activities within the watershed, as well as characterization of the current water quality in the lakes and their tributaries.

This report provides the findings from our scientific research and environmental monitoring for the three-year period from June 2011 to May 2014. Additionally, it includes information and data from previous studies dating back to the 1970s and 1980s. E.coli data collected by members of the Kawartha Lakes Stewards Association and Balsam Lake Association were also used.

Based on our findings, we identified a number of areas of interest in the Balsam and Cameron lakes watershed that require close attention and high priority status through recommended management actions. These areas include the Fenelon Falls urban area, agricultural areas south of the lakes within the Pearns Creek, Martin Creek

South and Staples River subwatersheds, as well as shoreline residential areas and private septic systems around the lakes.

Continuous and comprehensive environmental monitoring is essential to achieving the main goal and objectives of the Balsam and Cameron Lake Management Plan. The information we gather will help us understand the issues and stressors affecting the lakes, provide an overview of watershed health, and develop effective recommendations for protecting and enhancing the lakes' environmental health in the short- and long-terms.

1.2 Project Goal and Objectives

The lake studies were initiated to characterize the current environmental health of Balsam and Cameron lakes and their surrounding watershed, identify problems and issues, consider how to more effectively plan for ongoing development pressures, and to determine the sources and amounts of phosphorus and nitrogen entering the lakes. These two primary nutrients are the only currently known contaminants of concern in the study area. They are entering some local water bodies in excessive amounts as a result of human activities and can accelerate the process of eutrophication in the lakes and their tributaries. This process can lead to over-abundant aquatic vegetation and increased occurrences of blue-green algae blooms. These cause unpleasant recreational and aesthetic conditions for people around the lakes, and can affect drinking water supplies in some communities.

The main goal of the lake management planning project is to ensure the long-term environmental and socio-economic sustainability of Balsam and Cameron lakes by:

- Identifying key environmental impacts and management issues;
- Setting priorities for management actions to maintain and improve water quality in the lakes;
- Increasing the environmental and socio-economical values of the lakes;
- Maintaining healthy aquatic and terrestrial ecosystems within the watershed;, and
- Protecting Cameron Lake as a primary source of drinking water for residents of Fenelon Falls.

In order to maintain and, where necessary, improve the current condition of the lakes, all areas of future urban growth within the watershed must meet the highest environmental standards for new developments. This will require a range of best management practices to be applied to both urban and agricultural land uses. Without informed management actions, we may experience escalating problems including more frequent public beach closures, stream degradation and habitat loss. Correspondingly, negative impacts may be observed upon fishery, recreational and tourism industries. Moreover, deteriorating water quality may lead to increased costs associated with drinking water treatment. It is becoming evident that there is a need to undertake a set of actions directed at the lakes' ecosystems and watershed health to prevent any possible decline, and to preserve the lakes and their tributaries for future generations.

The collection of sound scientific data and evaluation of the current condition of the Balsam and Cameron lake ecosystems and their watershed will form the base for designing remedial measures. Reducing inputs of phosphorus, nitrogen and other contaminants to the lakes and their tributaries - through a wide range of actions including stormwater management, stewardship, education, and legislation - will help to maintain and improve the environmental health of the lakes and their watershed. Continuing research will enable the evaluation of action plan implementation, as well as increasing our understanding of a complex and continually evolving lake environment.

1.3 Study Area

The Kawartha Region Conservation Authority watershed is located in the east-central portion of Southern Ontario. The area of the watershed is 2,563 km^2. The watershed is part of the larger Trent River watershed, which drains into Lake Ontario, and includes among others the Gull River and Burnt River watersheds. The Balsam and Cameron lakes combined subwatershed occupies 336.3 km^2 within the north-western portion of the Kawartha Conservation watershed ***(Figure 1.1).*** In addition, Balsam Lake has the highest elevation in the Trent-Severn Waterway system (256.2 m.a.s.l.). The Balsam Lake water surface area is 47.7 km^2, while Cameron Lake area is 14.7 km^2. The Balsam Lake maximum and average depths are 14.9 m and 4.8 m respectively. The Cameron Lake maximum and average depths are 18.2 m and 6.9 m respectively.

The Town of Fenelon Falls has a population of more than 2,000 residents (Statistics Canada, 2012) and is the only large urban centre situated on Cameron Lake, near its outlet to Sturgeon Lake. As well, about 10 villages, hamlets and subdivisions are situated within the lakes' watershed. Many of these are located in areas adjacent to the lakes' shorelines.

McLaren Creek subwatershed to the south, the Burnt River, Gull River and Corben Creek watersheds to the north, the Sturgeon Lake basin to the east and the Talbot River and Beaver River watersheds to the west all border the Balsam and Cameron lakes drainage basin.

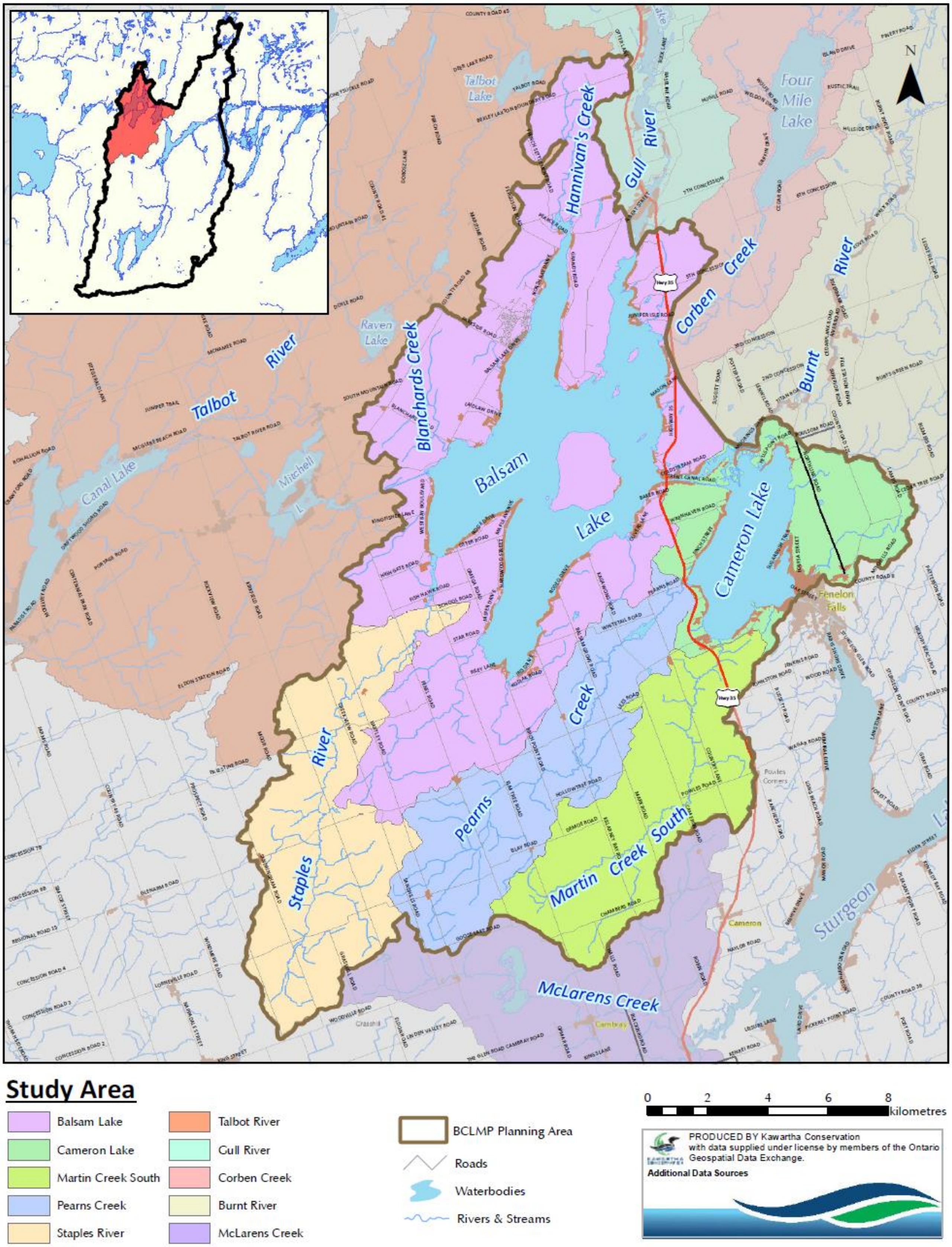

Figure 1.1. Balsam and Cameron Lakes Study Area

2.0 Socio-Economic Characterization

2.1 Summary of Observations and Issues

- The population of City of Kawartha Lakes has been decreasing since 2006;
- The City of Kawartha Lakes has a low population density with 65% of the population living in rural areas;
- The seasonal population is growing and is projected to reach 37,000 by 2031. This increase in population could increase pressures on the lakes;.
- Balsam Lake has a lower density of buildings on the shoreline (22 buildings/km) compared to the more populated Cameron Lake (46.4 buildings/km);
- Tourism is a major industry to the City of Kawartha Lakes, contributing up to $100 million/year;
- The City of Kawartha Lakes has a thriving agriculture community that contributes $243 million to the city. Agricultural lands occupy a substantial portion of the Balsam and Cameron lakes watershed. If those lands are not managed properly, they can have a negative impact on the lakes health; and
- Balsam and Cameron lakes each had over 5,500 vessels pass through their locks in 2013. This is a significant tourism activity and is positive for the City of Kawartha Lakes' economy. This level of boat traffic has the potential to impact the health of the lakes and mitigation measures should be considered to avoid negative effects.

2.2 Brief History

First Nation populations lived in the Kawartha Lakes area thousands years before the Europeans arrived in the beginning of 19th century. The area of the City of Kawartha Lakes (CKL) as we know it today was settled when the Government of Canada put the land up for sale in 1821. As the population of the area quickly increased, Lindsay was incorporated as a town in 1857 (CKL, 2010). The County of Victoria was established in 1863. The county of was composed of the Town of Lindsay, the villages of Bobcaygeon, Fenelon Falls, Omemee, Sturgeon Point and Woodville and the Townships of Bexley, Carden, Dalton, Eldon, Emily, Fenelon, Mariposa, Ops, Somerville and Verulam and the United Townships of Laxton, Digby and Longford (CKL, 2010). This collection of towns and villages remained physically unchanged until 1974 when the Regional Municipality of Durham was established and Manvers Township was added to the County of Victoria. The City of Kawartha Lakes was created on January 1, 2001 by the amalgamation of municipalities formed within the County of Victoria (CKL, 2010).

Fenelon Falls is a small town of approximately 2,000 people situated on the east side of Cameron Lake. It is home to Lock 34 of the Trent-Severn Waterway where the locally named Fenelon River flows from Cameron Lake into Sturgeon Lake (CKL, 2014). Fenelon Falls was incorporated in 1874. As a result of the town's incorporation, in 1876 the Victoria Railway was extended into Fenelon Falls (CKL, 2014). The village was an important stop for the railway as it marked the end of the line until later construction allowed the line to continue north. The railway was abandoned when the McLaren's Creek Bridge burned down in 1980, and was removed in 1984 (Rayburn, 1997). Lock 34, which was constructed in 1885 and allowed travellers to visit the area by boat, remains a tourist attraction to this day (CKL, 2014). Fenelon Falls also has many other attractions that draw in tourists every year. These include fairs, parks and trails, seasonal events, museums and quaint shops. The Village of Coboconk is located on the Gull River, just 2 km upstream of Balsam Lake. The village has a rich history, beginning with settlement in 1851 and the construction of a saw mill on the Gull River. The saw mill was built to serve the important logging industry that became established in this community, similar to many other communities in Ontario at the time. Coboconk eventually became home to many saw mills and brick kilns for brick makers including the Toronto Brick Company and the Canada Lime Company (Kirkconnell, 1967). When lock 35 was completed in 1873, it was recognized as the furthest point one could travel by boat from Lake Ontario. It was not until 1907 that construction on the Trent Severn Waterway continued and travel beyond Coboconk was possible (Angus, 1998).

Coboconk has never been incorporated, therefore, no census data exists for the village prior to its amalgamation into the CKL. Now that Coboconk is part of the CKL, census data for this village is incorporated into the total population for the CKL. While no breakdown is available specifically for the Village of Coboconk, the CKL website states that the population is around 800 (CKL, 2014).

2.3 Population and Housing

According to the 2011 Census, the permanent population of the City of Kawartha Lakes was 73,214, a decrease of 1.8% from the 2006 Census population of 74,561 (Statistics Canada, 2012) ***(Table 2.1).*** The CKL has an aging population that is older than many other areas in Ontario. The median age was 48.4 in 2011, while the median age for the province was only 40.4. There were 29,680 private households in 2011, with most of these occupied by two or more persons. The CKL has a low population density with only 23.7 persons per square kilometer. Approximately 65% of the population lives in rural areas (CKL, 2009) with the remainder living in the larger towns of Lindsay, Bobcaygeon and Fenelon Falls (Richard Fortin Associates, 2012). The city's Growth Management Strategy predicts a fairly moderate increase in households through 2031 (MHBC Planning Inc., 2011).

Table 2.1. Population, Employment, and Housing Statistics for the City of Kawartha Lakes

Variable	Census Year			
	1996	2001	2006	2011
Population (year round)	67,926	69,179	74,561	73,214
Employment rate (%)	52.5	56.1	57.6	NA
Households (Permanent Residences)	25,685	26,785	29,500	NA

Source: (Statistics Canada, 2010)

Seasonal Population

The CKL has a significant seasonal population due to its many cottages and vacation properties. In 2011, the seasonal population was estimated at 32,000 (MHBC Planning Inc., 2011). It is projected to reach approximately 37,000 by 2031, as shown in ***Table 2.2***. A growing trend has been for seasonal residents (such as cottagers) to convert their seasonal properties to permanent residences as they retire. This trend is expected to increase in the future due to the aging population. It is predicted that 17.9% of the seasonal residents will convert to permanent residency by 2031 (Tim Welsh Consulting and Lapoint Consulting, 2013). This boost in population will increase pressures on the lakes if not managed properly. A higher population means more lake usage. As lake usage increases, the greater the impact to the lake from pleasure craft, fishing, waterfront property construction and road expansions, etc. An increase in waterfront homes also means the installation of septic systems which are known to contribute large amounts of excess nutrients to lakes (Whitehead, et al., 2011).

Table 2.2. CKL Projections for Seasonal Population and Conversions of Seasonal Residences to Permanent Residences (2001-2031)

Variable	2001	2006	2011	2021	2026	2031
Seasonal Population	29,000	31,000	32,000	35,000	36,000	37,000
Seasonal Conversions	NA	NA	480	1,580	2,030	2,330

Source: (Tim Welsh Consulting and Lapoint Consulting, 2013).

Real Estate

It is estimated that 16,437 single detached homes (not including seasonal dwellings) face onto (i.e. have frontage) on waterway areas in the TSW corridor communities. A large portion of these properties are located in the area from Lakefield to Lake Simcoe, accounting for 6,871 properties, and over half of them are located within the Kawartha Lakes area (TCI Management Consulting and EDP Consulting, 2007).

According to the Royal LePage's Recreational Property Report (2013), in the Kawartha Lakes, a standard waterfront property with land-access costs approximately $325,000. This price is low compared to neighbouring cottage country in Muskoka where average cottage prices are $700,000. Due to low list prices, waterfront property is in high demand in the Kawartha Lakes and is expected to increase. The main buyers moving to the area are families who plan to use the property, rather than investors (Royal LePage, 2013). Currently in the City of Kawartha Lakes, in the areas of Balsam and Cameron lakes, property taxes average 0.97% (CKL, 2014). The average value of waterfront properties significantly depends on healthy aquatic systems in the local lakes.

Balsam Lake's shoreline has a low density of buildings compared to Cameron Lake ***(Table 2.3).***

Table 2.3. Different Lake Parameters for Balsam and Cameron Lakes

Lake parameters	Balsam	Cameron
Building Count	1730	1077
Lake Area (ha)	4769	1473
Shoreline (km)	78.7	23.2
Density (Bldgs/km)	22	46.4
Average Frontage (m)	45.5	21.5
Average Frontage (ft)	149	71
Density (Bldgs/ha)	0.37	0.83

Source: (Gartner Lee Limited, 2002)

2.4 Industry and Employment

The main industries in the CKL include retail, manufacturing, agriculture, and tourism, as shown in ***Table 2.4***

Agriculture

Agriculture is one of four largest economic contributors to the City of Kawartha Lakes and brings in millions of dollars for the city every year. This industry brings jobs, businesses and economic development (CKL, 2010). At the same time, it is largest land user within the city boundaries and in the Balsam and Cameron lakes watershed.

Tables 2.5 and 2.6 show the large areas of land dedicated to agriculture and their values. While dairy and cattle farms show significant economic returns, they can also contribute substantial amounts of nutrients to the water bodies.

Table 2.4. CKL 2007 Economic Contributions by Industry

Industry	Economic Contribution (2007)
Manufacturing	$340 million
Agriculture	$243 million
Retail	$600 million
Tourism	$100 million

Source: (CKL, 2010).

Table 2.5. Farming Statistics for the City of Kawartha Lakes

Some Basic Farming Statistics for the City of Kawartha Lakes	
Total experienced labour force employed in the agricultural sector, persons	15,558
Census farms (all farms reporting)	1,366
Land area used for farming, hectares	53,446
In crops, hectares	26,645
Natural land for pasture, hectares	11,828

Source: (OMAFRA, 2013).

Table 2.6. The Number of Farms by Industry in the City of Kawartha Lakes

Farms by Industry Group	Number of Farms	Gross Income, $
Dairy cattle and milk	64	21,400,000
Beef cattle ranching	411	20,400,000
Hog and pig production	3	2,700,000
Sheep and goat farming	56	-
Poultry and egg production	14	-
Other animal production	246	-
Oilseed and grain farming	146	29,000,000
Vegetable and melon farming	19	2,700,000
Fruit and tree nut farming	10	-
Greenhouse, nursery and floriculture	31	4,500,000
Other crop farming	366	-

Source: (OMAFRA, 2013).

In the Balsam and Cameron lakes subwatersheds, 37% and 49% respectively of their areas are dedicated to agriculture. Even though it is mostly concentrated in the southern portion of the subwatersheds, the movement of nutrients from manure and fertilizers via lake tributaries can have lake-wide impacts.

Recreation and Tourism

The CKL, including the areas around Cameron and Balsam lakes, offers a wide variety of recreational opportunities. Healthy local lakes encourage tourism, which in turn strengthens the job market within tourism industry. Seasonal and permanent residences around the lakes have resulted in the growth of property management businesses, food services and other support industries. Due to the large number of navigable lakes and waterways, the main recreation attractions tend to be seasonal outdoor activities. Some of the key recreation opportunities available around Cameron and Balsam lakes include:

- The navigable waterways of the TSW system;
- Indian Point Provincial Park and Balsam Lake Provincial Park on Balsam Lake;
- Seasonal locations such as private cottages, campsites and trailer parks;
- Fishing, including leisure and competitive tournaments; and
- Local parks and beaches (The Tourism Company and CKL, 2008).

Tourism is extremely important to the regional economy of the CKL, contributing $100 million in 2007. The tourism industry employs approximately 715 people every year, which represents almost 2% of all jobs in the CKL. It is expected that much of the city's growth will be in the commercial sector with the focus on tourists and seasonal and permanent residents (Dillon Consulting, 2012).

In 2004, it was estimated that there were a total of 1.05 million visits to CKL which generated $ 66.9 million in expenditures and $1 million in municipal tax revenue (The Tourism Company and CKL, 2008). Approximately 56% of the visitors stayed overnight, with 44% visiting only for the day. Of the overnight visitors, 93% were from Ontario, with the remainder coming from the U.S.A, other provinces, and overseas ***(Appendix 1)***. Most of the visitors to the area were travelling for pleasure or visiting friends or relatives. The most popular times of the year for people to visit the area were January through March and July through September.

Both Balsam and Cameron lakes support recreational fishing. According to the 2005 Survey of Recreational Fishing in Canada, Balsam Lake was ranked 25th in Ontario for the number of days fished by all anglers (98,520 total days fished), and was 20th for the number of days fished by resident anglers (93,534 total days fished) (OMNR, 2009). The most common species of fish caught and kept by anglers were sunfish, yellow perch, smallmouth bass, walleye, and crappie. Balsam Lake holds several different competitive fishing events each year, including the Top Bass Series fishing tournament. Ice fishing is also a very popular attraction for tourists and permanent residents. Every February, there is a two-day opportunity for anyone to try ice fishing. The Ministry of Natural Resources dedicates this weekend as the Ontario Family Fishing Weekend during which anyone can fish, even without a license.

There are many private businesses in the vicinity of Cameron and Balsam lakes that support the tourist industry and water-based recreation ***(Appendix 2).*** These businesses benefit from the recreational opportunities the lakes provide, and help re-circulate money into the local economy.

Parks

There are two provincial parks along the shores of Balsam Lake. Balsam Lake Provincial Park, on the northwestern shore of Balsam Lake, attracted 161,501 visitors in 2010 (Ontario Parks, 2010). This park offers opportunities for camping, hiking, wildlife viewing, swimming, paddling and biking. Indian Point Provincial Park is on the peninsula that extends into the lake from the northern shore of Balsam Lake and features one of the longest undeveloped shorelines in the Kawartha Lakes region. Its unique features include a limestone escarpment, while the lakeshore property is an alvar (an area with a thin covering of soil or no soil over a base of limestone that creates a unique habitat). Only day-use is permitted at this park; all camping is prohibited and no visitor statistics are available. Municipal parks around Balsam and Cameron lakes include Coboconk Lions Park, Birch Point, Garnet Graham Park and Island Park.

Special Events

The Balsam and Cameron lake areas are popular tourist destinations and host many different activities throughout the year. The Fresh Water Summit is celebrated every summer in Coboconk. This event celebrates Balsam Lake as the highest point in Canada from where a boater can navigate north to the Arctic Ocean, south to the Caribbean Sea, east to the Atlantic Ocean and west to the Pacific Ocean (CKL, 2014).

Fenelon Falls is popular for its annual Kawartha Arts Festival on Labour Day weekend, the Fenelon Falls Car, Truck and Bike Show, and the Fenelon Fair which happens on the second weekend in August every year.

Overall, the Kawartha's excellent fishing, boating, swimming, etc. keeps tourists coming back. In many instances, they purchase waterfront properties in the area. It has been noted during last 17 years that seasonal visitors are retiring here and becoming permanent residents. As noted above, the City of Kawartha Lakes receives $100 million from tourism, which is a large part of the city's revenue. A small representation of the businesses that rely on tourism is listed in ***Appendix 2***. There are other businesses such as landscape companies, home building companies, septic/well installers etc. that rely on waterfront properties as a major part of their business. The health of the lakes is imperative for the success of these tourism and waterfront-based businesses.

2.5 Trent-Severn Waterway

One of the most unique features of the CKL area is the Trent-Severn Waterway (TSW), which is managed by Parks Canada. This series of lakes and rivers allows boaters to navigate from Lake Ontario to Georgian Bay using the lock system (Parks Canada, 2009). Lock 34 is located on Cameron Lake at Fenelon Falls and provides passage between Cameron Lake and Sturgeon Lake. In 2013, a total of 5,955 vessels used this lock (***Table 2.7)***. That was 16% fewer vessels than in 2012, when 7,054 vessels used the lock. Lock 35 on Balsam Lake at Rosedale provides passage between Cameron Lake and Balsam Lake. It was used by 5,748 vessels in 2013 (***Table 2.7)*** and 7,719 vessels in 2012. These boaters create positive economic impacts to the local economy, as noted below.

Table 2.7. Number of Vessels through Trent-Severn Waterway Locks in 2013

Lock	Station	May	June	July	Aug	Sept	Oct	Total
34	Fenelon Falls	192	758	1972	2272	643	118	5,955
35	Rosedale	183	648	1956	2221	638	102	5,748

Source: (TrentSevern.com, 2014)

Parks Canada estimated that the average annual boating-related expenditure per seasonal household in 2006 for resident boaters, assuming a 10-week season, was $180 per week, for a total of $1,800 per year (TCI Management Consultants and EDP Consulting, 2007). For transient boaters (those that do not live on the waterway), the average annual direct expenditure per boat transient slip was estimated at $5,000. It was estimated that the Kawartha Lakes have approximately 3,436 single detached homes (not including seasonal dwellings) that face onto waterway areas in the TSW corridor (TCI Management Consultants and EDP Consulting, 2007). If even half of those homeowners in the Kawartha Lakes owned boats, they could be contributing up to $3,091,500 in direct expenditures to the CKL.

3.0 Land Use

Land use within the Balsam and Cameron lakes watershed has been determined with the aid of aerial photography using the Ecological Land Classification (ELC) system for Southern Ontario and Geographic Information System (GIS) software by the GIS technicians of Kawartha Conservation. The watershed land use has been subdivided into agriculture (cropland and pasture), forest, wetland and treed wetland, meadow, urban areas, rural development, manicured open space and transportation (roads). Agriculture represents approximately 42% of total land use, while forest represents almost 22% and wetlands 20% of the land use. The remaining 16% is composed of the other above-mentioned land uses ***(Figure 3.1).***

3.1 Summary of Observations and Issues

OBSERVATIONS

- 42% of the watershed land area is utilized for agricultural activities, with implications on terrestrial ecosystem and water quality;
- 0.33% of the watershed land area is occupied by urban developments. It is mostly the Fenelon Falls area and small portion within the Rosedale area. With projected urban growth in Fenelon Falls, there will be an increase in impervious surfaces within the Cameron Lake subwatershed;
- 22% of the study area is forest-covered, with that amount being below the recommended guideline of a minimum of 30%. However, if treed wetlands are included in the forest cover category, it exceeds 30% guideline and reaches 38%;
- 20% of the study area is wetlands and treed wetlands. It is double the recommended guideline of 10%. Wetlands alone occupy 4.3% of the watershed;
- 52.1% of the Balsam Lake shoreline is developed. Within a 30-metre buffer, 3.7% of the shoreline area is occupied by urban development and 48.0% by rural development; and
- 52.4% of the Cameron Lake shoreline is developed. Within a 30-metre buffer, 5.5% of the shoreline area is occupied by urban development and 40.1% by rural development.

3.2 Human Use Areas

Agricultural Lands

As mentioned above, more than 42% of the Balsam and Cameron lakes watershed is in some form of agriculture-related land use. Total land use for farming is slightly over 115 km^2. Croplands occupy 75 km^2 or 27% of the watershed, and 40 km^2 or 15% is used for non-intensive agriculture such as pasture. Within individual subwatersheds, agriculture occupies the largest portion of land in the Staples River subwatershed (63.4%) and in the Pearns Creek subwatershed (61.1%). In the Balsam Lake subwatershed, agricultural lands occupy only 26.1% of the land area. Cameron Lake and Martin Creek South subwatersheds have 41.4% and 41.7% of agricultural lands respectively ***(Table 3.1).***

According to the 2011 Census data, the major crops produced in the City of Kawartha Lakes are, in descending order, alfalfa and alfalfa mixtures (226 km^2), soybeans (118 km^2), corn (99 km^2), hay and fodder crops (84 km^2) and wheat (74 km^2) (Statistics Canada, 2012). Considering that the study area is situated in the middle of the City, it can be assumed with a high degree of confidence that the same crops dominate within the Balsam and Cameron lakes watershed.

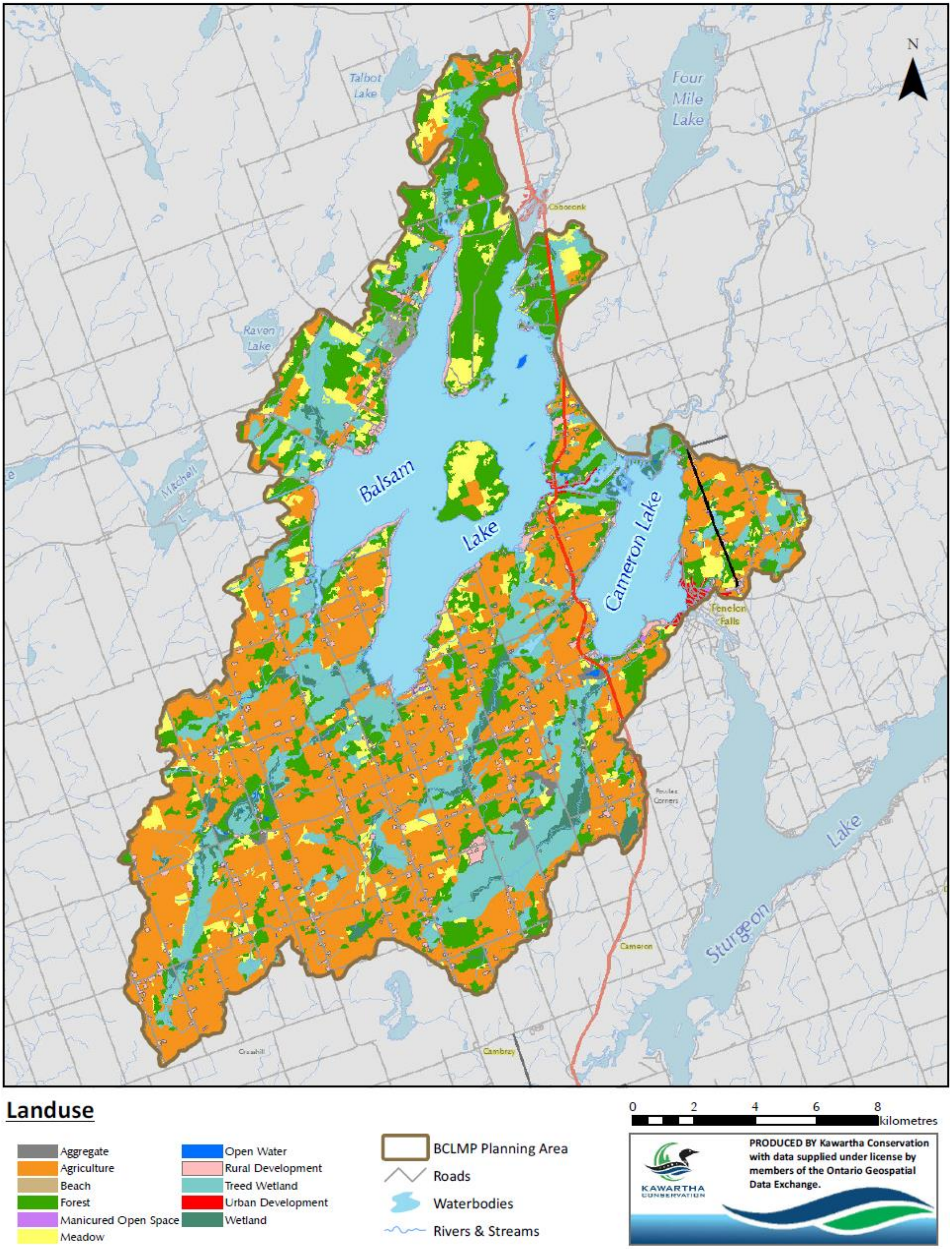

Figure 3.1. Land Use in the Balsam and Cameron Lakes Watershed

Table 3.1. Major Land Use Within the Balsam and Cameron Lakes Watershed

Subwatershed	Drainage Area, km^2	Agriculture, %	Forest, %	Wetland, %	Meadow, %	Roads, %	Development	
							Urban, %	Rural, %
Balsam Lake	114.85	26.1	32.3	20.7	11.8	2.0	0.2	6.0
Staples River	47.90	63.4	11.2	14.1	6.3	1.4	0	3.3
Cameron Lake	25.39	41.4	20.7	14.3	8.1	2.8	2.6	8.8
Martin Creek S.	41.82	41.7	14.8	32.5	3.1	1.4	0	4.1
Pearns Creek	43.90	61.1	12.7	17.1	3.8	1.6	0	3.5
Balsam Cameron Watershed Total	273.86	42.0	21.7	20.2	7.9	1.8	0.33	5.1

Livestock production is dominated by beef cattle, with 13,712 head present in the City of Kawartha Lakes (Statistics Canada, 2012). There are also 4,632 dairy cows. In addition, total number of swine in the city is approximately 6,149 (Statistics Canada, 2012). The exact number present within the study area is unknown.

A large number of farms within the watershed use various forms of soil conservation practices including, but not limited to, crop rotation, minimum or no-till (28% of all cultivated lands), crop residue retention on the surface (42%), and permanent grass cover and grassed waterways. 30% of crop lands are still prepared for seeding with use of conventional tillage (Statistics Canada, 2012).

Over 138 km^2 (or 21% of agricultural land in the City of Kawartha Lakes) receives manure application as fertilizer (Statistics Canada, 2012). Farmers apply manure by several methods. These include incorporation into soil in solid or liquid form, and manure application on the surface without incorporation. Furthermore, commercial fertilizers are applied to 348 km^2 (which is 53% of agricultural lands or 89% of all seeded lands) in the City of Kawartha Lakes (Statistics Canada, 2012).

Rural Residential Developments

Rural residential developments are closely related to agricultural land use - many farm households fall under this land use category. As well, this land use category includes a number of recently developed small residential settlements throughout the study area, including those situated along lake shorelines. Some older villages and hamlets that exist in the watershed also fall under this land use category. These include Glenarm and Islay. Rural developments, according to the 2008 ELC data, occupy approximately 14 km^2 or 5.1% of the Balsam and Cameron lakes watershed ***(Table 3.1).*** This is an increase over the 1988 data which showed 6.5 km^2 of rural development or 2.4% of the total watershed land area. Such a considerable increase probably can be explained by differences in ELC calculations between 1988 and 2008.

Urban Development

The only major urban center in the watershed is Fenelon Falls. The majority of future growth, according to the City of Kawartha Lakes Official Plan, is expected within the Fenelon Falls designated urban area (City of Kawartha Lakes, 2010). Two other settlements within or on the edge of the study area, Rosedale and Coboconk, are much smaller and can be placed either into urban development category or rural development category. Fenelon Falls has a much higher population density than the surrounding rural areas and comprises approximately 0.66 km^2 or 0.24% of the watershed land area ***(Table 3.1).*** In 2008, the area of urban development in the watershed did not change much in comparison with 1988.

The nature of urban development results in an increased proportion of impervious surfaces (concrete, asphalt, etc.) and associated urban stormwater runoff with high concentrations of various pollutants, greater demand on water supplies, and an increase in waste (both landfill items and sewage) that can impact adjacent water bodies.

Lakeshore Areas

The shoreline areas of both lakes are already highly impacted by human activities. According to aerial photo interpretation using Ecological Land Classification methodology (Lee et al., 1998), currently 46.4 km or 49.7% of the Balsam Lake shoreline is developed. Around Cameron Lake, 23.2 km or 44.9% of the shoreline is developed. In summer 2014, Kawartha Conservation conducted a rapid shoreline classification project along the east-shore of Balsam Lake. This study, conducted by travelling along the shoreline in a boat and documenting the major types of land use along the shore-water interface, resulted in characterizing 25% of the shoreline. The remaining shoreline was characterized through aerial imagery (34% - natural areas) and through estimation (41%) by using the relative percentages acquired through field sampling along the east-shore and interpolating based on existing land use as determined from Ecological Land Classification. In total, 87.7 km of shoreline along Balsam Lake was characterized using these methods. Results from the data indicate that approximately 43% (37.9 km) of the shore-water interface is occupied by natural vegetation, 32% (28.0 km) is occupied by natural non-vegetated lands, and 25% (21.8 km) is occupied by artificial installations ***(Tables 3.2, 3.3 and 3.4)***.

The good water quality in Balsam and Cameron lakes is an attractive feature to both landowners and visitors. As a result, the population of the lakeshore areas is growing. More and more cottages are being converted into permanent residences. In order to protect the ecological integrity of the lakes' ecosystems, it is important to recommend science-based guidelines for further shoreline development.

Within a 30 m buffer of Balsam Lake, 3.7% of the area is occupied by urban development and 48.0% by rural development. Roads cover another 1.6% of the area. Lakeshore areas with a considerable density of residential properties are located along eastern, southern and south-western shore of the lake. Within a 30 m buffer of Cameron Lake, 5.5% of the area is occupied by urban development and 40.1% by rural development. Roads cover 3.7% of the area. Lakeshore areas with a considerable density of residential properties, excluding the Fenelon Falls area, are located along southern and western shore of the lake. According to the 1970 survey data, there were 414 cottages around Cameron Lake at that time (OMOE, 1971). As of 2012, 588 shoreline residential properties are situated within 75m of Cameron Lake. There are 174 new houses and cottages, a 42% increase in 40 years. Around Balsam Lake, there were 1,380 properties in 2012. (No data are available for 1970s.)

Many of houses along shorelines were initially built as summer cottages but later converted to permanent residences. Furthermore, the majority of the waterfront residences have altered shorelines that tend to lack the buffering capacity and habitat-producing aspects of a natural shoreline. These residences usually have private septic systems and private wells for water use. A number of trailer parks and camps exist on the shorelines of Balsam and Cameron lakes. They concentrate human activities and place additional burdens on the lakes' water quality. It is anticipated that shoreline development will increase as recreational opportunities attract more tourists to the watershed, and as shoreline cottages continue to be transformed into year-round homes. More nearshore subdivisions and houses in backlots will also be built.

Transportation

The road network within the study area is quite intensive. It includes a provincial highway (Hwy 35), regional roads (County Roads 8, 35, 48 and 121) and numerous local roads, drives and lanes (both paved and unpaved). According to ELC calculations, 4.9 km^2 or 1.8% of the watershed is covered by the transportation network. The most intensive road network is around Cameron Lake, where roads cover 0.71 km^2 or 2.8% of the subwatershed. As well, roads occupy 2.0% of the Balsam Lake subwatershed, 1.6% of the Pearns Creek subwatershed and 1.4% of both the Staples River and Martin Creek South subwatersheds ***(Table 3.1).***

Table 3.2. Length and Percentage of the Surveyed Balsam Lake Shoreline Occupied by Categories of Natural Vegetation

Shoreline Category	Length (m)	Percentage of Total Shoreline (%)
Forest	24380	27.8
Marsh	7278	8.3
Swamp	5686	6.5
Meadow	528	0.6
Fen	0	0.0
Other	0	0.0
Total	**37872**	**43.2**

Table 3.3. Length and Percentage of the Surveyed Balsam Lake Shoreline Occupied by Categories of Natural Non-Vegetated Units

Shoreline Category	Length (m)	Percentage of Total Shoreline (%)
Cobble	14173	16.2
Boulder	5228	6.0
Bedrock	5124	5.8
Open Water	2436	2.8
Gravel	614	0.7
Sand	463	0.5
Other	0	0.0
Total	**28038**	**32.0**

Table 3.4. Length and Percentage of the Surveyed Balsam Lake Shoreline Occupied by Categories of Artificial Installations

Shoreline Category	Length (m)	Percentage of Total Shoreline (%)
Concrete	10158	11.6
Wooden	5120	5.8
Manicured Lawn	2148	2.4
Armourstone	1919	2.2
Flagstone	642	0.7
Gabion Baskets	521	0.6
Steel	503	0.6
Riprap	497	0.6
Beach	291	0.3
Rubber	0	0.0
Other	0	0.0
Total	**21799**	**24.9**

3.3 Natural Areas

Forests

A detailed forest characterization is given in Chapter 9. In this section, forests are described only as a category of land use.

Prior to the arrival of European settlers, most of the study area was forested, locally interspersed with lakes, wetlands and rock barrens. On the better drained loamy soils, sandy and more gravelly soils, the forests were dominated by sugar maple, American beech, American basswood, white ash, red, white and bur oak, red pine, white spruce and scattered white pine. In locations where the soil had more moisture, the dominant forest cover shifted to American and white elm, poplar or aspen, black ash and eastern white cedar (Helleiner et al., 2009). Drier sites tend to host white pine, red pine and red oak (Ecological Stratification Working Group, 1995).

As of 2008, ELC calculations indicate that the Balsam and Cameron lakes watershed contains 59.5 km^2 of forest, representing 21.7% of the total land area ***(Table 3.1).*** The forest cover in each individual subwatershed varies from 11.2% in the Staples River subwatershed to 32.2% in the Balsam Lake subwatershed. The study area also contains an additional 43.6 km^2 of treed wetland, representing another 15.9% of forested area within the watershed. As a result, the total forested cover is 37.6% (103.1 km^2) which is above the recommended guideline of 30%. There is a considerable variation in forested areas according to the 1988 and 2008 ELC data that probably can be explained by differences in ELC calculations in 1988 and 2008. As a result, it is not possible to reliably compare changes in forest cover in the watershed over this period of time.

Wetlands

A detailed wetland characterization is given in Chapter 9. In this section, wetlands are described only as a category of land use.

A wetland is land that is saturated with water for a sufficient period of time to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation (plants adapted to grow in water), and biological activities which are adapted to a wet environment (National Wetlands Working Group, 1988).

The Balsam and Cameron lakes watershed contains 11.76 km^2 of wetland (4.3% of the watershed), and 43.56 km^2 of treed wetland (15.9% of the watershed), for a total of 55.32 km^2, or 20.2% of the watershed land area ***(Table 3.1).*** Wetland cover for the subwatersheds varies from 3.25% for the Staples River up to 5.29% for Martin Creek South. Treed wetland areas vary from 9.5% for the Cameron Lake subwatershed, up to 27.2% for the Martin Creek South subwatershed. There are a total of 12 evaluated and designated Provincially Significant Wetlands in the Balsam and Cameron lakes watershed, occupying 37.59 km^2 ***(Figure 9.8, Chapter 9).***

Provincially Significant Wetlands (PSWs) are those that have been evaluated and scored using a point-based system known as the Ontario Wetland Evaluation System (OWES), developed by the Ministry of Natural Resources (MNR, 2011). Wetlands are evaluated based on four different criteria. The first, the biological component, measures the productivity and habitat diversity of the wetland. The second, the social component, grades the direct human uses of wetlands including economic products, recreational and educational activities. The third, the hydrological component, assesses water-related values, including contributions to groundwater recharge, improvements to water quality, and minimizing flooding. The last, the special features component, is focused on the rarity of wetlands in the area. This can be the occurrence of rare or species at risk, habitat quality or the age of the ecosystem, among other variables (MNR, 2011). A wetland is deemed significant if it gets a total of 600 or more points (to a maximum of 1000), or 200 or more points in either the biological component or the special features component.

Meadows

Meadow ecosystems describe a community type in which herbaceous plants such as grasses, sedges and forbs (wildflowers) dominate over woody plants. They are treeless or nearly treeless, typically occurring on deep soils (Rodger, 1998).

The Balsam and Cameron lakes watershed contains 21.5 km^2 of meadow, representing 7.9% of the total watershed area ***(Table 3.1).*** The proportion of meadow in each subwatershed varies from 3.05% in Martin Creek South, to 11.8% in the Balsam Lake subwatershed.

Protected Areas

Protected areas within the Balsam and Cameron lakes watershed include provincial and conservation authority owned or operated lands.

Provincial Parks: A division of the provincial government, Ontario Parks has the responsibility of ensuring that Ontario's Provincial Parks protect significant natural, cultural and recreational environments. There are two Provincial Parks in the study area: Balsam Lake Provincial Park and Indian Point Provincial Park.

Balsam Lake Provincial Park, located on the western shore of Balsam Lake's North Bay, encompasses 448 hectares. This park offers opportunities for camping, hiking, wildlife viewing, paddling and biking. It has nice long beach for swimming. It attracted 161,501 visitors in 2010 (Ontario Parks, 2010).

Indian Point Provincial Park encompasses 947 hectares on a peninsula on the north shore of Balsam Lake and features one of the longest undeveloped shorelines in the Kawartha Lakes region. It is classified as a Natural Environment Park, the purpose of which is to protect the landscapes and special features of the region in question. Camping is therefore prohibited and there are no permanent visitor facilities. The land on which the park is situated is an alvar. It has a thin layer of soil or no soil over a base of limestone that creates a unique habitat. It is a provincially significant feature and a rare environmental community type on a global scale (Ontario Parks, 2008).

Conservation Areas: Kawartha Conservation is responsible for managing protected areas within the study area in the form of Conservation Areas (CAs) and other regulated natural areas.

Since 1995, Kawartha Conservation has managed Deweys Island Nature Reserve. It was acquired in partnership with the Nature Conservancy of Canada, the Trent-Severn Waterway and the Ontario Heritage Foundation in 1994. This natural area is located between Balsam Lake and Cameron Lake near the Burnt River mouth, just east of Rosedale. It encompasses 31 hectares and is located within a large wetland complex known as Balsam Lake #15 (Kawartha Region Conservation Authority, 1995).

4.0 Physical Characteristics

4.1 Summary of Observations and Issues

- Much of the study area surrounding Balsam and Cameron lakes is primarily limestone;
- The dominant physiographic regions surrounding Balsam and Cameron lakes are the Carden Plain, Dummer Moraine and Peterborough Drumlin Field;
- The north-western shore of Balsam Lake is Carden Plain. This area can be characterized as an alvar (which are considered a provincially significant feature, and are a rare environmental community type on a global scale); and
- Otonabee Loam is the most important agricultural soil in the City of Kawartha Lakes due to the ease of cultivation - a result of the surface soil possessing a granular, crumb-like structure. The Otonabee soils are very widespread. They are found south and east of Balsam Lake, extending around Cameron Lake to just north of Fenelon Falls and the north shore of Sturgeon Lake to County Road 8.

4.2 Geology

Approximately 480 to 460 million years ago, the Gulf of St Lawrence to the east and the Michigan Basin to the south flooded a large proportion of North America. The marine submergence lasted less than 20 million years in the vicinity of the Kawartha Lakes (Ecclestone & Cogley, 2009). The sediment deposited during this time began as a coarse grained conglomerate (reflecting proximity to shoreline) and eventually changed to a lime mud (similar to material deposited in shallow seas today that lack sediment input from rivers). Over time, this was compacted and cemented to form limestone which makes up much of the Kawartha Lakes watershed today (Ecclestone & Cogley, 2009).

The Wisconsinan advance, the most recent glaciation, receded from the region approximately 12,000 years ago. Many of the surficial deposits from the glacier's advance were transported to the watershed (Ecclestone & Cogley, 2009). As the glaciers ceased their advance, this facilitated the ponding of melt-water and resulted in pro-glacial lakes. As they retreated, the glaciers deposited material which represents the sand and clay till plains found today in the Kawartha Conservation watershed.

The dominant surficial material in the Balsam and Cameron lakes watershed is a Diamicton, a poorly sorted glacial deposit that includes both large grains (gravel and larger) surrounded by a matrix of smaller grained material ***(Figure 4.1)***. The thicker glacial sediments tend to be coarser grained, ice-contact, stratified drift and glaciofluvial deposits. Surficial deposits not falling into these categories include smaller proportions of clay, sand, silt and gravel, in various combinations and proportions.

The northern portions of the Balsam Lake subwatershed, as well as some areas to the west and south of the lake, are occupied by Paleozoic bedrocks, limestone and dolomite specifically ***(Figure 4.1).*** The river valleys are often filled with organic deposits.

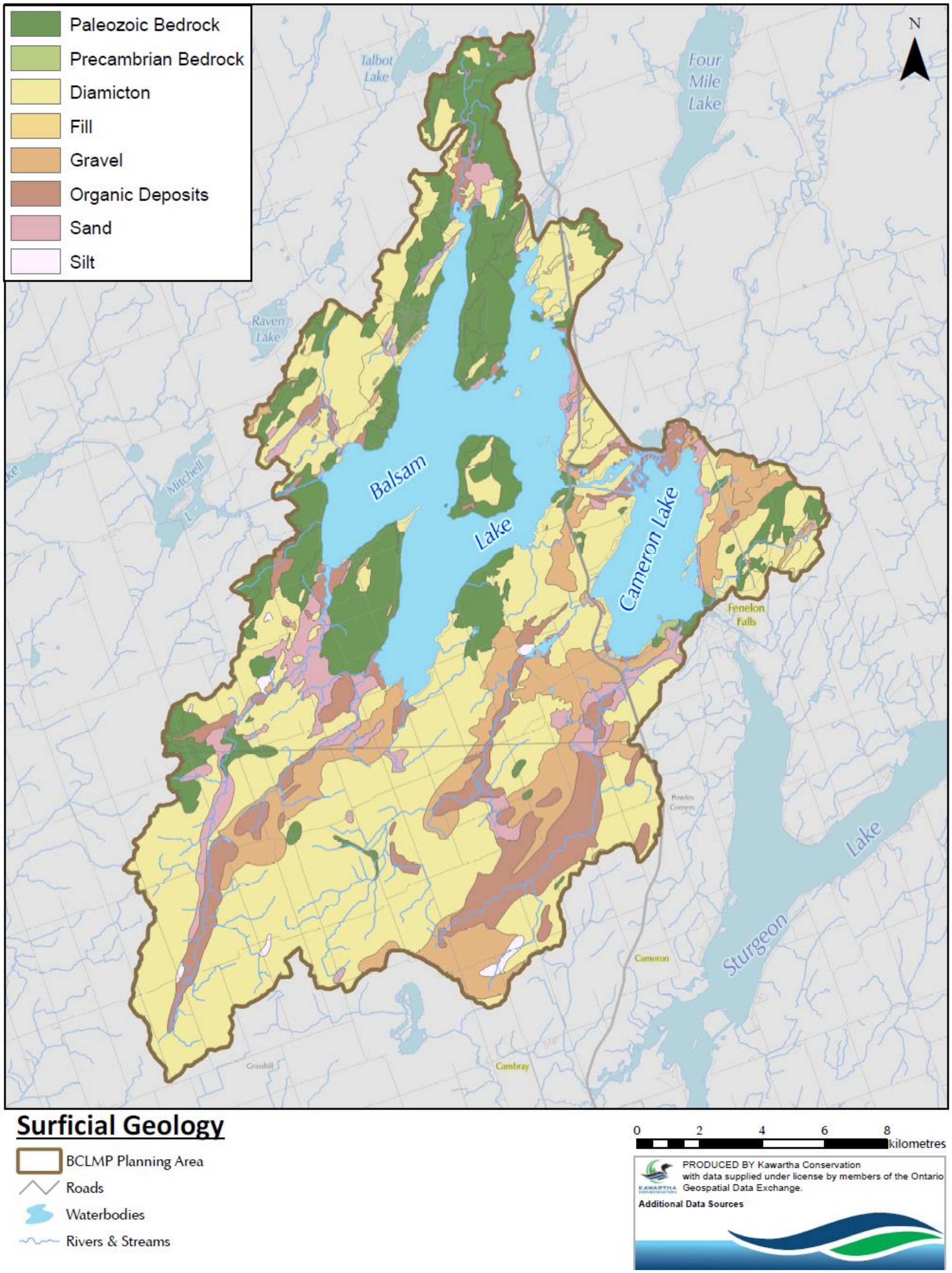

Figure 4.1. Surficial Geology of the Balsam and Cameron Lakes Watershed

4.3 Physiography and Topography

Physiography

The physiographic regions surrounding Balsam and Cameron Lakes are till moraines and limestone plains such as the Carden Plain, Dummer Moraine and Peterborough Drumlin Field ***(Figure 4.2)*** (Trent Source Protection Committee, 2013).

The Carden Plain represents the area of the watershed surrounding the northern shore of Balsam Lake and extending north to the Georgian Bay Fringe. The plain contains localized beach and over-shore sand deposits that overlie limestone bedrock (Chapman & Putnam, 1984). Due to the thin soil cover on top of a limestone plain, the Carden Plain can be characterized as an alvar, an environment with sparse, adapted vegetation due to thin soil overlying a limestone formation. Alvars are considered a provincially significant feature, and are a rare environmental community type on a global scale (Chapman & Putnam, 1984).

The Dummer Moraine represents an area of rough, hummocky stony land bordering the Canadian Shield (to the north) from the Kawartha Lakes eastward to Kingston that spans approximately 180 kilometres and roughly follows the boundary between the Paleozoic and Shield rocks (Chapman & Putnam, 1984; Ecclestone & Cogley, 2009). The Dummer Moraine encompasses part of the northern portion of the watershed, lying between the Georgian Bay Fringe to the north, Carden Plain to the west and Sturgeon Lake to the south. The till is composed of coarse boulders (both Paleozoic and Precambrian rock fragments) and sandy material, with local bedrock outcrops occurring in the region north of the Kawartha Lakes. Frequently, the limestone bedrock of the area is exposed in limestone plains (Hewitt, 1969). The finer matrix of the moraine has a faint reddish colour owing to the red shale and siltstone which occur just under and appear along the northern border of the Gull River Formation (Chapman and Putnam, 1984). The Dummer Moraine likely formed as a recessional moraine during a pause in the retreat of the Simcoe ice lobe (Ecclestone & Cogley, 2009).

The Peterborough Drumlin Field encompasses the majority of the watershed south of Balsam and Cameron lakes. Drumlins in this region are typically elongated, low-lying hills, less than 1.5 km long, 400 metres or less wide, and 25 metres in height. They are composed of highly calcareous (chalky) glacial till consisting of sand and gravels. Soils in the Peterborough Drumlin Field are useful for agricultural activities and thus, many agricultural operations in the watershed are located in this region. In addition to the drumlins, the region contains many drumlinoid hills and surface flutings of the till sheet (Chapman & Putnam, 1984). A flute is a streamlined subglacial form, parallel to the direction of ice movement, which commonly forms due to the squeezing of saturated debris into linear cavities behind large boulders during lodgment (Barnett, 1992).

Topography

The current surface topography and landscape of the study area is a direct result of Pleistocene glacial activity that impacted the area through deposition and meltwater. Local high points are represented by glacial deposits such as eskers and drumlins which are up to 25 metres in elevation ***(Figure 4.3)***. The study area contains over 30 drumlins and 15 eskers with more of these features immediately outside of the area boundary.

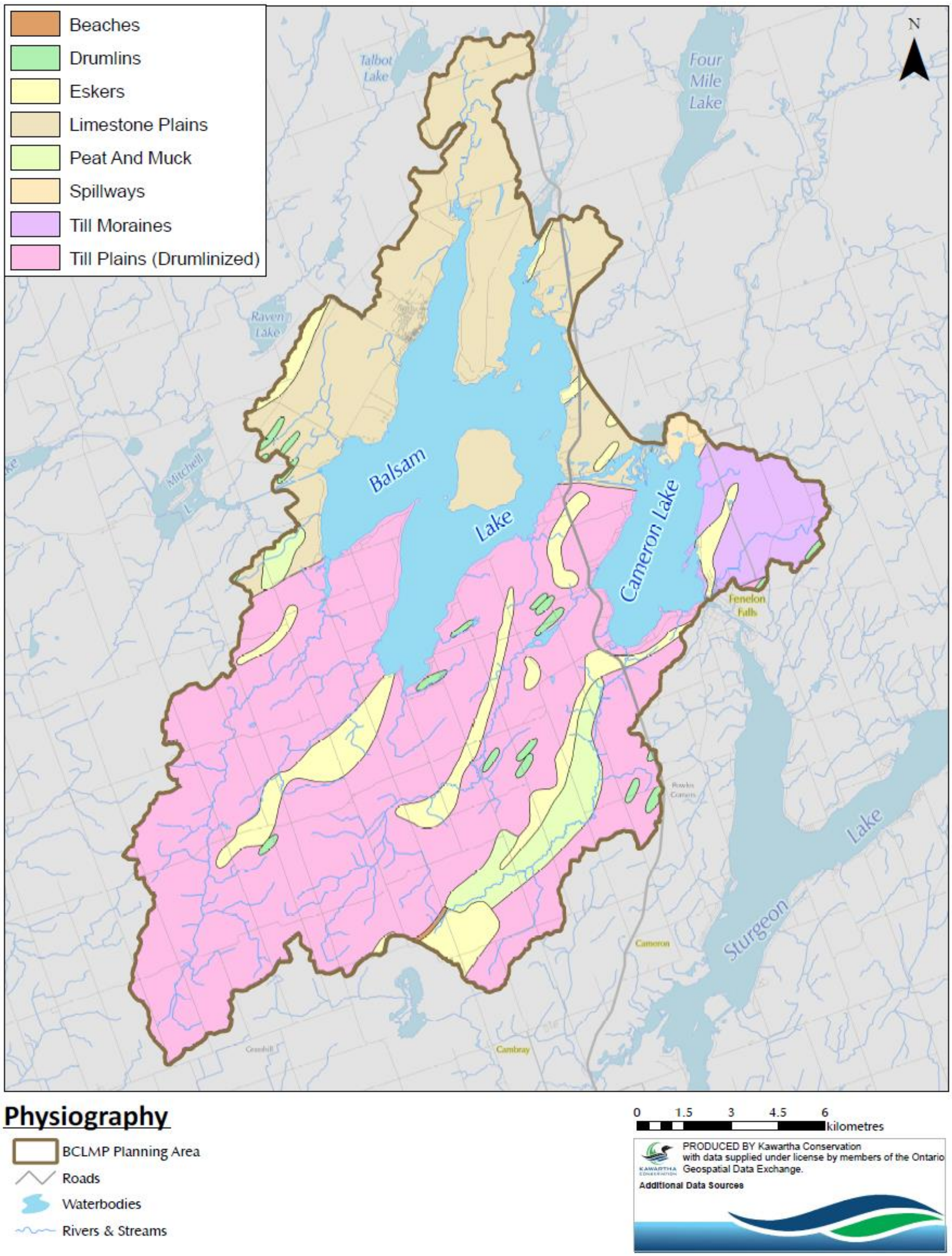

Figure 4.2. Physiography of the Balsam and Cameron Lakes Watershed

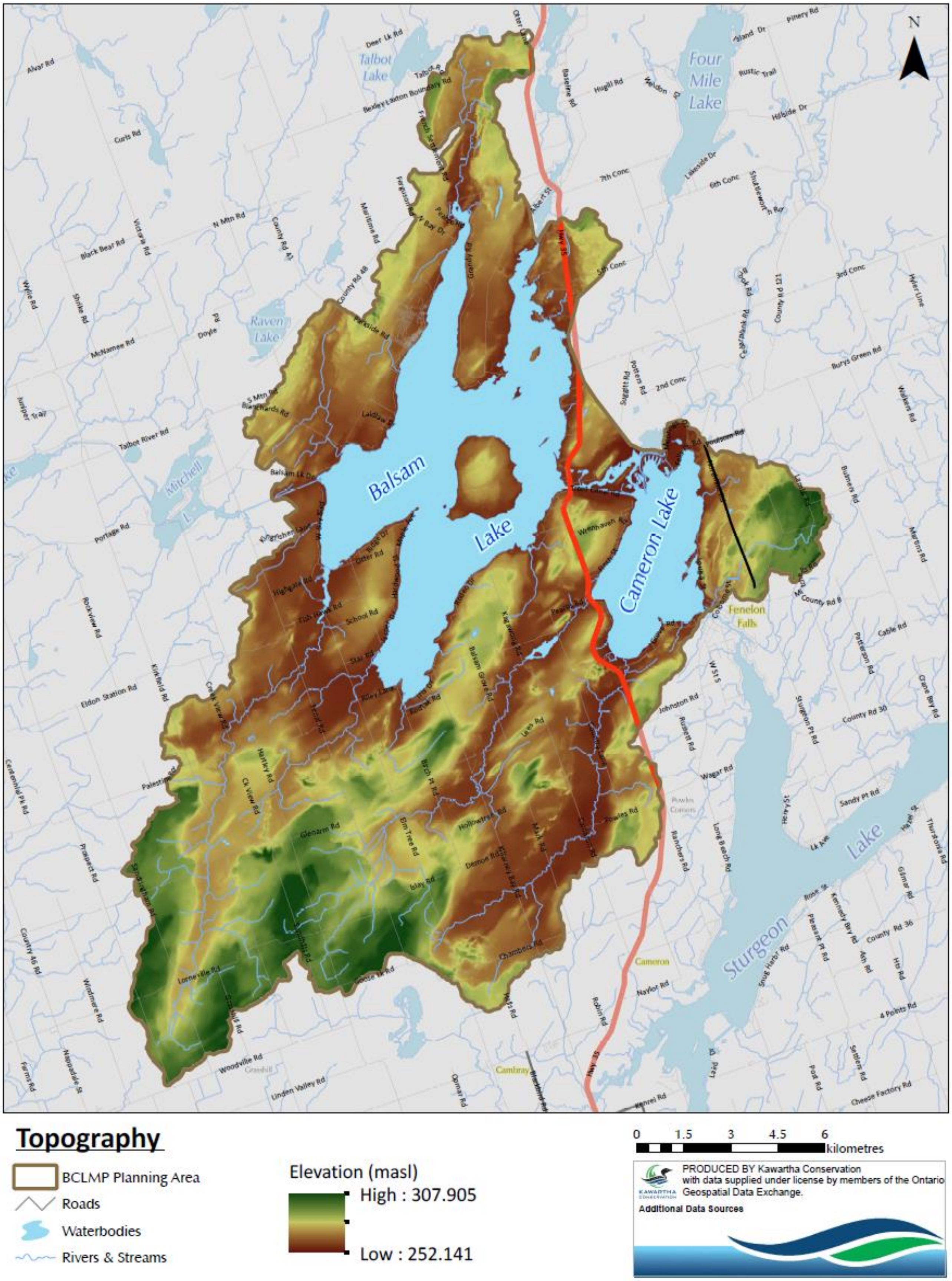

Figure 4.3. Topography of the Balsam and Cameron Lakes Watershed

4.4 Soils

The landscapes, and by association the soils, differ greatly between the north and the south. The zone of delineation closely mimics the major geological/physiographic boundary between the Canadian Shield and Great Lakes-St. Lawrence Lowland. On and adjacent to the Canadian Shield, the soils are frequently too thin to support successful agricultural activities and, as a result, large areas of land have reverted back to modified forest cover (Hellenier, McMurtry, & Pond, 2009). In fact, much of the higher ground on the Canadian Shield is exposed bedrock devoid of soil, as the glaciers removed and transported the soil (Hellenier, McMurtry, & Pond, 2009).

The major soil type in the Balsam and Cameron lakes watershed is loam ***(Figure 4.4).*** Two soil sub-types include Dummer Loam and Otonabee Loam. The soils to the north of the lakes are shallow which coincides with the transition into the Canadian Shield. To the south of the lakes, the soils are deeper, thus more suited for intensive agriculture.

The Dummer soils are well-drained with a variable topography from moderately to steeply hilly (where the till is deeper). The parent material is a very stony loam till (Gillespie & Richards, 1957). The Dummer loam is a thin and very stony soil that is rich in carbonates. In a natural state, it has a very dark grayish-brown surface horizon rich in organic matter (Hellenier, McMurtry, & Pond, 2009). The Dummer soils are most suitable for pastureland, with some areas under cultivation after extensive stone removal (Gillespie & Richards, 1957). The Dummer Loam shallow phase extends from north of the Trent-Severn Canal on the northwestern side of Balsam Lake, north to Norland, and east towards Four Mile Lake (Experimental Farm Service, 1956).

The Otonabee soils are very widespread and found south and east of Balsam Lake, extending around Cameron Lake to just north of Fenelon Falls and then along the north shore of Sturgeon Lake to County Road 8 (Experimental Farm Service, 1956). The Otonabee soils are well-drained externally and internally, with a general surface soil texture of a loam (but in a number of areas it is a sandy loam). The soil parent material is a sandy loam-textured glacial till containing a moderate amount of stone. It is calcareous, having been derived from limestone (Gillespie & Richards, 1957). The Otonabee Loam is commonly found on top of the drumlins in the area, with thin upper horizons that have undergone the vertical transfer of clay particles to deeper soil depths (Hellenier, McMurtry, & Pond, 2009). The side slopes of the drumlins and eskers of the region are too steep for good farming (Gillespie & Richards, 1957).

The Otonabee soils are the most important agricultural soils in the City of Kawartha Lakes due to their ease of cultivation - a result of the surface soil possessing a granular, crumb-like structure (Gillespie & Richards, 1957). According to the soil rating (which was based on the yield of farm crops and used in the soil survey of the Victoria County), the Otonabee Loam belongs to the “Good” cropland group. The Dummer Loam soils were included in the “Poor” cropland group, which can be used mainly for pasture or woodlot (Gillespie & Richards, 1957).

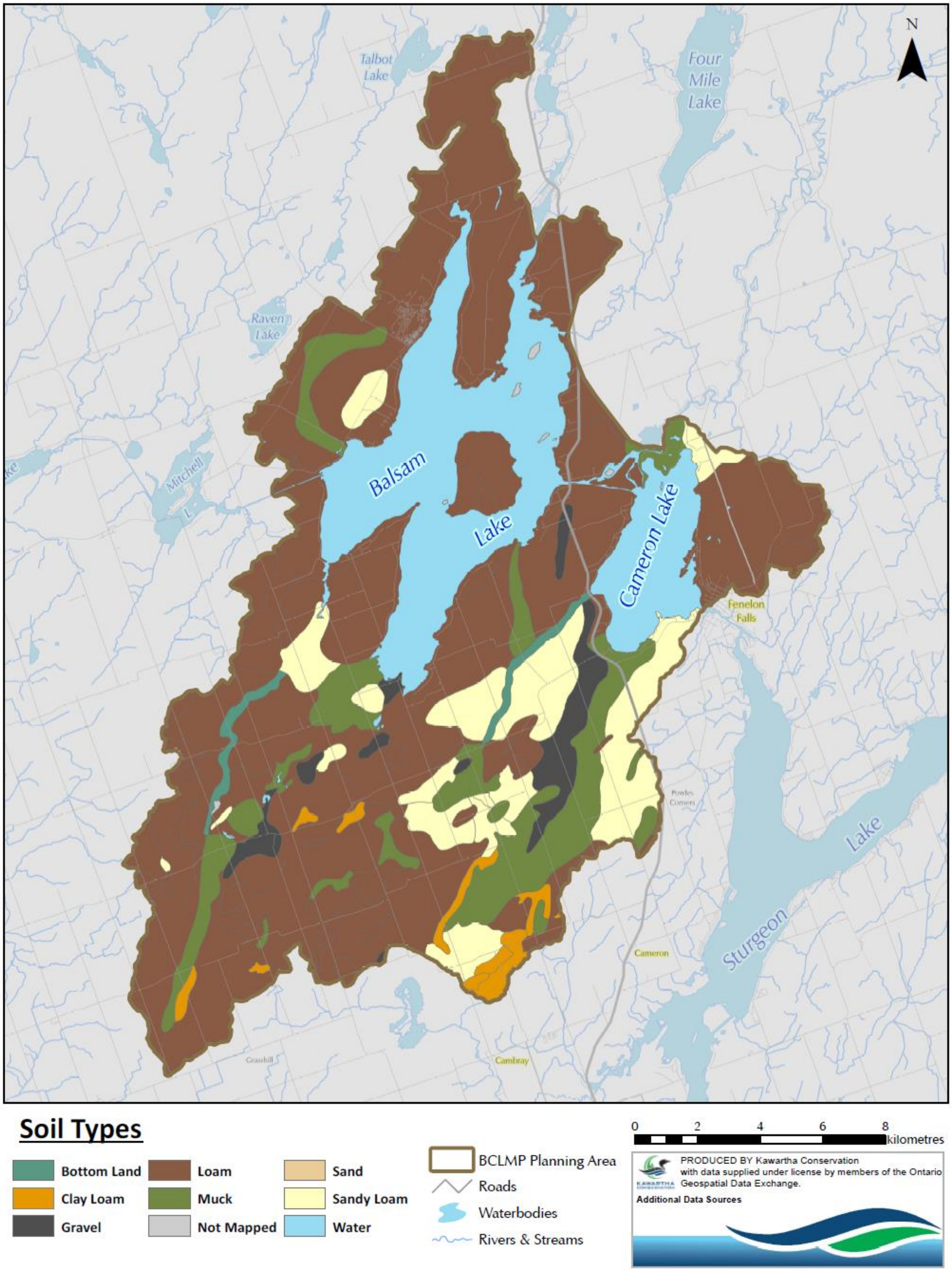

Figure 4.4. Soils in the Balsam and Cameron Lakes Watershed

5.0 Climate

5.1 Summary of Observations and Issues

OBSERVATIONS

- The climate of the Balsam and Cameron lakes watershed is described as moist continental, mid-latitude. It is characterized by warm summers with occasional hot and humid spells, and cold winters with snowstorms, strong winds and cold air from Continental Polar or Arctic air masses. Precipitation is equally distributed through the year.

KEY ISSUES

- Climate conditions are currently projected to change as a part of the global climate change process. Some of the possible changes to weather are:
    - Higher temperatures in all seasons, but especially in winter;
    - More variable precipitation, with increases in both the incidence of drought and intense precipitation;
    - Decreased snow cover, increased amounts of rain in winter; and
    - More storms and higher wind speeds.
- Change in climate will bring changes to the lakes' ecosystems that will require advance preparation and planning.

5.2 Introduction

Climate is a pattern or cycle of weather conditions, including temperature, precipitation, wind, humidity and cloud movement over a given region, averaged over many years. The climate of a region is affected by its location on the planet, topography, as well as nearby water bodies and their respective currents.

The climate conditions of the Balsam and Cameron lakes watershed is classified as a moist continental mid-latitude climate (Dfb climate category), with warm to cool summers and cold winters as categorized by the Köppen Climate Classification System. The Köppen Climate Classification System is one of the most widely used climate classification systems (Strahler & Strahler, 1979). The system was developed by German climatologist Wladimir Köppen (1846-1940) who divided the world's climates into six major categories based upon general air temperature and precipitation profiles in relation to latitude.

The Köppen system classifies a location's climate using mainly annual and monthly averages of temperature and precipitation ("normals"). The length of record required to determine climate normals for any particular location is 30 years, as defined by the World Meteorological Organization (WMO). For Canada, the normals are computed every 10 years by Environment Canada, utilizing all qualified monitoring stations. The current 30-year normals are determined from the weather data obtained during the 30-year period of 1981-2010.

According to the Köppen classification, the moist continental mid-latitude climate (Dfb climate category) is characterized by the average temperature of the warmest month being greater than 10^{o}C, while the coldest month is below -3^{o}C. Also, no month has an average temperature over 22^{o}C; precipitation is equally distributed across the year. Summers are warm with occasional hot and humid spells; winters are rather severe with snowstorms, strong winds and bitter cold from Continental Polar or Arctic air masses. This climate prevails in most of east-central Ontario with only little variability throughout the region ***(Figure 5.1).***

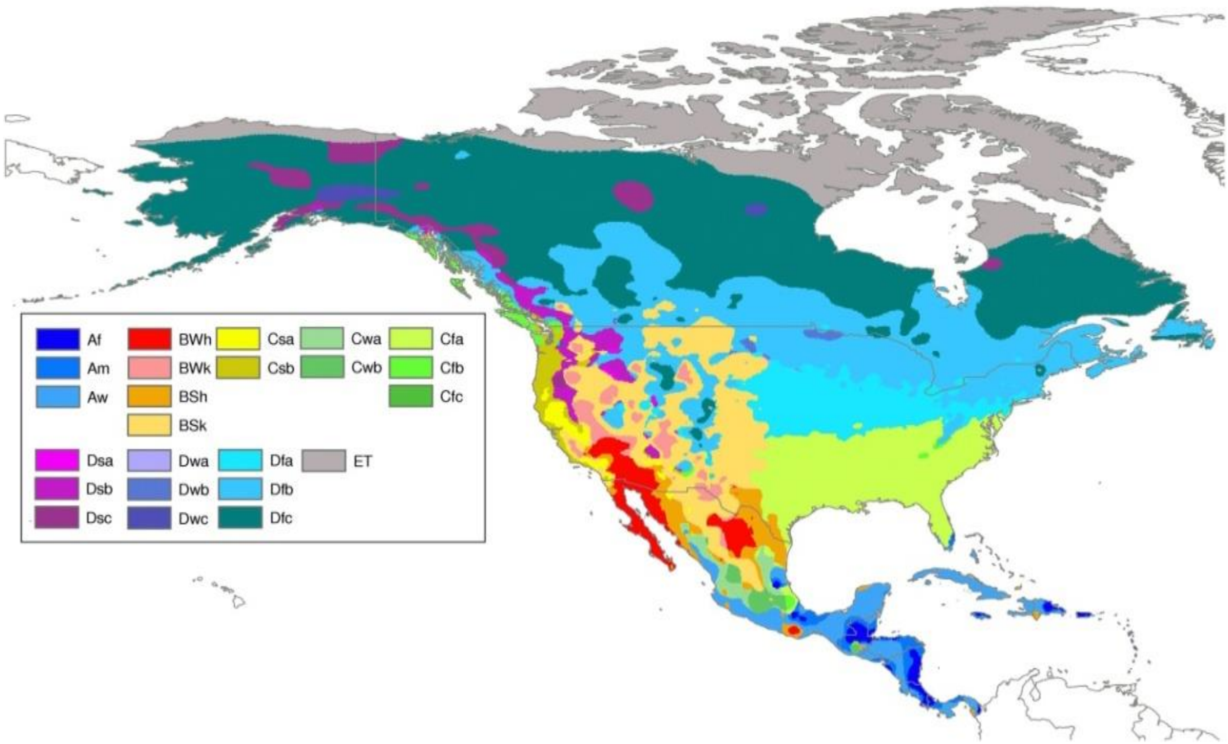

Figure 5.1. The Köppen Climate Classification System for North America
Source: http://www.eoearth.org

The climate monitoring station in Lindsay (Lindsay Frost, Station ID 6164433) is the closest monitoring location from which data can be used to characterize climate variables of the study area. It is located outside of the study area, but no stations with the long-term records exist within the Balsam and Cameron lakes watershed. The Lindsay Frost station was a component of the Environment Canada climate monitoring network, working in accordance with the United Nation's World Meteorological Organization standards and providing high quality monitoring data for over 36 years. Unfortunately, the station was shut down in 2009.

Average monthly temperatures and precipitation values for the Lindsay Frost monitoring location are shown in ***Table 5.1*** and ***Figure 5.2.*** These data confirm the study area as belonging to the moist continental mid-latitude climate category.

5.3 Air Temperature

The average winter monthly air temperature for the Lindsay Frost climate station ranges from -4.4°C in December to -8.4°C in January, which is the coldest month of the year ***(Table 5.1)***.

July is the warmest month with the average monthly temperature reaching 20.3°C. August is the second warmest month, with an average temperature of 19.2°C, while the average temperature in June is 17.7°C.

Table 5.1. Average Monthly and Daily Extreme Values of Air Temperature and Precipitation for the Lindsay Frost Climate Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Air Temperature, ^{0}C													
Daily Average	-8.4	-6.8	-1.8	6	12.5	17.7	20.3	19.2	14.8	8.2	2	-4.4	6.6
Daily Maximum Average	-4.1	-2.1	2.9	11.2	18.2	23.4	26	24.8	20	12.8	5.6	-0.6	11.5
Daily Minimum Average	-12.7	-11.4	-6.6	0.7	6.8	11.9	14.4	13.5	9.4	3.5	-1.6	-8.1	1.7
Extreme Maximum	11.5	11.5	24	29.5	32	34	36.5	36.5	32.5	27	21.1	17.5	
Year	2005	2000	1998	1985	1980	2005	1988	2001	2002	2002	1974	1982	
Extreme Minimum	-36.5	-35	-30.5	-14	-4	-2.5	5	1.7	-3.5	-9.4	-18.5	-34	
Year	1994	1979	1980	1982	1986	1978	1977	1976	1991	1975	1977	1980	
Precipitation (mm)													
Rainfall	22.4	22.2	30.4	57.5	87.3	82.6	75.8	85.7	88.2	74.9	72.3	29.4	728.6
Snowfall	44.4	32.7	25.3	7.7	0	0	0	0	0	1.7	17.5	39	168.3
Total Precipitation	66.8	54.9	55.7	65.2	87.3	82.6	75.8	85.7	88.2	76.6	89.8	68.5	896.9
% of yearly amount	7	6	6	7	10	9	8	10	10	9	10	8	
Extreme Daily Rainfall	31.8	36.8	37.2	36.3	44.2	59.2	92.4	81.2	52.2	53.2	58.8	35.6	
Year	1995	1985	1990	1976	2000	2002	1980	2005	2000	1995	1999	2006	
Extreme Daily Snowfall, cm	20	28	26	26.2	7.6	0	0	0	0	13	19	35.6	
Year	1979	1993	1982	2003	1976	1975	1975	1975	1975	1981	1995	1992	
Extreme Daily Precipitation	40	36.8	37.8	36.3	44.2	59.2	92.4	81.2	52.2	53.2	58.8	36.6	
Year	1979	1985	1980	1976	2000	2002	1980	2005	2000	1995	1999	2006	
Extreme Snow Depth, cm	50	50	48	21	0	0	0	0	0	13	24	36	
Year	1984	1982	1982	1987	1983	1983	1983	1983	1983	1981	1995	1992	

Adopted from http://climate.weather.gc.ca/climate_normals

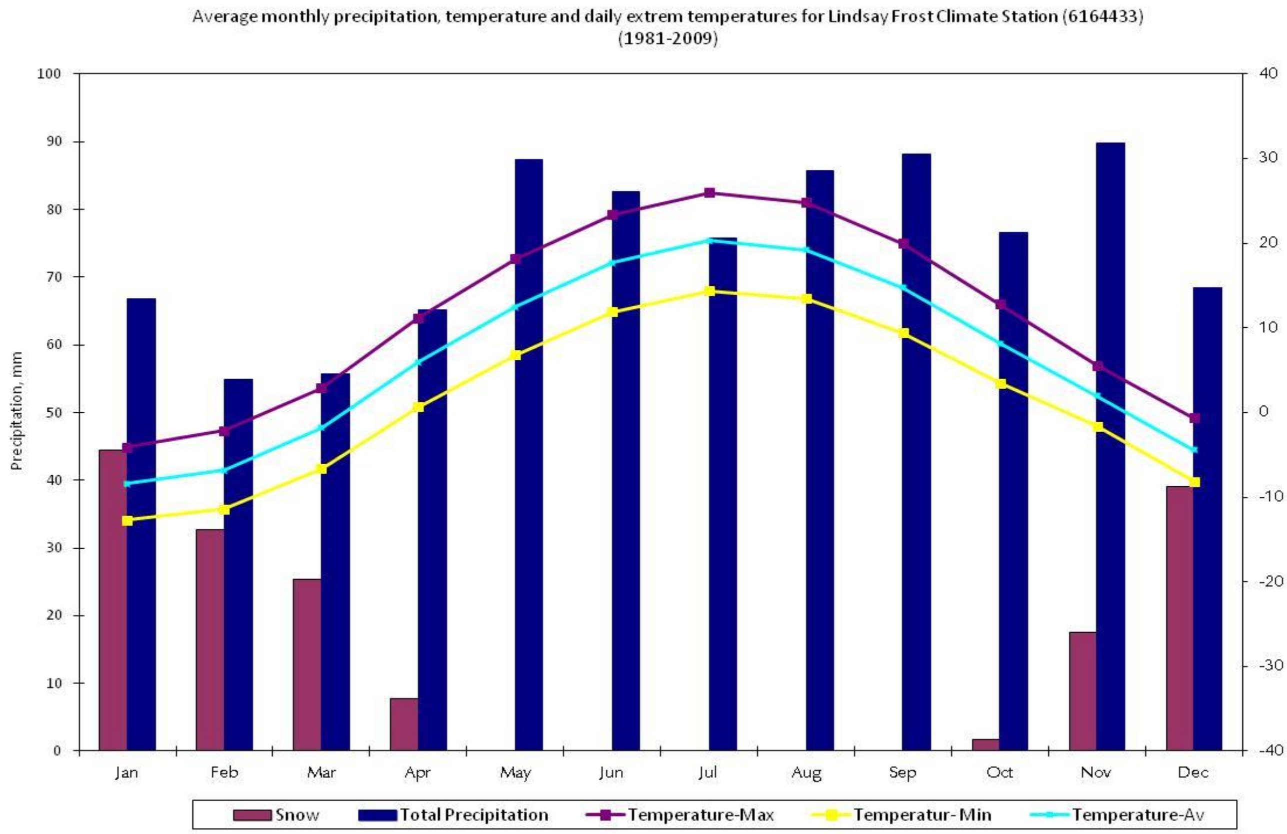

Figure 5.2. Climate Normals and Extremes for the Lindsay Frost Climate Station

An extreme minimum temperature was observed in January 1994 at -36.5°C, while July 7, 1988 was the hottest day recorded with the temperature at 36.5°C. The average yearly air temperature is 6.6°C.

5.4 Precipitation

Based on the data from the Lindsay Frost climate station, the Balsam and Cameron lakes watershed typically receives over 890 mm of precipitation annually, of which an average of 180 mm (18.7%) falls in the form of snow. Precipitation is fairly evenly distributed throughout the year, with January-April being slightly drier than the rest of the year. The driest month of the year is February, which has on average 54.9 mm of precipitation or approximately 6% of the total annual amount. The largest average monthly amount of precipitation is usually observed in November, 89.8 mm, or more than 10% of the total annual amount. September, August and June follow November closely, with an average monthly precipitation amount ranging from 82.6 mm to 88.2 mm. An extreme daily rainfall of 92.4 mm for the Lindsay Frost monitoring location was observed on July 20, 1980.

Currently, there are two active precipitation monitoring locations within the Balsam and Cameron lakes watershed that are maintained by Kawartha Conservation. One is located at the Staples River where it crosses Fenel Road, and another at the outlet of Four Mile Lake (Corben Creek). However, the latter was installed in December 2013, so it does not have enough monitoring data to draw any conclusions. Therefore, a rain gauge located near the mouth of Hawkers Creek (east from the study area) was used for precipitation monitoring. That station was established for the purpose of the Sturgeon Lake Management Plan monitoring in 2010.

All three mentioned monitoring locations have simple manual accumulative gauges that collect and store precipitation, until a reading is taken. Precipitation amounts for the monitoring locations at the Staples River and Hawkers Creek are shown in ***Table 5.2*****.**

Table 5.2. Precipitation Amounts for the Staples River and Hawkers Creek Precipitation Monitoring Stations Presented by Hydrologic Year

Year,	**2011-2012**		**2012-2013**		**2013-2014**	
hydrologic	Staples R.	Hawkers Cr.	Staples R.	Hawkers Cr.	Staples R.	Hawkers Cr.
June	89.6	115.7	90.5	112.3	82.2	86.0
July	97.3	91.0	46.9	35.9	48.7	52.1
August	81.7	74.4	78.2	39.5	171.4	143.4
September	83.4	83.5	113.4	103.9	81.7	71.3
October	114.8	90.3	115.4	116.3	142.3	165.9
November	85.8	86.4	25.8	36.4	59.9	53.8
December	81.9	99.2	73.4	87.2	72.7	76.1
January	57.8	67.3	73.2	79.9	52.8	64.5
February	29.3	28.1	58.7	75.8	36.2	40.6
March	23.6	25.8	12.9	11.3	39.0	52.2
April	42.6	47.6	116.1	104.7	87.0	102.0
May	50.7	40.1	76.2	59.7	44.1	48.5
Total	**838.5**	**849.4**	**880.7**	**862.9**	**918.0**	**956.4**

The total annual amount of precipitation observed at both locations was close to the long-term average value recorded for the Lindsay climate monitoring station. However, variations in monthly amounts of precipitation, up to 25%, were observed during the monitoring period (***Table 5.2***). The variation is the greatest within the summer months of June, July and August. This can be explained by the effect of convectional precipitation that occurs during the warm period of the year and is often distributed unevenly.

5.5 Evapotranspiration

Evapotranspiration (ET) is the combination of two simultaneous processes: **evaporation** and **transpiration**, both of which release moisture into the air. Evapotranspiration is a major component of the water balance equation. During evaporation, water is converted from liquid to vapour and evaporates from ground and surface water. During transpiration, water that was drawn up from the soil by tree roots evaporates from the tree's leaves ***(Figure 5.3).***

Rates of evapotranspiration vary considerably, both spatially and seasonally. Seasonal trends of evapotranspiration within a given climatic region follow the seasonal declination of solar radiation and the resulting air temperatures. Minimum evapotranspiration rates generally occur during the coldest months of the year. Maximum rates generally coincide with the summer season.

Measuring evapotranspiration is a complex and costly process. Because of that, ET is commonly computed from weather data, such as air temperature, daily precipitation and wind speed. A large number of empirical or semi-empirical equations have been developed for assessing evapotranspiration from meteorological data. Numerous studies have been done to analyze the performance of the various calculation methods for different locations. The Penman-Monteith method is now recommended as the standard method for the definition and computation of the reference evapotranspiration by the United Nations. The National Atlas of Canada, published in 1974, includes a coarse-scale map of the potential evapotranspiration (PET) for Canada (***Figure 5.4***). According to that map, the PET value for the area that encompasses the Balsam and Cameron lakes watershed is about 560 mm (22 inches).

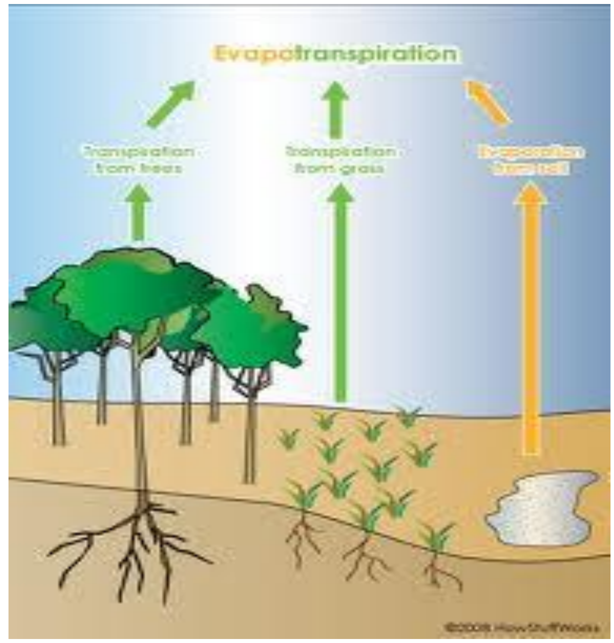

Figure 5.3. Process of Evapotranspiration
Source: http://science.howstuffworks.com

More recent data are available from the National Soil Database (Ecological Stratification Working Group, 1995). This database provides climate normals, including evapotranspiration, for area units that are called Ecodistricts. Each Ecodistrict is characterized by relatively homogeneous biophysical and climatic conditions including: regional landform, local surface form, permafrost distribution, soil development, textural group, vegetation cover/land use classes, range of annual precipitation, and mean temperature. Average monthly and annual potential evapotranspiration values, available in the database, were estimated from monthly climatic normals for each Ecodistrict using the Penman empirical method.

According to this classification, the central and southern portion of the Balsam and Cameron lakes watershed is located in the Manitoulin-Lake Simcoe Mixwood Plains Ecoregion within Mixed Plains Ecozone, District 552. The northern parts of the Gull River and Burnt River watersheds are situated in Ecodistrict 413, which belongs to the Algonquin-Lake Nipissing Ecoregion, Boreal Shield Ecozone. Estimated values of the potential evapotranspiration for those regions are shown in ***Table 5.3*.**

Table 5.3. Average Monthly and Annual Potential Evapotranspiration (mm)

Eco Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
552	0	0	9.4	65.0	103	117	132	103	64.2	29.7	7.3	0	630.6
413	0	0	11.6	63.0	97.6	115	129	103	64.7	30.5	8.2	0	612.8

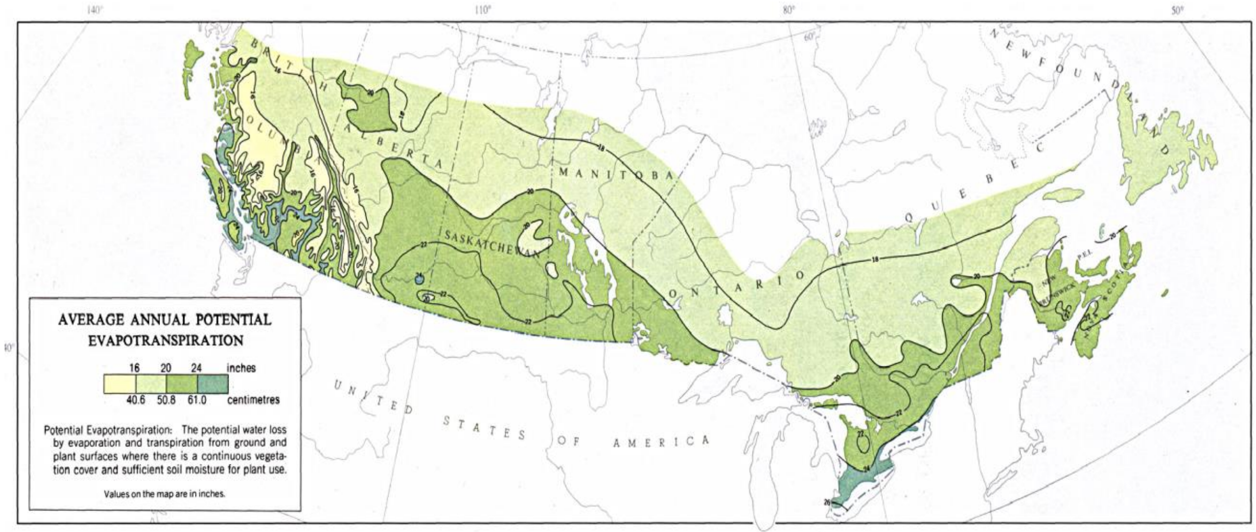

Figure 5.4. Average Annual Potential Evapotranspiration
Source: The National Atlas of Canada, 1974

As was mentioned before, ET values follow the trend of the air temperature. The maximum values for both regions are observed during the summer months: July, June and August. Evapotranspiration in March and November is very low, less than 12 mm, declining to 0 mm in winter season. The average annual evapotranspiration for both ecodistricts is 622 mm.

5.6 Climate Change

Climate change is defined as a shift in long-term average weather patterns (with respect to a baseline or a reference period), that can include changes in temperature and precipitation amounts. Climate change may be due to both natural (i.e. internal or external processes of the climate system) and anthropogenic reasons (i.e. increase in concentrations of greenhouse gases). Climate variability is defined as a deviation from the overall trend or from a stationary state, and refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales (CCCSN, 2014). Climate variability can be thought of as a short-term fluctuation superimposed on top of the long-term climate change or trend.

Observations around the globe show that the atmospheric temperature has exhibited an increasing trend during the last century. This somewhat rapid increase in temperatures is referred to as atmospheric global warming. Increasing concentrations of carbon dioxide and methane (greenhouse gases or GHG) in the atmosphere caused by human activities are believed to be an important contributing factor to this phenomenon. It is expected that climatic warming in some portions of the globe will bring significant changes to weather and climate conditions, including its variability and magnitude, in the near future.

There is a general consensus in the international scientific community that the impacts of climate change are already being felt in some regions. An increase of atmospheric greenhouse gas concentrations is expected to occur even if the global-wide commitments to reduce GHG emissions are fully met by all participating countries. While the absolute magnitude of predicted changes is uncertain, there is a high degree of confidence in the direction of change, and the belief that climate change effects will persist for many centuries. As atmospheric concentrations of both carbon dioxide and methane increase, we can expect the increasing impacts of climate change to have both negative and positive impacts on communities everywhere: in our watershed and communities, in our province, in our country and around the world.

An important tool within this area of study is the construction of climate change scenarios (alternatives or future options), termed climate change modeling. Each scenario shows how the future might unfold under a different combination of factors such as population growth, energy use, land use change, technology change, etc. A set of scenarios assists in the understanding of possible future developments of complex systems.

Under all scenarios, it is expected that mean annual temperature will increase for the study area (***Table 5.4, Figure 5.5***). The highest increase in temperature will be observed during winter (5.1^{o}C increase according to High Emission Scenario) compared to current normals.

Table 5.4. Mean Air Temperature Predictions Under Different Emission Scenarios

Time Period	Annual	Winter	Spring	Summer	Autumn
1971-2000	6.3	-7.1	5.6	18.8	7.9
Low Emission Scenario (LES)					
2020s	7.6 ± 0.4	-5.6 ± 0.5	6.7 ± 0.4	19.9 ± 0.4	9.2 ± 0.4
2050s	8.3 ± 0.6	-4.8 ± 0.7	7.5 ± 0.7	20.7 ± 0.7	9.9 ± 0.6
2080s	9.0 ± 0.7	-3.9 ± 0.8	8.1 ± 0.8	21.3 ± 0.8	10.5 ± 0.8
Medium Emission Scenario (MES)					
2020s	7.7 ± 0.4	-5.5 ± 0.6	6.8 ± 0.5	20.1 ± 0.5	9.2 ± 0.4
2050s	9.0 ± 0.8	-3.9 ± 0.8	8.1 ± 0.9	21.4 ± 0.8	10.5 ± 0.8
2080s	10.1 ± 1.0	-2.7 ± 1.2	9.2 ± 1.1	22.4 ± 1.2	11.6 ± 1.0
High Emission Scenario (HES)					
2020s	7.5 ± 0.4	-5.7 ± 0.5	6.7 ± 0.5	19.9 ± 0.4	9.2 ± 0.4
2050s	9.0 ± 0.6	-3.9 ± 0.8	8.0 ± 0.7	21.4 ± 0.7	10.4 ± 0.6
2080s	10.8 ± 1.0	-2.0 ± 1.1	9.7 ± 1.1	23.3 ± 1.3	12.3 ± 0.9

An increase of annual mean precipitation is expected under all scenarios, with winter and spring experiencing the highest rise - up to 30 mm per season under the Medium Emission Scenario (***Table 5.5, Figure 5.6***). It is important to note that with winter being milder, winter precipitation will fall as rain, affecting the hydrological cycle, monthly stream flows, lake levels, and water resources overall.

These expected weather and climate changes will trigger shifts in all aspects of the environment, including water resources, ecosystems and biodiversity. For example, more frequent and intense rainfall events may lead to increased occurrence of minor and major flooding; development of new, unsuspected flood-prone areas; and increased transportation of contaminants, pollutants and nutrients from the land surface to lakes, rivers and streams. In addition, increased bank and channel erosion should be anticipated from the rapid rise of water which will contribute to surging of streams and rivers.

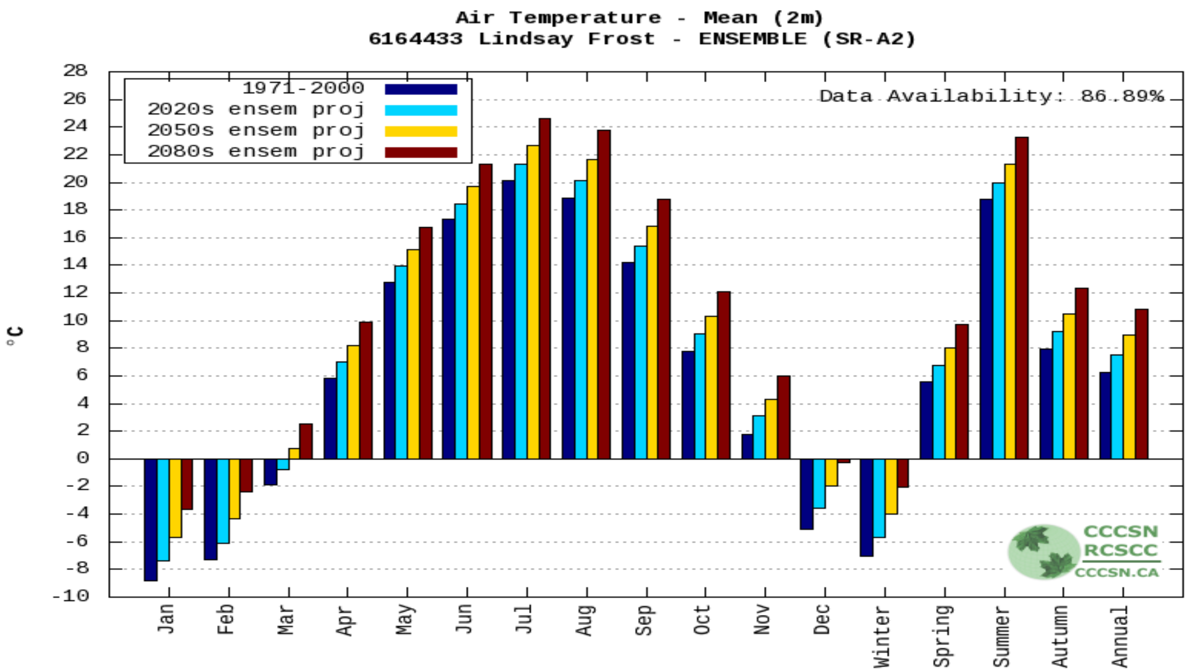

Figure 5.5. Mean Air Temperature - High Emissions Scenario (CCCSN, 2014)

Decreased summer runoff will result in low flow conditions that, in turn, will stress fish habitat and can lead to degraded water quality. Less water will be available for diluting sewage treatment plant effluents, agricultural runoff and nutrients entering waterways from urban lands. Low flow conditions may cause increased competition and conflict over reduced water supplies among water users during drought periods.

As winter precipitation increasingly falls as rain, and the accumulated snowpack decreases, groundwater recharge will most likely be negatively impacted, consequently decreasing the groundwater levels and rates of groundwater discharge to local streams and lakes. As a result, streams dependent on base flow (base flow is the portion of stream flow that comes from groundwater discharge, rather than direct runoff related to rain or snowmelt events) will experience lower levels and reduced flows, adding stress on aquatic ecosystems. Some portions of the Balsam and Cameron lakes watershed, as shown further in Chapter 6, could be especially vulnerable to an increase in periods of dry or low-flow watercourses.

Decreased groundwater levels and discharges may change the form and functions of wetlands. Some wetlands may become dry. In addition, decreased groundwater levels will also put strain on the groundwater supply, possibly affecting private wells. Risk of water shortages and additional competition for a scarce supply will increase. More private wells may dry up, perhaps causing water shortages to develop in areas that have never experienced them before.

The above-mentioned outcomes are only a small portion of the possible local changes as a result of global climate change. Beyond the environmental effects, a changing climate can also impact the social and economic well-being of the Balsam and Cameron lakes watershed residents.

Table 5.5. Total Precipitation Predictions Under Different Emission Scenarios

Time Period	Annual	Winter	Spring	Summer	Autumn
1971-2000	**878.3**	**182.9**	**200.7**	**247.0**	**247.7**
Low Emission Scenario					
2020s	903.3 ± 26.0	196.1 ± 6.8	207.6 ± 10.5	251.3 ± 10.8	247.9 ± 15.6
2050s	923.1 ± 31.5	199.1 ± 9.1	216.1 ± 8.9	253.3 ± 17.5	254.9 ± 20.4
2080s	939.9 ± 29.6	207.3 ± 9.9	223.0 ± 12.4	251.0 ± 16.2	256.9 ± 18.0
Medium Emission Scenario					
2020s	910.6 ± 25.2	196.9 ± 7.2	209.9 ± 8.2	251.0 ± 14.3	252.3 ± 14.4
2050s	930.1 ± 33.6	203.9 ± 10.4	219.3 ± 16.4	249.7 ± 17.3	257.1 ± 17.3
2080s	960.3 ± 43.3	213.8 ± 13.4	231.0 ± 19.6	250.4 ± 24.2	264.5 ± 22.6
High Emission Scenario					
2020s	903.3 ± 26.0	196.1 ± 6.8	207.6 ± 10.5	251.3 ± 10.8	247.9 ± 15.6
2050s	923.1 ± 31.5	199.1 ± 9.1	216.1 ± 8.9	253.3 ± 17.5	254.9 ± 20.4
2080s	939.9 ± 29.6	207.3 ± 9.9	223.0 ± 12.4	251.0 ± 16.2	256.9 ± 18.0

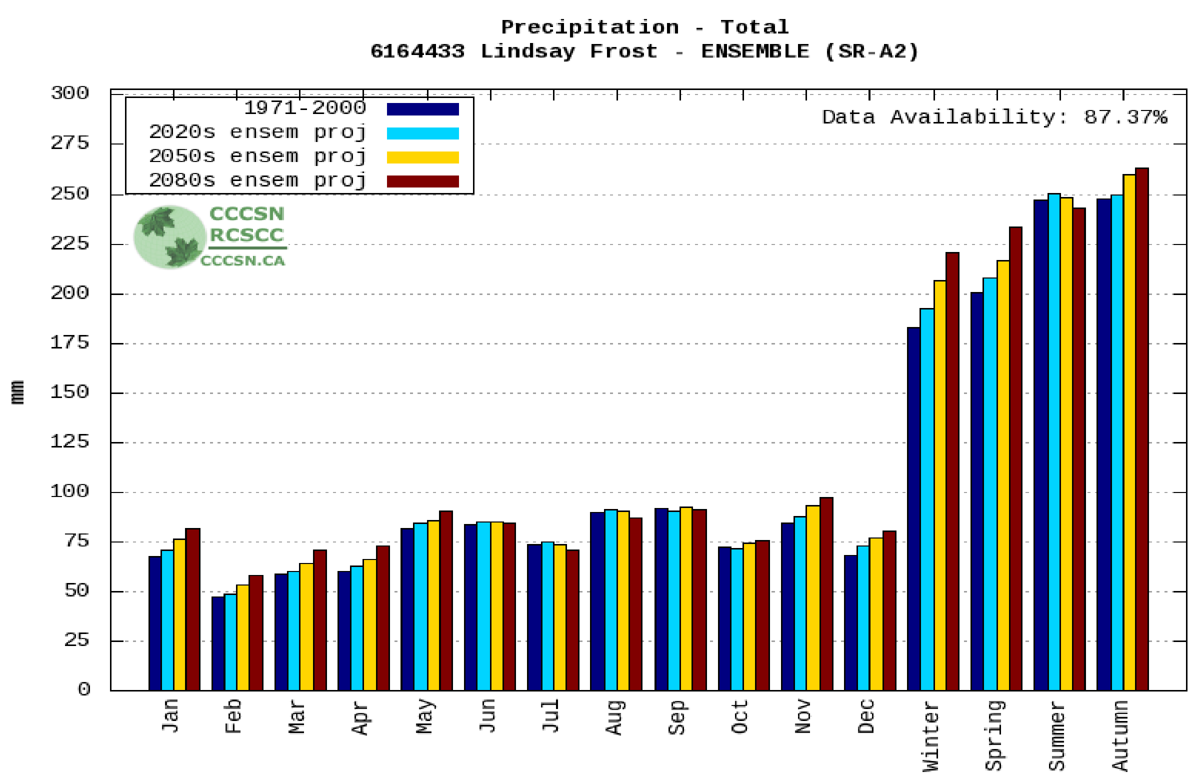

Figure 5.6. Total Precipitation - High Emissions Scenario (CCCSN, 2014)

6.0 Water Quantity

6.1 Summary of Observations and Issues

OBSERVATIONS

- The water level regime in Balsam and Cameron lakes generally follows the natural pattern, but it is defined and regulated in accordance with the Trent-Severn Waterway water level management strategy;
- Southern, unregulated tributaries of Balsam and Cameron lakes exhibit a natural flow regime with well-defined seasonal flow patterns. High flows typically occur in spring, associated with snowmelt, and throughout the year following high-volume precipitation events. Low flows are typically observed in the summer and winter months;
- Even though two large northern tributaries, the Gull and Burnt rivers, are highly regulated for the purpose of the Trent-Severn Waterway navigation system, they still keep the seasonal flow pattern with the highest flow observed in spring and low-water periods during the summer and winter months;
- Wetlands and forested areas that are abundant in the Balsam and Cameron lakes watershed provide significant benefits for the surface water, moderating stream flow, providing high and low-flow mitigation and assisting in groundwater recharge;
- Water-taking from Balsam and Cameron lakes, that falls under the regulation of the “Permit To Take Water Program” (PTTW), is not significant. However, the cumulative effect of water-taking a(both from surface and ground water sources) that does not require permitting, is unknown;
- Annual monitoring data on lake evaporation are not available. This adds uncertainty to the calculations of a water budget.

KEY ISSUES

- The groundwater discharge to the tributaries of Balsam and Cameron lakes that supports baseflow and is a main component of the stream flow during the dry periods is extremely low or non-existent in the prevailing portion of the watershed. This causes small and medium southern watercourses to flow very low or to go stagnant or dry during periods of limited precipitation due to limited capacity of the shallow aquifers in the study area that provide groundwater input to the stream flow;
- Flow monitoring data from the southern portions of the Balsam and Cameron lakes watershed are limited to three years of monitoring in the framework of the BCLMP. Monitoring data are a key source of information on the water resources’ conditions and trends. Water level and flow monitoring should be continued;
- Some aspects of land use change, such as increasing impervious surfaces, urban development and agricultural practices, can affect the quantity of both surface and groundwater resources;
- Climate change has the potential to impact the flow regime of local watercourses by reducing the duration and intensity of spring runoff and aquifer recharge, and by increasing the potential for dry conditions and/or extreme high-flow events during summer.

6.2 Drainage Network

Balsam and Cameron lakes have the highest elevations in the Kawartha Lakes system. Other lakes, located downstream in this system are Sturgeon, Pigeon, Buckhorn, Chemong and Stoney lakes. Together, they form the backbone of the Trent River watershed***.***

Balsam Lake

Balsam Lake is the most westerly lake in the Kawartha chain of lakes. The west boundary of the Balsam Lake watershed forms a natural divide between the Lake Ontario and Lake Huron/Georgian Bay watersheds, so water from the lake naturally flows in an easterly direction toward Lake Ontario (***Figure 6.1***).

In spite of the natural topography, water from Balsam Lake crosses the divide into the Lake Huron watershed. By means of the man-made Trent-Severn Canal, Balsam Lake is connected to Mitchell Lake which is part of the Talbot River watershed and drains into Lake Simcoe.

Water levels in Balsam and Mitchell lakes are artificially maintained by the Trent-Severn Waterway. According to the TSW water management strategy, water levels in the two lakes are kept at the same level during the summer and fall, therefore minimal outflow occurs from the Balsam Lake watershed to the Lake Simcoe watershed. In the fall and winter seasons, a guard gate (a type of a temporary dam) is installed in the canal that maintains the lakes at different levels, as the overall TSW water management strategy requires. Some flow, in the range of 1-5 m^3/sec, is allowed to pass into Mitchell Lake, depending on difference in water levels and weather conditions. These flows are maintained through the vaults at the guard gate; they also assist in sustaining an amount of dissolved oxygen sufficient for the aquatic ecosystem in Mitchell Lake.

As mentioned, at its east end Balsam Lake is connected to Cameron Lake by means of a short channel (~2 km) locally called the Rosedale River, and a constructed navigational canal.

The Balsam Lake drainage area is composed of a number of tributaries that drain into the lake (***Figure 6.1, Table 6.1***). The Gull River is the largest tributary. It empties into Balsam Lake at its north end, downstream of Coboconk. It is a large river system of 122 km in length that drains almost 1,350 km^2 of land within Canadian Shield. There are 17 reservoir lakes controlled by 21 dams within the Gull River system operated by the Trent-Severn Waterway. The lakes within the Gull River watershed have significant capacity that provides flood mitigation and seasonal water level management functions (AECOM, 2013).

Corben Creek is another tributary that flows into Balsam Lake at its northern end. It is a smaller size watercourse, about 25 km in length and with a drainage area of 68.4 km^2. Karst formation features along the channel make this watercourse unique and affect its flow regime.

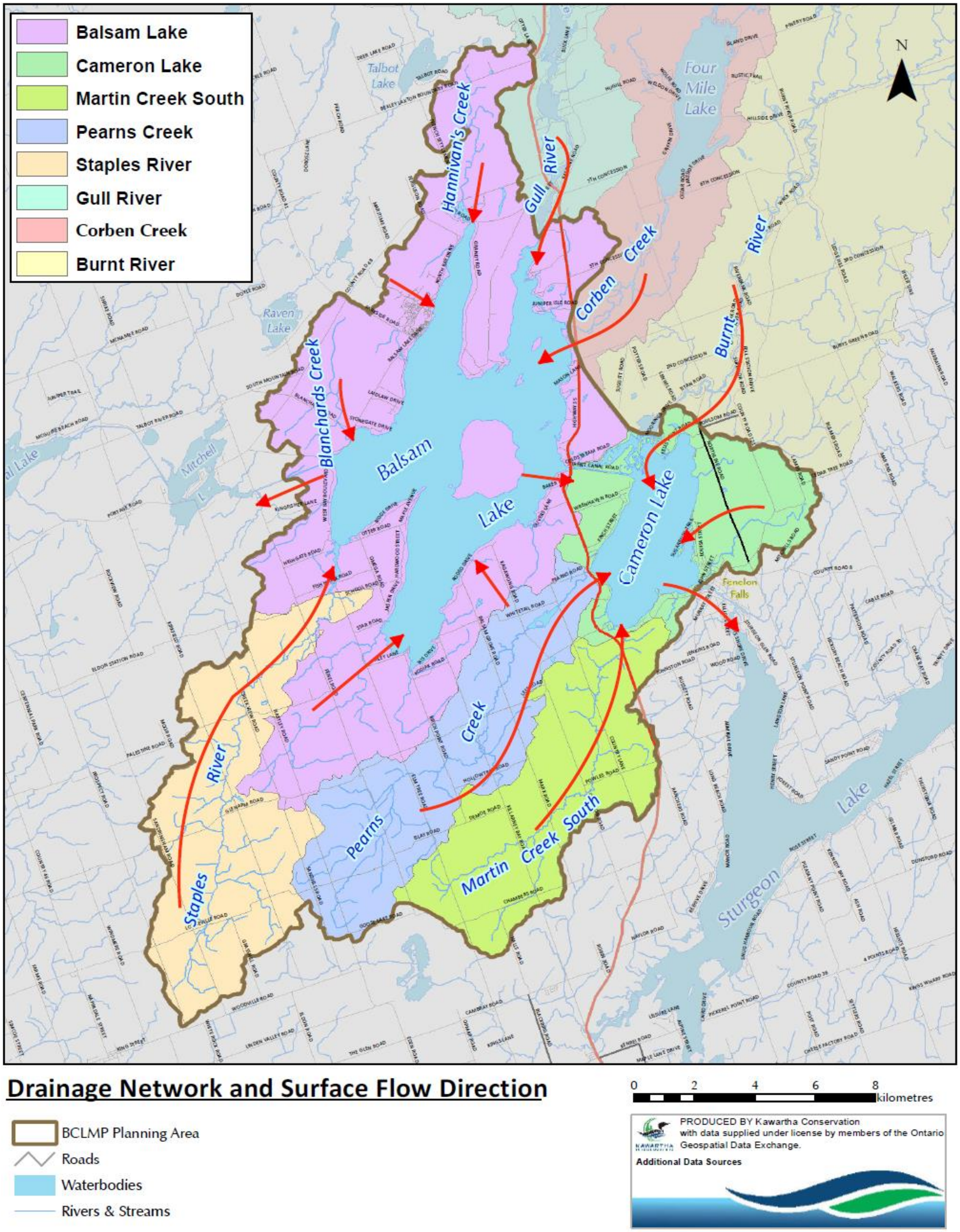

Figure 6.1. Drainage Network and Flow Directions in the Balsam and Cameron Lakes Watershed

Table 6.1. Stream and Subwatershed Characteristics, the Balsam and Cameron Lakes Watershed

Sub watershed	Drainage area (km^2)	Stream Network Length (km)	Main Channel Length (km)	Main Channel Gradient (m/km)	Natural Cover (%)	Agriculture (%)	Rural/Urban Development (%)	Stream Density (km/km^2)	Average Watershed Slope (%)
Balsam Lake Subwatershed	114.8	87.37	n/a	n/a	64.8	26.1	6.2	0.76	1.97
Staples River	47.90	66.99	20.55	2.51	31.6	63.4	3.3	1.40	2.24
Cameron Lake Subwatershed	25.39	14.07	n/a	n/a	43.1	41.4	11.4	0.55	2.20
Pearns Creek	43.90	64.37	20.65	2.61	33.6	61.1	3.5	1.46	2.85
Martin Creek South	41.82	43.36	17.82	2.95	50.4	41.7	4.1	1.04	2.82

The other tributaries that drain the southern portion of the Balsam Lake watershed are small to medium in size and only one of them is named, the Staples River. The drainage area of the Staples River is 47.9 km^2 and it flows through agricultural lands within the Peterborough Drumlin Field. The length of its main channel is 20.6 km, the average main channel gradient is only 2.51 m/km. As a result, the Staples River is characterized by a broad floodplain with associated wetlands and poorly defined channel.

Land use within a watershed affects the hydrological regime of a watercourse. Naturally covered areas provide significant benefits in keeping water resources abundant and clean. Forest cover helps to moderate stream flow, providing high and low flow mitigation and assisting in groundwater recharge. Similar to forest cover, wetlands provide peak flow mitigation and flood storage capacity as well as assist in improving water quality by sediment trapping and nutrient retention and removal.

Development areas, on the other hand, have greater areas of impervious surfaces which alter the spatial and temporal distribution of flow, increasing the flood peaks and volumes, and decreasing groundwater recharge, storage and discharge.

While agricultural activities impact water quality more than quantity, they can also change some aspects of the stream flow regime, including higher velocity run-off over tilled soils that can alter peak flows.

As described in Chapter 3 - Land Use, about 26% of the Balsam Lake subwatershed lands are used for agriculture, and almost 65% of the watershed area is occupied by forests (32%), wetlands (21%) and meadows that are collectively classified as natural cover. The agricultural lands are not evenly distributed throughout the drainage area adjacent to Balsam Lake. The majority are located in the southern portion of the watershed where soils and drainage are more suitable for agriculture.

The Staples River catchment area, a part of the overall Balsam Lake watershed, has the highest degree of agricultural development - more than 63%. Consequently, only about 30% of the Staples River subwatershed is occupied by natural cover (14% wetlands, 11% forest and 6.3% meadows).

Cameron Lake

Cameron Lake is the smallest of the Kawartha Lakes within the Kawartha Conservation watershed. Its water surface area is about 14.7 km^2. Cameron Lake is connected to Balsam Lake at its north-west end and to Sturgeon Lake at the south-east end (***Figure 6.1***).

There are three major tributaries that flow into Cameron Lake. The Burnt River is the largest tributary of Cameron Lake. It flows in a southern direction through the rugged landscape of the Canadian Shield, entering Cameron Lake at its northern end and bringing a significant flow volume. The Burnt River is more than 128 km in length, with a drainage area about 1,490 km^2. Water levels and flow of the Burnt River are controlled by 18 dams, 13 of them are operated by the Trent-Severn Waterway (Parks Canada, 2014). The majority of dams are situated in the upper reaches of the Burnt River. The low gradient, meandering character of the river and insufficient channel storage capacity make the river's lower portion vulnerable to flooding, especially during the spring freshet. Structures, including residential dwellings that were built in the floodplain prior to the current development standards, become inundated on a regular basis.

The two other tributaries with names that form the southern portion of the Cameron Lake subwatershed are Pearns Creek and Martin Creek South. These streams are situated within the Peterborough Drumlin Field physiographic region and flow in a northern direction toward Cameron Lake. The length of the main channel of

Pearns Creek is 20.6 km, and Martin Creek South is 17.8 km. Both watercourses are characterized by low average channel gradients (2.61 m/km for Pearns Creek and 2.91 m/km for Martin Creek South), poorly defined channels and broad floodplains that are occupied by large wetlands.

About half of the Cameron Lake watershed is used for agricultural production. A considerable portion of the watershed, 43.1%, is covered by wetlands, forests and meadows that are classified as natural cover.

Approximately 5% of the Balsam and Cameron lakes watershed is occupied by rural and urban development (towns, villages, residential subdivisions and farms). Due to its low level, urban development within the study area does not affect the natural hydrological functions of the local watercourses.

There are water control structures, such as dams and locks, at major connections between the Kawartha Lakes, including Balsam and Cameron lakes (***Figure 6.2***). A dam and a lock are located on the Rosedale River and the canal between Balsam and Cameron lakes, as well as on the Fenelon River between Cameron and Sturgeon lakes. Locks facilitate boating between the lakes and are operated and maintained by the Trent-Severn Waterway.

6.3 Water Levels and Flow Regime

Surface water quantity (volume of water in watercourses and water bodies) assessments are usually achieved through water level and flow monitoring. Collected long-term data assist in identifying changes that may affect water quality, geomorphic stability and aquatic health of a watercourse as well as providing invaluable data for modeling of water resources, water budget calculation and water allocation. Changes in flow conditions may reflect changes in climate (precipitation, evapotranspiration), water demand, land use or the watershed's natural cover. Water level monitoring data also provide information for flood forecasting, warning and emergency management.

Continuous water level monitoring for the Balsam and Cameron lakes management planning project has been done by seven gauge stations ***(Figure 6.3).*** Two gauges monitor lake water levels; three monitoring locations are situated on watercourses within the Balsam Lake watershed, and another two on watercourses in the Cameron Lake watershed. All monitoring gauges consist of a sensor that measures the water level at pre-set intervals (15 min, 30 min or 1 hour) and a data logger that records measured values. Details on the flow monitoring locations are shown in ***Table 6.2.***

Water levels represent heights of water above the sensor. Information on water levels is very important for flood forecasting and emergency management, floodplain development and other applications. In order to develop a water budget or calculate the amount of pollutants carried with water into a lake, data on the volume of water that flows through the watercourse is required. In order to convert observed water level data into flow information, a rating curve has to be developed. Discharge (volume of water that flows through a cross section of a watercourse in one second) and corresponding water levels are measured numerous times at the monitoring location and graphed to develop a relationship. A wide range of water levels and flow (from the highest to the lowest) are targeted in order to establish reliable relationship. Once a rating curve and an equation that describes it are developed, water level values are converted to discharges that characterize water quantity at the gauging location.

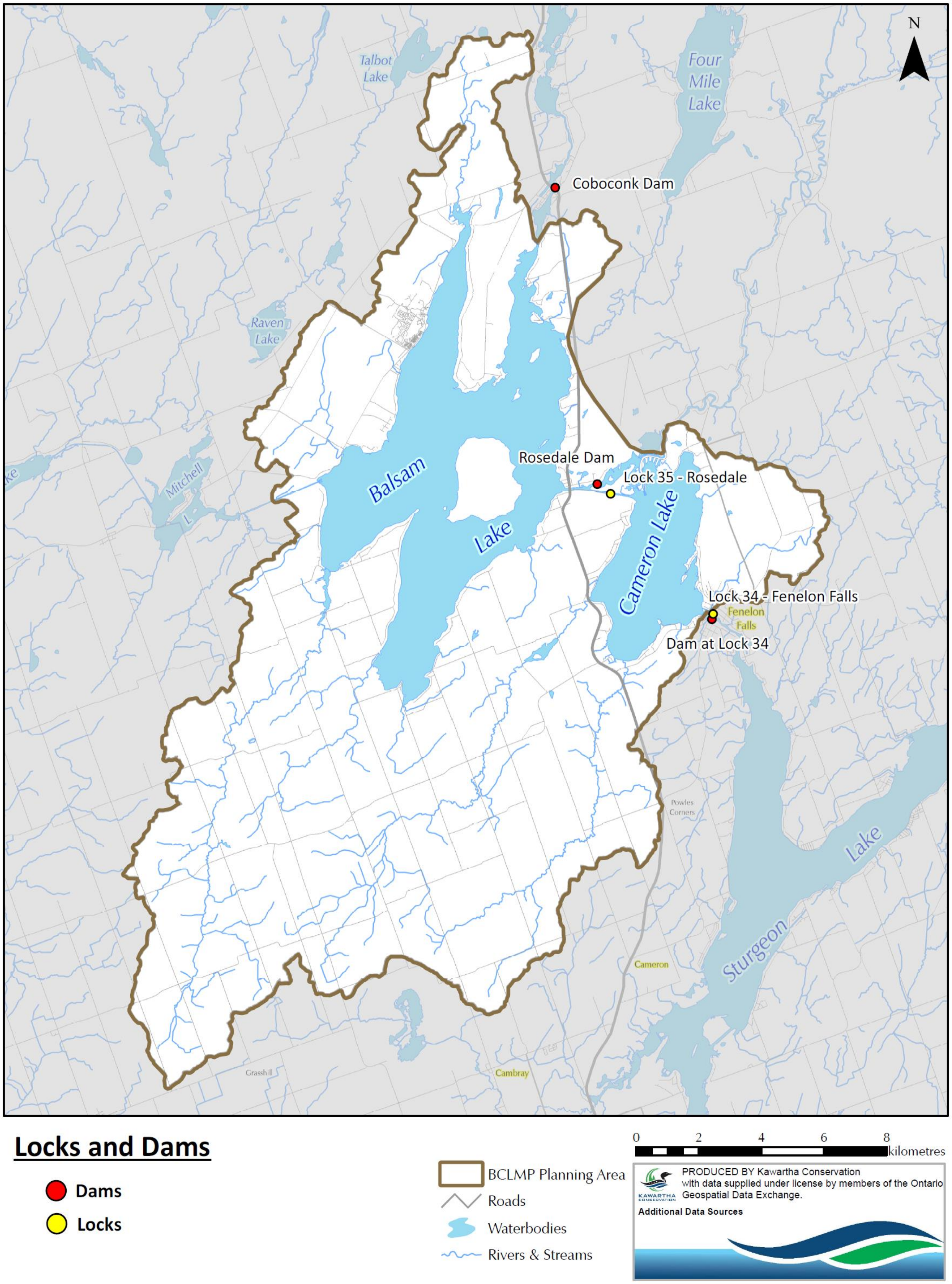

Figure 6.2. Water Structures in the Balsam and Cameron Lakes Watershed

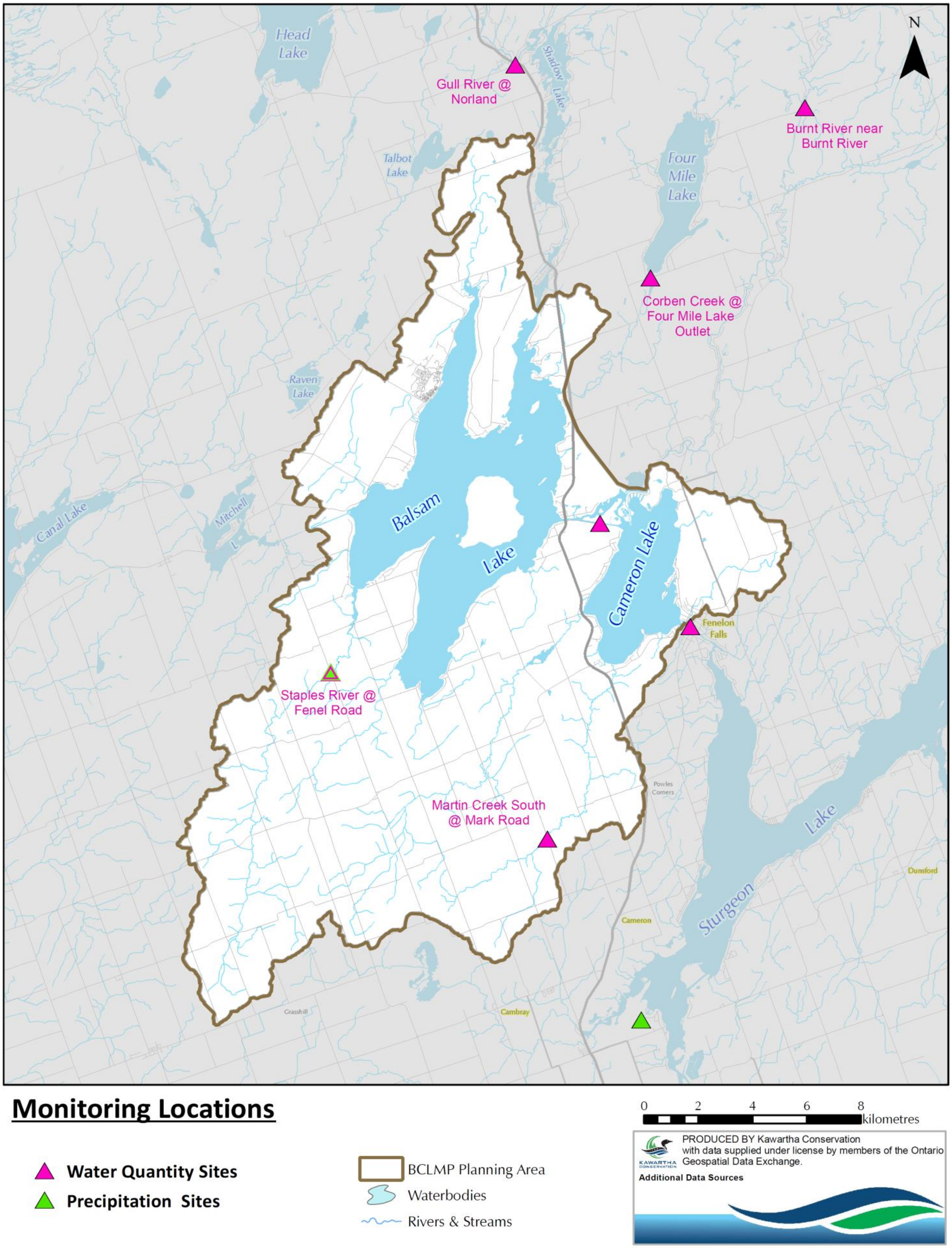

Figure 6.3. Flow Monitoring Locations in the Balsam and Cameron Lakes Watershed

Table 6.2. Continuous Water Level and Stream Flow Monitoring Locations

Waterbody / Watercourse	Location	Drainage Area, km^2	% of total subwatershed area	Data Interval	Data Record	Type	Ownership
Balsam Lake Watershed							
Balsam Lake	Rosedale Dam	n/a	n/a	1 hour		Permanent, stilling well	Trent-Severn Waterway
Gull River	Norland	1281.5	95	15 min	1962 - current	Permanent, stilling well	Environment Canada - Water Survey Division, 02HF002
Staples River	at Fenel Road	45.09	94	30 min	2011 - 2014	Temporary, pressure transducer	Kawartha Conservation
Corben Creek	Four Mile Lake outlet	52.6	77	1 hour	2013 - current	Temporary, pressure transducer	Kawartha Conservation
Cameron Lake Watershed							
Cameron Lake	Fenelon Falls Dam	n/a	n/a	1 hour		Permanent, stilling well	Trent-Severn Waterway
Burnt River	near Burnt River	1251.74	84	1 hour	1962 - current	Permanent, stilling well	Environment Canada - Water Survey Division, 02HF003
Martin Creek South	at Mark Road	20.8	50	30 min	2012 - 2014	Temporary, pressure transducer	Kawartha Conservation

Water levels and flow vary over time and space. Floods and low-flow periods occur, sometimes in a predictable seasonal pattern, and sometimes less predictably. Rivers and lakes in variable climates tend to have variable flows, and rivers and lakes that are groundwater fed tend to have more constant and predictable water levels and flows. Flow regime describes the average seasonal water level and flow variability for a particular river or lake and reflect climatic and physiographic conditions in a watershed. The best way to explore the regime of a watercourse or a waterbody is to study its long-term average water levels and flow.

Balsam and Cameron Lakes

Water levels in Balsam and Cameron lakes are highly regulated by the Trent-Severn Waterway. The dam in Rosedale controls Balsam Lake's level, and the dam in Fenelon Falls controls Cameron Lake's level. ***Appendix 3*** summarizes the basis, approach and special considerations applied to the water management of the Kawartha Lakes sector by the TSW.

Water levels in both lakes are also monitored by the Trent-Severn Waterway. The gauge that monitors water levels of Balsam Lake is located upstream of the Rosedale dam, while the Cameron Lake gauge is located at the Fenelon Falls dam. Both are permanent, automated water level monitoring gauges with real-time connection capacity.

Long-term data is available for both monitoring locations. Water levels data are used to estimate the amount of flow that passes through the dams on a daily basis. These data were used for the calculation of the lake water budget and nutrient loads, in addition to the monitoring data collected by Kawartha Conservation.

Management of water levels is one of the great challenges for the TSW. It is based on an annual cycle of operations augmented by over 100 years of recorded water levels, flows, weather data and new technologies. Water levels, water current velocities and precipitation data from monitoring network are accessed and analyzed on a daily basis by TSW officials.

A variety of groups, including cottagers, year-round residents, commercial operators, power generators, and others, are all concerned about water level fluctuations. The TSW water management goal is to provide for safe navigation while trying to accommodate the other water users (Ecoplans Limited, 2007). There are a variety of constraints to reconciling the conflicting demands to regulate water levels and flows within the watersheds, not the least of which is climate and weather, which can be neither controlled nor guaranteed.

Overall water level management on lakes and rivers within the Waterway, including Balsam and Cameron lakes, is based on a yearly cycle. Cameron Lake, as one of the smaller navigation lakes, is lowered to the target winter levels between October 15 and December 1 to avoid problems of dam access by operational staff and to reduce water control costs. Balsam Lake, as one of the larger Kawartha Lakes, is allowed to decline to the middle or bottom of the TSW's navigation range and then is drawn down from January 1 to March 15. Normally, this ensures that the lakes are at their natural low levels prior to the spring freshet. The date by which the final level is attained varies with the natural inflow during the winter. Winters with high inflows mean that lakes would not drop as far as is desirable, thus reducing flood storage. Dry cold winters with low inflow can cause some lakes to drop lower than normal (Ecoplans Limited, 2007).

Throughout the spring freshet, the TSW has two difficult and sometimes competing objectives:

1. Create reservoir space for the spring freshet to reduce or eliminate possible flooding, and
2. Store as much water as possible for summer use.

Once the freshet starts, some reservoir lakes (lakes located at headwaters of the TSW including the Gull and Burnt rivers) and many Kawartha Lakes fill or overfill even with fully open dams. Downstream conditions are also critical to take into consideration. For example, during extreme flood conditions, a decision may be required to fill the lakes above normal levels in order to prevent much more serious flooding downstream.

It is important to remember that the size of the system makes the water level management very challenging, requiring a balancing of multiple needs. For example, if Balsam Lake is rising too high due to rainfall or freshet, the obvious response is to increase the flow at the Rosedale Dam. But this flow goes to Cameron Lake, which is much smaller in volume. If no further adjustment is made, the Cameron Lake shoreline would be flooded. Therefore, the flows must be passed on downstream at Fenelon Falls. Under heavy runoff conditions a cascading effect usually occurs all the way to Trenton.

During the summer, attention shifts to maintaining water levels and flows. The three main objectives for summer water control are:

1. Maintain the lakes within navigable depth ranges;
2. Use as little water as possible from the reservoir lakes, and maintain them at the same percentage of storage depth; and
3. Maintain sufficient flows through the system to ensure water quality.

During the summer season, evaporation from the Kawartha Lakes is usually greater than water inflow from unregulated tributaries, precipitation and ground water. Therefore, additional water must be supplied to the lakes from the reservoir lakes.

Lake Tributaries

Data from five flow monitoring locations in the Balsam and Cameron lakes watershed were used to characterize their hydrological regime and calculate volume of water that enters the lakes (***Table 6.2***). The monitoring locations on the Burnt and Gull rivers are components of the Canada-wide hydrometric monitoring network that is maintained by the Water Survey Division, a division of Environment Canada. These two stations are the oldest flow monitoring locations within the Balsam and Cameron lakes watershed, established in 1962. Both are permanent monitoring locations with a real-time connection capacity. It is a very important feature for flood emergency management, since both the Burnt River and Gull River have an extensive history of flooding.

Hydrometric station **02HF003 Burnt River near Burnt River** is situated at the downstream portion of the river system, just north of the Village of Burnt River. The main purpose of this gauge is to provide a flood warning thresholds for areas located downstream. The gauge captures flow that is generated by more than 80% of the watershed's drainage area. Long-term (over 50 years) water level and flow datasets are available for this monitoring location. The hydrometric station **02HF002 Gull River at Norland** is located just north of the Village of Norland. The gauge station measures flow generated by more than 90% of the river's catchment area. The water level monitoring gauge on the **Staples River at Fenel Road** provides information on flow and its regime at the southern portion of the Balsam Lake watershed. This station is located in the middle part of the Staples River and monitors flow that is generated by 49% of the subwatershed. This monitoring location is temporary; it was established specifically for the purposes of the Balsam and Cameron Lake Management Planning Project. It is operated and maintained by Kawartha Conservation. The southern portion of the Cameron Lake watershed is monitored by means of a water level monitoring station established on **Martin Creek South** downstream of its crossing with Mark Road. This station was established and is operated by Kawartha Conservation.

The measuring location on the **Corben Creek at the outlet of Four Mile Lake** was set up by Kawartha Conservation for the purpose of developing a Lake Management Plan for Four Mile Lake. The monitoring commenced during the first year of the project, in June 2013. Data, available at time of this report, is not sufficient for analysis.

Two monitoring locations, the Burnt River (near Burnt River) and the Gull River (at Norland) have a period of records long enough to determine average monthly and yearly water levels and discharges (***Figures 6.4 and 6.5***). Both monitoring locations describe the flow regime of the northern portions of the entire Balsam and Cameron lakes catchment basin.

For gauging stations on the Staples River and Martin Creek South, discharges as observed in 2012 and 2013 are used for interpretation (***Figures 6.6 and 6.7***). Datasets from the Staples River and Martin Creeks South monitoring locations are not satisfactory for the statistical analysis due to their short length. As such, any conclusions derived from these data should be treated as strictly preliminary.

It is important to note that precipitation conditions in 2012 and 2013 were different, with 2013 being close to a normal year and 2012 being extremely dry with almost no snow cover during the 2011-2012 winter season. The air temperatures observed in 2012 were abnormal as well: record breaking heat in mid-March with prolonged periods of very hot weather during the summer months.

The water level and flow data, including the long-term average values, confirms that all monitored watercourses have well-defined seasonal patterns, reflecting seasonal variations of water inflow. The highest flows and water levels on the Gull and Burnt rivers are typically observed in April in response to the spring freshet. On the Staples River, during the two-year observation period, the peak flows occurred in March, and in April on Martin Creek South in 2013.

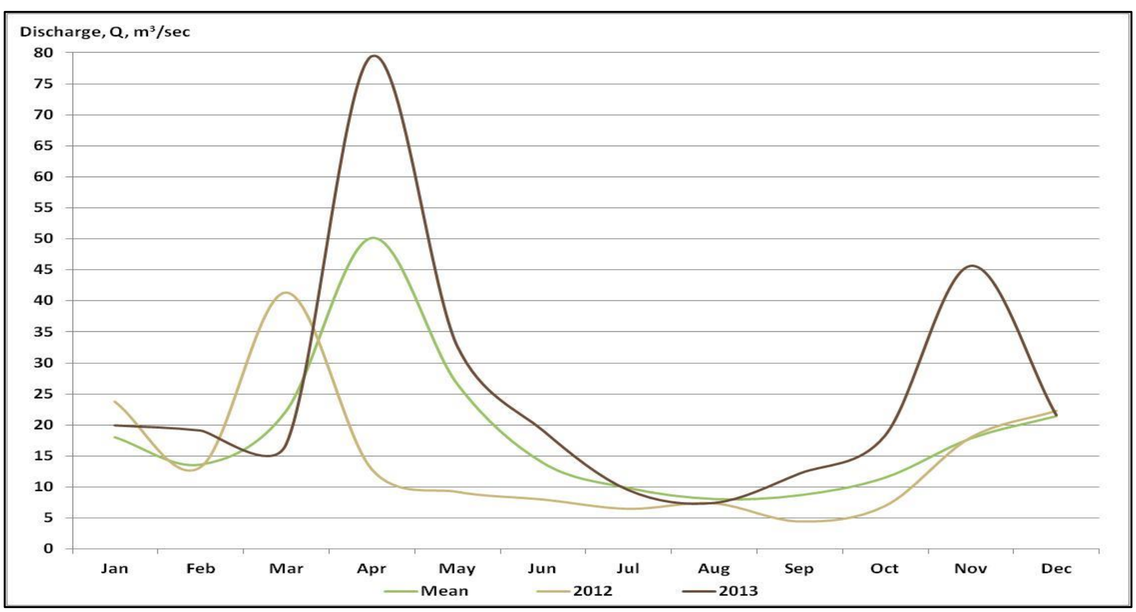

Figure 6.4. Average Monthly Flow of the Burnt River near Burnt River: Long Term Average, 2012 and 2013

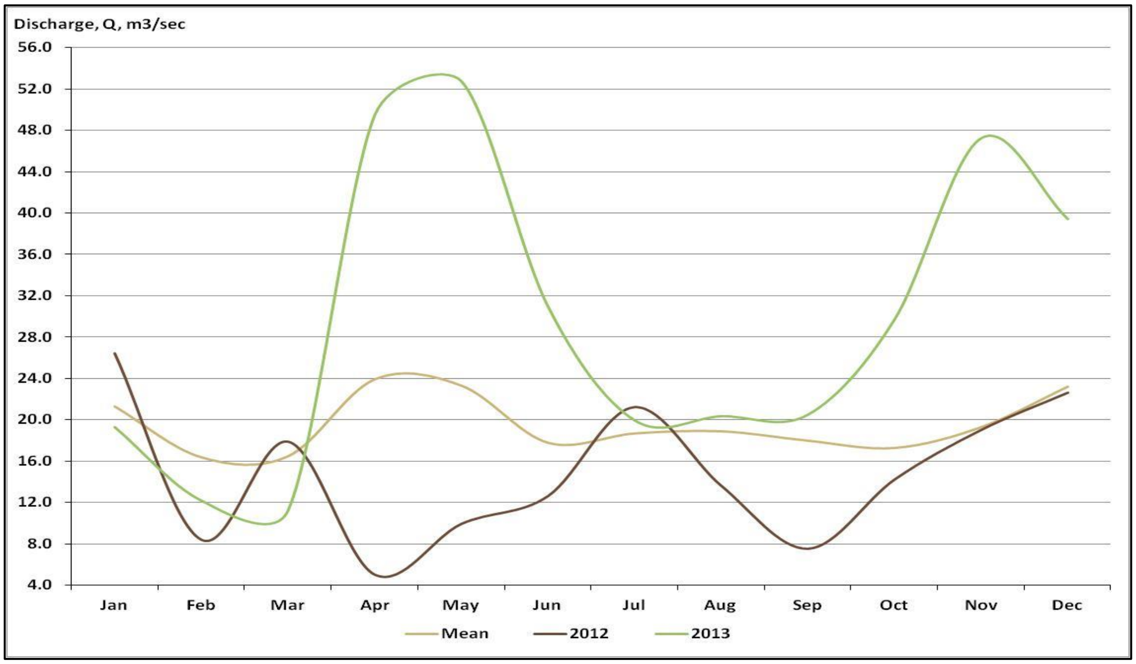

Figure 6.5. Average Monthly Flow of the Gull River at Norland: Long Term Average, 2012 and 2013

There are at least two reasons for the different timing of maximum flows on these tributaries. First of all, the Burnt and Gull river watersheds extend to the north, where spring warming starts later and snow melt occurs slower, while the Staples River and Martin Creek South represent the southern portion of the Balsam and Cameron lakes watershed. In addition, as mentioned, both the Burnt and Gull river systems have drainage areas that are substantially larger than the Staples River and Martin Creek South. The smaller watercourses react to the changing runoff conditions faster, while it takes much longer for the larger rivers.

According to the long-term monitoring data, July-October is a period of low flow in local watercourses. By that time, the groundwater reserve is already depleted and sporadic precipitation and high evapotranspiration rates keep the surface run-off component of stream flow low. For the Gull and Burnt rivers, lowest monthly flow is typically observed in August through October, while for the Staples River and Martin Creek South it was observed in July in both 2012 and 2013, with August being the second-driest month.

Because of exceptionally dry summer conditions in 2012, the flow observed during that period deserves special note. As mentioned, precipitation and weather conditions observed in 2012 could be considered abnormal. Limited snowpack and unprecedented warm temperatures in March caused very a early and lower than normal freshet. Precipitation during the subsequent months was about 60-80 % of normal. As a result, water levels and flows in local rivers and streams were very low. The occasional rain events, even those of higher amounts and intensity, did not produce much runoff because the overall watershed conditions were dry. Under these circumstances, a number of smaller watercourses within the Balsam and Cameron lakes subwatersheds, including the Staples River, became dry for an extended period of time. At the monitoring location at Fennel Road, the Staples River had turned into a series of disconnected pools and puddles. It had no flow from July 7 to August 12 and from August 23 to September 9.

The lowest flows in Martin Creek South in 2012 occurred as early as July. However, it is important to note that the groundwater supply to this watercourse was low but steady. This allowed for maintaining some flow in a channel during the driest periods. Extended wetlands that occupy almost 33% of the watercourse drainage area are believed to have assisted both surface and ground water retention.

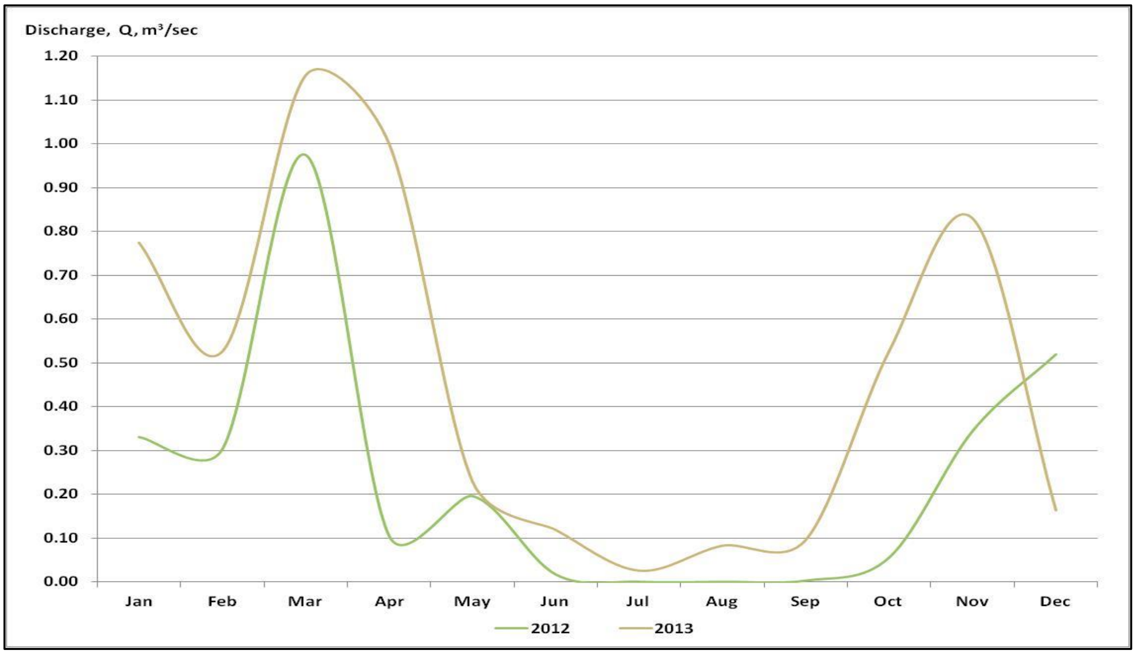

Figure 6.6. Average Monthly Flow of the Staples River at Fennel Road in 2012 and 2013

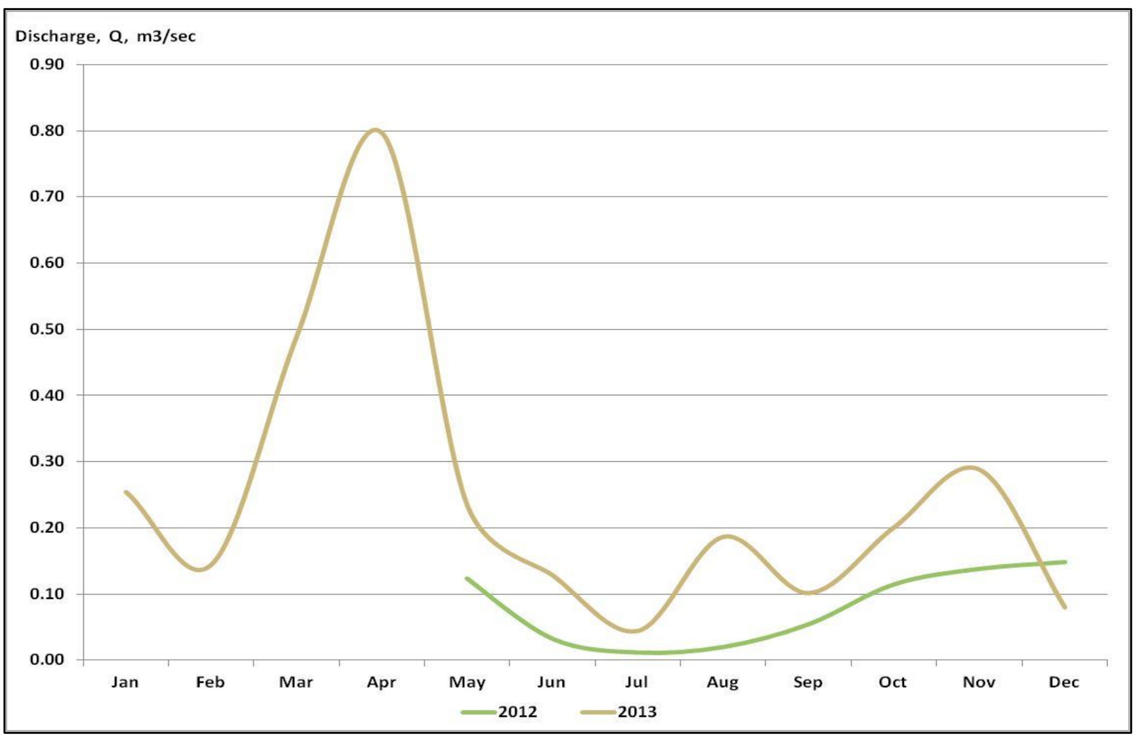

Figure 6.7. Average Monthly Flow of Martin Creek South at Mark Road in 2012 and 2013

On both the Gull and Burnt rivers, the lowest instantaneous, daily and monthly flows in 2012 were recorded in September, at or below previously recorded values.

Typically, water levels start gradually increasing in October and keep rising in November-December, responding to the higher precipitation volumes and lower rates of evapotranspiration. During the winter months (December-February), ice cover forms on the tributaries of Balsam and Cameron lakes and the water levels remain low. The major source of water inflow during that time is groundwater. Sometimes cold winter weather is interrupted by milder temperatures and even occasional rains. Especially typical is a January thaw. When a thaw is significant enough to melt the existing snowpack and create a runoff, water levels and flows in the local watercourses increase, sometimes significantly.

6.4 Baseflow

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

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

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

Methodology

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

Criteria for the site selection include:

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

Baseflow sampling was conducted following standardized procedures (Hinton, 2005). In order to collect comparable and reliable data, the stream flow measurements are to be performed under consistent groundwater inflow conditions; meaning the volume of groundwater storage should not experience significant change. Therefore, the survey is to be conducted under dry conditions when no significant precipitation has occurred during the previous two weeks, in the shortest possible period of time. Data analysis involves calculation and mapping of discharge and net discharge at every measured point and net discharges per a square kilometer ***(Figure 6.8).***

The baseflow data for the Balsam and Cameron lakes watershed were collected during the summer of 2011. In total, 32 sites throughout the study area were visited ***(Table 6.3).*** Four sites were found flowing and were measured. Two sites were visibly flowing, but not suitable for measurements (too deep to measure).

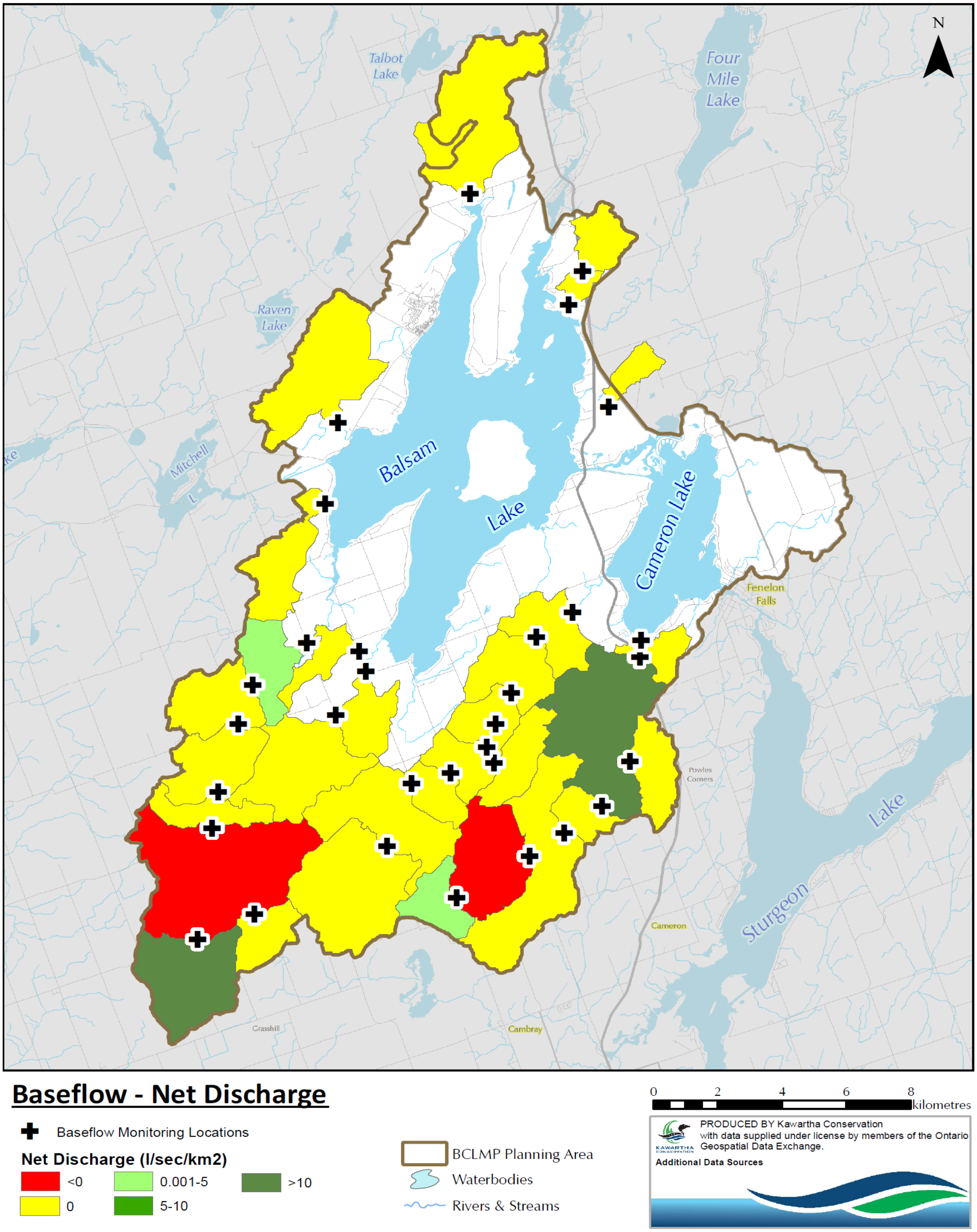

Figure 6.8. Baseflow Distribution in the Balsam and Cameron Lakes Watershed

Twenty six sites were found dry or with standing water in the channel, indicating that no groundwater contribution was occurring upstream of the sampling location.

Further data analysis involves calculating net discharges at every measuring point and net discharges per square kilometer. Based on the observed data, a map of the groundwater net discharge has been created ***(Figure 6.8).*** This map shows distribution of the groundwater discharge throughout the watershed.

Table 6.3. Baseflow Monitoring in the Balsam and Cameron Lakes Watershed

Watershed	Number of Stations				
	Total	Measured	Not suitable for measurement	Dry / No Flow	Not found / Not accessible
Balsam Lake	8	0	0	8	0
Staples River	7	2	0	5	0
Cameron Lake	0	0	0	0	0
Pearns Creek	9	0	1	8	0
Martin Creek South	8	2	1	5	0
Total	**32**	**4**	**2**	**26**	**0**

Overall, analysis has revealed that:

- The study area is characterized by very limited baseflow (groundwater inflow) discharge. More than 80% of sampled locations(which represent almost 90% of the study area) were found dry or filled with standing water, indicating no groundwater inflow;
- Less than 5% of the study area produces groundwater discharge more than 10 L/sec/km^2. (That area is located at the headwaters of the Staples River and lower portion of Martin Creek South. The surficial geology of those areas is characterized by deposits of sand and gravel that usually indicate productive aquifers.);
- Groundwater inflow with a rate less than 5 L/sec/km^2 was measured at downstream portions of the Staples River and Pearns Creek. That is ~4% of the Balsam and Cameron lakes watershed; and
- At least two areas within the studied subwatershed were determined to lose flow. Combined, they occupy about 14% of the study area. There are a number of possible reasons for a watercourse to lose flow on a particular stretch, including geology of the area, large wetlands that may retain water and cause extensive evaporation and extensive water taking.

In addition to the field monitoring of baseflow, baseflow separation analysis was performed for monitoring locations where data permitted. The WHAT (Web Based Hydrological Assessment Tool) application, developed by a group of researchers from Purdue University, West Lafayette, Indiana, was used (Lim, 2005). This analysis allows one to separate the groundwater component of the flow for the different hydrological conditions. ***Figures 6.9 and 6.10*** demonstrate the example of the baseflow separation analysis for the Staples River and Martin Creek South. As a part of the analysis, the baseflow indexes (BFI) were calculated (***Table 6.4***). A BFI indicates the proportion of baseflow component in the total runoff of a catchment and describes the influence of watershed's geology and soils on river flow. It varies between 0 and 1, indicating the range of conditions from an absence of the groundwater inflow to fully groundwater-fed watercourses, respectively.

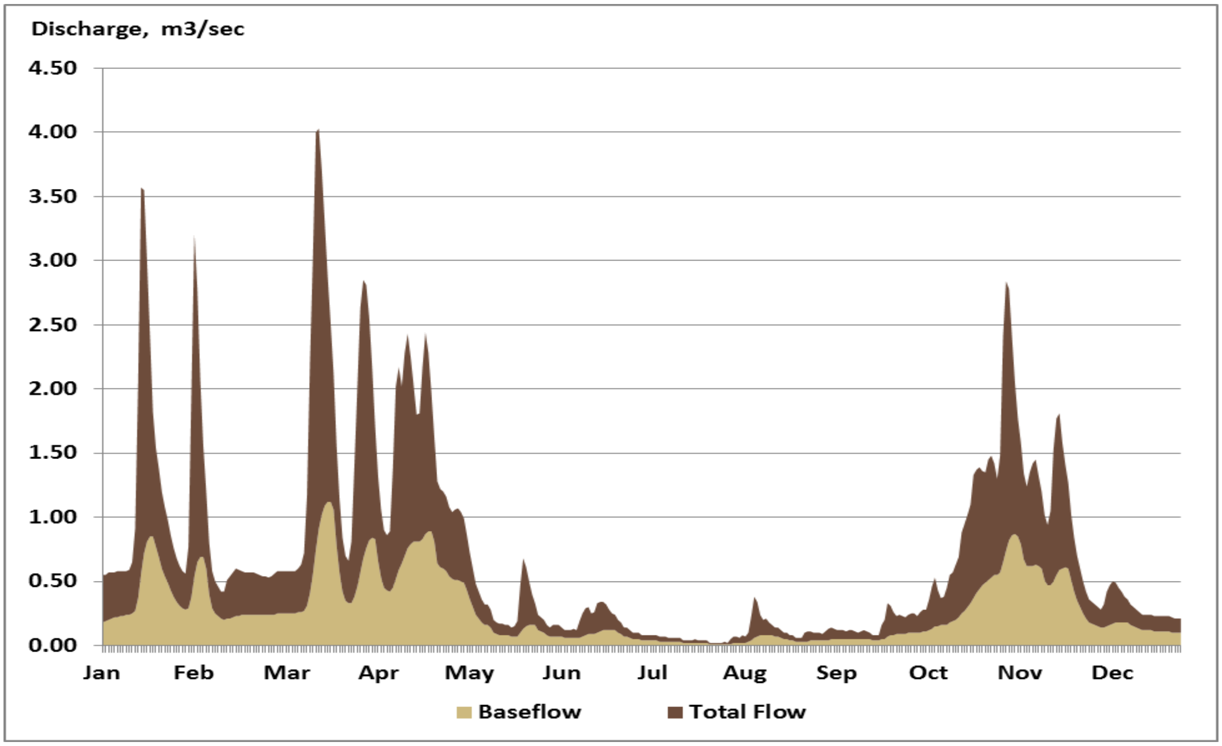

Figure 6.9. The Staples River Hydrograph and its Baseflow Component in 2013

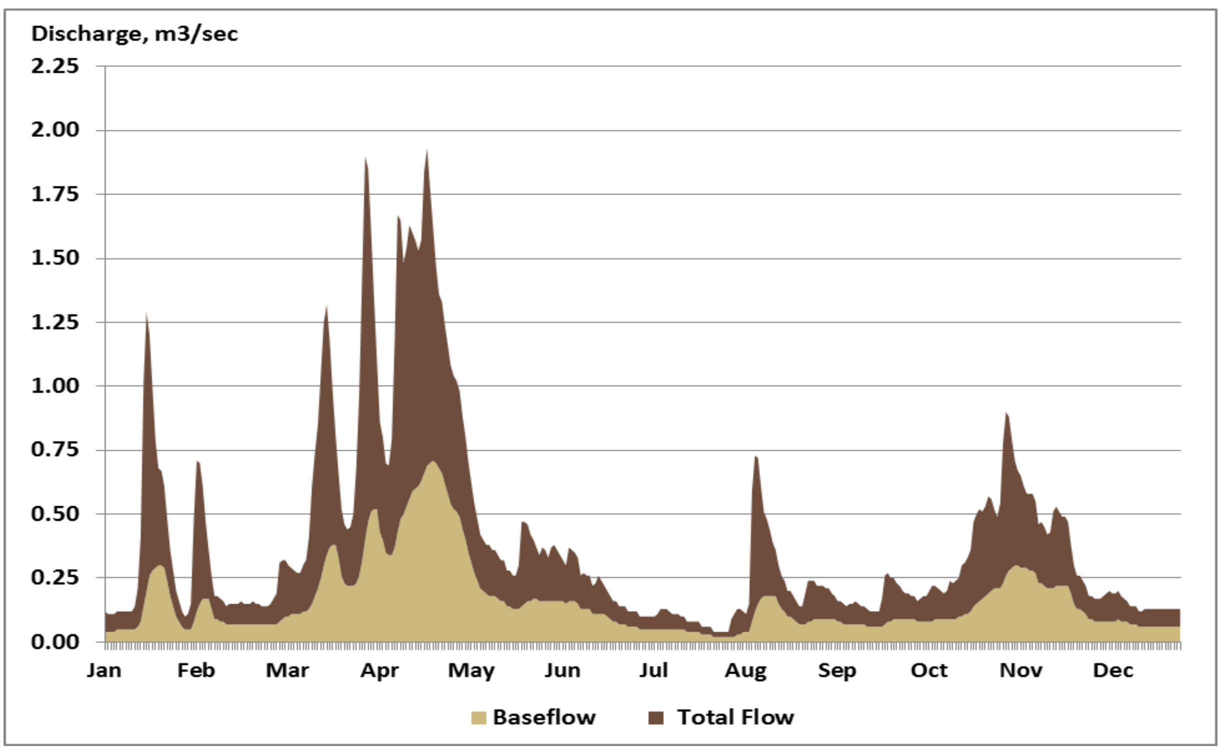

Figure 6.10. The Martin Creek South Hydrograph and its Baseflow Component in 2013

Table 6.4. Calculated Baseflow Indexes for the Staples River and Martin Creek South

Year	Staples River	Martin Creek South
2012	0.583	n/a
2013	0.594	0.65

For the Staples River at the Fenel Road monitoring location, the BFI calculated for 2012 and 2013 is 0.583 and 0.594 (58% and 59%) respectively. For Martin Creek South, as it was calculated for 2013, baseflow makes up to 65% (BFI=0.65) of the total yearly flow. Therefore, the data demonstrate that the groundwater inflow to Martin Creek South is more significant compared to the Staples River. As a result, even during the extensive drought period in summer 2012, there was some flow at Martin Creek while the Staples River and some other tributaries of Balsam and Cameron lakes went dry. However, both watercourses are still very dependent on the surface runoff component of the stream flow.

6.5 Water Use

An abundant water supply is critical to maintaining both the hydrological integrity and ecological integrity of watersheds. Humans are also heavily dependent upon surface water and groundwater for drinking and potable purposes, agricultural use, industrial and recreational use. The intent of this chapter is to provide a summary of permitted water use within the Balsam and Cameron lakes watersheds.

Water users that withdraw or holdback (e.g., through impoundments) more than 50,000 litres of water per day are considered major water takings and are regulated under the Ontario Water Resources Act. These activities require a Permit to Take Water (PTTW) from the Ontario Ministry of Environment and the amount of water used is documented and reported to the MOE. Water takings for domestic use, agriculture and emergency purposes (e.g., firefighting) do not require a permit. Major water taking information is managed in a provincial dataset, maintained by the Ministry of the Environment, which contains specific information including the name of permit holder, location of withdrawal, permitted purpose, maximum permitted water taking volumes and maximum number of water taking days per year. As of 2008, all major water takers are required to report the total volume of water taken each year.

The current water taking information for study area was obtained from Ontario Ministry of Environment. The best available data were used to determine active permits and volume of permitted water withdrawals within the watershed (as of August 2013).

Overall, the permitted water taking within the study area is not significant. There are only six active Permits to Take Water within the Balsam and Cameron lakes watershed (***Table 6.5, Figure 6.11***). Furthermore, one of those is issued for construction dewatering which involves removing ground or surface water from a construction site and is considered a non-consumptive use of water resources. Those permit accounts for 96% of maximum allowed daily water taking in the study area.

Three permits are used for water supply - one municipal, one communal and one other drinking water system. The total maximum permitted water taking in one day for this category is about 4,600 m^3 (7.7% of total daily permitted water withdrawal). There is one municipal drinking water system within the study area, namely the Fenelon Falls DWS that takes water from Cameron Lake. It serves 2,000 residents of Fenelon Falls and pumps, on average, about 1,000 m^3/day (as per data from 2011-2013), well below the maximum permitted volume of 4,100 m^3/sec. Two other drinking water systems are considerably smaller in size with maximum permitted withdrawal amounts between 125 - 350 m^3/day. They are used to supply drinking water to a golf course and a campground.

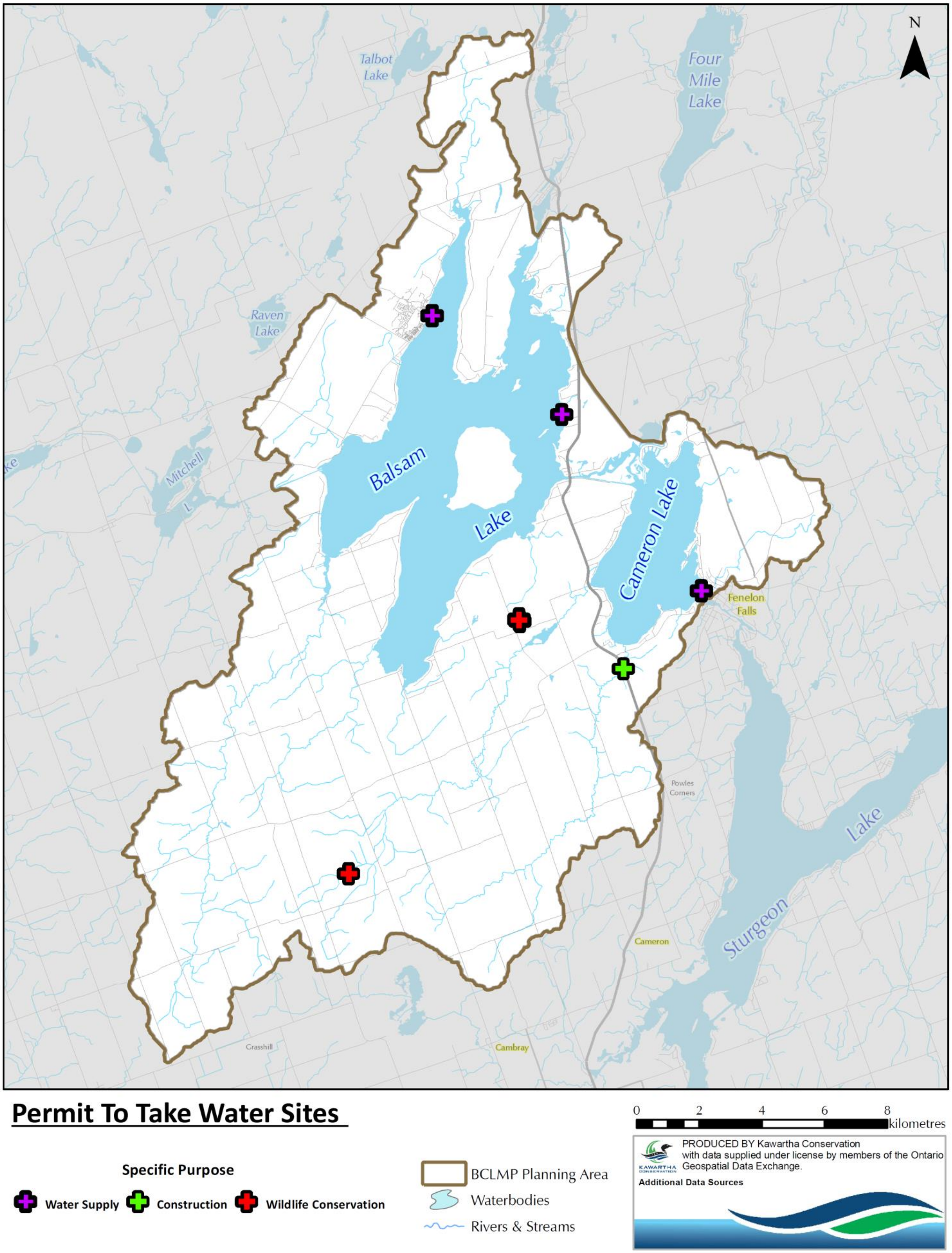

Figure 6.11. Permit to Take Water Sites in the Balsam and Cameron Lakes Watershed

The second largest volume of water (maximum up to 12,738 m^3/day or 2.7 % of the total permitted volume) is allocated for wildlife conservation. (Two permits, five locations). This type of water taking includes works to create artificial impoundments or improve existing ponds and wetlands. It is considered a non-consumptive water use.

Table 6.5. Summary of Permits to Take Water in the Balsam and Cameron Lakes Watershed

Category	Purpose	Source	Water Body	Number of Permits	Maximum allowed water taking, m^3/day
Water Supply	Municipal	Surface Water	Cameron Lake	1	4,100
	Communal	Surface Water	Balsam Lake	1	125
	Other drinking water systems	Surface Water	Balsam Lake	1	350
Construction	Construction dewatering	Ground and Surface Water	Martin Creek	1	578,880
Wildlife Conservation		Surface Water	Various	2	12,738
Total				**6**	**596,193**

6.6 Water Budget

A water budget is an essential component of any hydrological and water quality study. In the framework of the Balsam and Cameron Lakes Management Plan, the water budget can be used for multiple purposes. For example, the water budget and its components are necessary to evaluate cumulative effects of various land uses on water quality in the lakes and their tributaries, as well as to determine priority areas for environmental monitoring. Moreover, an accurate water budget of Balsam and Cameron lakes is crucial for further calculations of phosphorus and nitrogen loadings and balances for the lakes.

A water budget for any given water body or watershed is a sum of all water inputs, outputs and changes in storage. All water inputs into a lake - such as precipitation, surface and groundwater inflows, discharges from sewage treatment plants and septic systems - should equal the sum of all water outputs from the lake such as evaporation and evapotranspiration, surface and groundwater outflows, and water extraction for water supply purposes. Consequently, the water budget equation for Balsam Lake and for Cameron Lake can be expressed as:

$$P - E + Q_{in} - Q_{out} + G_{in} - G_{out} + A_{in} - A_{out} \pm \Delta S \pm \Delta = 0$$

Where:
P – precipitation on the water surface of the lake,
E – evaporation from the water surface of the lake,
Q_{in} – sum of all surface inflows into the lake,
Q_{out} – sum of all surface outflows,
G_{in} – groundwater inflow into the lake,
G_{out} – groundwater outflow from the lake (in this case no measurements have been done for the groundwater flows),
A_{in} – anthropogenic inputs from the septic systems along the shorelines,

A_{out} – anthropogenic extraction from Cameron Lake for the Fenelon Falls Water Treatment Plant,
ΔS – change in lake storage,
±Δ – imbalance.

The Balsam Lake and Cameron Lake water budgets for the 2011–2012, 2012–2013 and 2013–2014 hydrologic years are shown below in ***Tables 6.6 and 6.7***. The hydrologic year in Ontario begins on June 1st and ends on May 31st of the next year. It reflects the natural hydrological cycle from the beginning of the summer low water period to the end of the spring freshet.

The total amount of precipitation for each lake has been calculated as an average from two precipitation gauges around the two lakes: the Staples River gauge (Balsam Lake subwatershed) and Hawkers Creek gauge, which is in close proximity to Cameron Lake. The average amount of precipitation between the two stations was 844 mm in 2011-2012, 872 mm in 2012-2013 and 937 mm in 2013-2014. Although the precipitation amount is usually expressed in millimetres, it was converted into cubic meters for the purposes of convenient comparison with flow components.

Evaporation from the water surface of the lakes is the least studied component of the water budget. Evaporation depends on many weather factors, for example, daily air temperature, relative humidity, solar radiation, wind speed and direction, as well as physiographic factors as local elevation, topography, vegetation and distance to the large water bodies (Great Lakes, oceans). There are no meteorological stations that monitor evaporation and evapotranspiration within the Kawartha Watershed, and none nearby. That's why evaporation and/or evapotranspiration values can be determined only theoretically, taking into consideration available information found in scientific literature. After extensive research using a variety of scientific sources, the long-term average amount of 625 mm per year was taken from the National Soil Database as the most accurate and appropriate potential evaporation/evapotranspiration value for Balsam and Cameron lakes (Ecological Stratification Working Group, 1995). It was also converted into cubic meters for the convenient comparison.

Two flow monitoring stations are currently located within the Balsam and Cameron lakes watershed on Martin Creek South and the Staples River. These stations have been used for calculating an annual average flow rate and a yearly flow volume. The Gull River and Burnt River flow stations are located outside the study area, but were used for the river flow and lake water budget calculations. All gauged watercourses have flow monitoring stations far upstream from their mouths and therefore calculated flow rates and volumes have been prorated accordingly to the size of the remaining ungauged portion of the corresponding watersheds. The flow of Pearns Creek, Corben Creek and other ungauged subwatersheds have been calculated with the use of the unit area discharge ($L/sec/km^2$) from similar gauged watersheds. For example, the Martin Creek South data were used for the flow volume calculations for Pearns Creek. In 2013, a new flow monitoring station was installed on Corben Creek as part of developing the monitoring network for the Four Mile Lake Management Plan.

Changes in lake storage (ΔS) have been calculated as a difference in the lake levels on June 1, 2011 and May 31, 2012; on June 1, 2012 and May 31, 2013; and on June 1, 2013 and May 31, 2014 multiplied by the lake water surface area. Those data have been obtained from the Trent-Severn Waterway water level monitoring stations on Cameron Lake near Fenelon Falls, and on Balsam Lake near Rosedale. The change in lake storage can be positive or negative depending on differences in lake water levels from year to year.

Table 6.6. Balsam Lake Annual Water Budget in the 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

	2011 – 2012		***2012 – 2013***		***2013 – 2014***		***Average***	
	Volume, mln. m^3	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**
Total water inflow:	***650.1***	***100***	***816.5***	***100***	***1053.1***	***100***	***839.9***	***100***
Precipitation (P)	*40.25*	*6.2*	*41.58*	*5.1*	*44.69*	*4.2*	*42.17*	*5.0*
Gull River	*540.6*	*83.2*	*699.7*	*85.7*	*925.7*	*87.9*	*722.0*	*86.0*
Corben Creek	*25.54*	*3.9*	*28.38*	*3.5*	*28.64*	*2.7*	*27.52*	*3.3*
Staples River	*10.08*	*1.6*	*12.95*	*1.6*	*15.15*	*1.4*	*12.73*	*1.5*
Local surface inflow	*33.42*	*5.1*	*33.81*	*4.1*	*38.79*	*3.7*	*35.34*	*4.2*
Anthropogenic inputs	*0.14*	*0.02*	*0.14*	*0.02*	*0.14*	*0.01*	*0.14*	*0.02*
Total water outflow:	***639.0***	***100***	***766.8***	***100***	***1043.0***	***100***	***816.3***	***100***
Evaporation (E)	*30.04*	*4.7*	*30.04*	*3.8*	*30.04*	*2.9*	*30.04*	*3.7*
Balsam Lake outlet	*506.8*	*79.3*	*633.1*	*79.9*	*871.8*	*83.6*	*670.6*	*82.2*
Mitchell Lake canal	*101.2*	*15.8*	*100.9*	*12.7*	*141.9*	*13.6*	*114.7*	*14.0*
Change in lake storage (ΔS)	*0.95*	*0.1*	*2.72*	*0.3*	*-0.72*	*-0.07*	*0.98*	*0.1*
Imbalance (±Δ)	*11.11*	*1.7*	*49.74*	*6.3*	*10.1*	*1.0*	*23.65*	*3.0*

During the three hydrologic years, the Balsam Lake water budget had a positive imbalance (1.7% or 11.1 million m^3) in 2011-2012, in 2012-2013 (6.3% or 49.7 million m^3) and again a positive imbalance (1.0% or 10.1 million m^3) in 2013-2014 ***(Table 6.6).*** A positive imbalance means that, according to calculations, more water entered the lake than left it. A negative imbalance means that more water left the lake than entered.

A positive imbalance in three years of monitoring likely means that there are some inaccuracies in the water outflow raw data from the three dams which are used to convey water from Balsam Lake, namely Rosedale dam, Victoria Road dam on Mitchell Lake and Kirkfield lift lock side dam. Nevertheless, all imbalance numbers are well within the acceptable limit (10%) for the water balance calculations (Scott et al., 2001), thus providing a high level of confidence for phosphorus and nitrogen load calculations.

Table 6.7. Cameron Lake Annual Water Budget in the 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

	2011 – 2012		***2012 – 2013***		***2013 – 2014***		***Average***	
	Volume, mln. m^3	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**	**Volume, mln. m^3**	**% of total supply or loss**
Total water inflow:	***1095.1***	***100***	***1414.2***	***100***	***1826.9***	***100***	***1445.4***	***100***
Precipitation (P)	*12.43*	*1.1*	*12.84*	*0.9*	*13.80*	*0.8*	*13.02*	*0.9*
Burnt River	*540.5*	*49.4*	*733.3*	*51.9*	*903.1*	*49.4*	*725.6*	*50.2*
Balsam Lake	*506.8*	*46.3*	*633.1*	*44.8*	*871.8*	*47.7*	*670.6*	*46.4*
Martin Creek South	*13.69*	*1.2*	*13.10*	*0.9*	*14.31*	*0.8*	*13.70*	*0.9*
Pearns Creek	*14.33*	*1.3*	*13.70*	*1.0*	*15.02*	*0.8*	*14.35*	*1.0*
Local surface inflow	*7.24*	*0.7*	*8.01*	*0.6*	*8.74*	*0.5*	*8.00*	*0.6*
Anthropogenic inputs	*0.13*	*0.01*	*0.13*	*0.01*	*0.13*	*0.01*	*0.13*	*0.01*
Total water outflow:	***1033.3***	***100***	***1403.7***	***100***	***1815.1***	***100***	***1417.4***	***100***
Evaporation (E)	*9.28*	*0.9*	*9.28*	*0.7*	*9.28*	*0.5*	*9.28*	*0.7*
Cameron Lake outlet	*1022.3*	*98.9*	*1394.1*	*99.3*	*1806.1*	*99.5*	*1407.5*	*99.3*
Anthropogenic extraction	*0.36*	*0.03*	*0.36*	*0.03*	*0.33*	*0.02*	*0.35*	*0.02*
Change in lake storage (ΔS)	*1.33*	*0.1*	*0.00*	*0.0*	*-0.68*	*-0.04*	*0.65*	*0.05*
Imbalance (±Δ)	*61.8*	*5.8*	*10.47*	*0.7*	*11.81*	*0.7*	*28.0*	*2.4*

During the same three hydrologic years, the Cameron Lake water budget also had a positive imbalance in 2011-2012 (5.8% or 61.8 million m^3), in 2012-2013 (0.7% or 10.5 million m^3) and again in 2013-2014 (0.7% or 11.8 million m^3) ***(Table 6.7).*** In the Cameron Lake case, a constant positive imbalance in three years of monitoring likely means that there are some inaccuracies in the water outflow raw data as the dam in Fenelon Falls often has water leakage between logs that is not possible to take into account. In this case, all imbalance numbers are also well within the acceptable limit (10%) for the water balance calculations (Scott et al., 2001).

7.0 Water Quality

7.1 Summary of Observations and Issues

Results and observations presented in this summary and the following chapter were obtained during the three-year monitoring period, which began in 2011 and finished in 2014. The monitoring network included eight water quality stations on tributaries across the study area, one station at the Cameron Lake outlet, nine water quality stations on the lakes and one precipitation sampler near the southern end of the study area.

OBSERVATIONS

- Both Balsam and Cameron lakes can be characterized as oligotrophic water bodies with a good water quality, but there is room for improvement. Both lakes are currently on the verge between the oligotrophic and mesotrophic categories;
- While average phosphorus concentrations in Cameron Lake are around 0.01 mg/L, in summer time they can reach as high as 0.024-0.031 mg/L;
- Average phosphorus concentrations in Balsam Lake are usually around 0.007-0.009 mg/L while the highest observed readings are 0.011-0.014 mg/L;
- Nitrogen concentrations in the water of both lakes fluctuate within a lower range, mostly below 0.5 mg/L;
- E.coli monitoring results have revealed that while monitored streams in the watershed usually have E.coli levels below the Provincial Water Quality Objective (100 cfu/100 mL), the number of exceedences can be quite high (up to 25-43% of all samples annually). The Staples River has had elevated E.coli concentrations the most often. In 2012, the seasonal geometrical mean E.coli concentration in this stream exceeded the PWQO and reached 112 cfu/100 mL.

KEY ISSUES

- Water quality monitoring revealed that Cameron Lake has occasionally elevated phosphorus levels that exceed the Provincial Water Quality Objective (0.01 mg/L) and can reach as high as 0.024-0.031 mg/L. This is a level that elevates the potential for blue-green algae blooms and excessive aquatic plant growth;
- Small southern tributaries, namely Pearns Creek, Martin Creek South and Staples River, quite often have elevated phosphorus levels as a result of human activities in the corresponding subwatersheds. Pearns Creek exhibited the highest levels of phosphorus throughout the monitoring period;
- The most significant anthropogenic sources of phosphorus to Balsam and Cameron lakes include urban runoff (Fenelon Falls and small urban areas along the shoreline) and septic systems around the lakes;
- Nitrogen concentrations were occasionally elevated in the water of the southern tributaries. While nitrate concentrations in these streams are very low (and far below the guideline), levels of total Kjeldahl nitrogen and, as a result, total nitrogen concentrations, are sometimes quite high during summer. For example, total nitrogen concentrations observed in Martin Creek South were measured as high as 1.76 mg/L in June 2013;
- Elevated E.coli levels in excess of the provincial objective have been often observed at the Bond Street beach in Fenelon Falls. As a result, that beach was frequently posted in 2010, 2012, 2013 and 2014. Another beach with repeatedly high E.coli concentrations is Lions Park beach in Coboconk on the Gull River. It is not located directly on Balsam Lake, but is in close proximity to it. This beach was frequently posted in 2011, 2013 and 2014.

7.2 Introduction

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

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

By sampling a wide variety of parameters it is possible to get an accurate, overall assessment of the water quality at a given point in time. To broaden the perspective, numerous samples are taken at different locations and periods of time providing for variances such as air and water temperature, flow volume, precipitation and land uses that vary throughout the year. Current results can be compared against historical results to establish trends in water quality over time. Obtained results can also be compared to the Provincial Water Quality Objectives (PWQOs) (MOE, 1994) and Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQGs) (CCME, 2007).

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

Canadian Water Quality Guidelines are intended to provide protection of freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical components (e.g., pH, temperature, and debris). Guidelines are numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameter of interest. Guideline values are meant to protect all forms of aquatic life and all aspects of aquatic life cycles, including the most sensitive life stages of the most sensitive species over the long-term. Ambient water quality guidelines developed for the protection of aquatic life provide the science-based benchmark for a nationally consistent level of protection for aquatic life in Canada (CCME, 1999).

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

7.3 Methodology

Water quality monitoring plays an important role in meeting the objectives of the Balsam and Cameron Lakes Management Plan. Water quality data are obtained by collecting water samples at monitoring sites across the study area. As of 2014, the Balsam and Cameron lake watershed has three long-term monitoring sites (ST2, BC3 and BC5) sampled in the framework of the Provincial Water Quality Monitoring Network (PWQMN). Water quality sampling started at the Cameron Lake outlet (ST2) and the Gull River (BC5) in 1966 and at the Balsam Lake outlet (BC3) in 1971. As well, extensive additional sampling for the purposes of the Balsam and Cameron Lake Management Plan development was undertaken in 2011-2014 at nine sites including those three PWQMN sites. There are also five open-water sampling sites on Balsam Lake and four sites on Cameron Lake ***(Figure 7.1).***

The monitoring stations are dispersed across the entire watershed at key locations covering all major tributaries. The monitoring stations on the lake are located in such way as to cover all main parts of the water body. At each site, water samples are collected by grab method according to the planned monitoring schedule and then sent to a certified private laboratory to be analyzed for total suspended solids and nutrients, including ammonia, nitrites, nitrates, total Kjeldahl nitrogen and total phosphorus. Samples for the lake management planning monitoring program are collected bi-weekly throughout the year from tributaries, and monthly (from May to September) from lake monitoring sites.

Samples for the PWQMN program are collected during the ice-free period eight times per year and sent to the MOE Laboratory Services Branch to be analyzed for alkalinity, metals, hardness, total suspended solids, anions such as chlorides, and all nutrients including ammonia, nitrites, nitrates, total Kjeldahl nitrogen, total phosphorus and orthophosphates. Furthermore, pH, dissolved oxygen, conductivity and temperature readings are taken at the time of sampling using an YSI hand-held multi-meter.

In order to characterize bacteriological quality of surface water, a number of tributaries have been sampled during summer periods for Escherichia Coli (E.coli). A complete list of parameters sampled and corresponding guidelines or objectives are available in **Appendix 4.**

Statistical analysis of data was completed for total phosphorus (TP), total nitrogen (TN), E.coli and total suspended solids (TSS) for sites with enough samples for analysis. Water temperature and dissolved oxygen data were also analyzed and graphically presented for the open lake monitoring sites. ***Table 7.1*** shows the site ID, location, number of samples and date of the most recent sample. Historical water quality information from the 1970s, 1980s and 1990s has also been used for a comparison of current water quality data against long-term data sets in order to determine whether the lakes' and tributaries' water quality is improving or deteriorating.

7.4 Balsam and Cameron Lake Tributaries

From a hydrological point-of-view, the Balsam and Cameron lakes watershed includes all areas that supply water to the lakes. This means that the Balsam and Cameron lakes watershed is comprised of not only small local subwatersheds (Martin Creek South, Pearns Creek and Staples River) but also includes the Gull River, Corben Creek with Four Mile Lake and the Burnt River watersheds. It is a vast area that extends far north beyond Kawartha Conservation's jurisdiction to the edge of Algonquin Park. Therefore, for practical purposes, we will consider only that portion of the Balsam and Cameron lakes watershed which is within the Kawartha Conservation jurisdiction and includes small and large tributaries that empty directly into the two lakes. The study area includes the Staples River, Pearns Creek and Martin Creek South subwatersheds as well as drainage areas adjacent to the both lakes. As previously mentioned, Balsam Lake also receives flow from the Gull River and Corben Creek, and Cameron Lake receives flow from the Burnt River. Those rivers supply the majority of the water flow that enters the lakes ***(Tables 6.6 and 6.7).***

The Balsam and Cameron lakes watershed occupies the north-western portion of the Kawartha Conservation watershed. The total area of the Balsam and Cameron lakes watershed within the Kawartha Conservation jurisdiction is 336.3 km^2 including the surface water area of the lakes, which is 62.4 km^2 for both lakes (47.7 km^2 for Balsam Lake and 14.7 km^2 for Cameron Lake). The major human land use in the watershed is agriculture, which occupies more than 42% of the land portion of the watershed. Rural development and roads occupy 5.1% and 1.8% of the watershed respectively. Natural areas such as forests (21.7%) and wetlands (20.2%) also cover a considerable portion of the study area.

The only water quality concern in the Balsam and Cameron lakes watershed is somewhat elevated concentrations of phosphorus in their southern tributaries. Other parameters of interest that can be a concern from the ambient water quality perspective include: nitrogen (specifically, total Kjeldahl nitrogen), *Escherichia Coli* in three smaller southern tributaries and total suspended solids in Martin Creek South. All other parameters have concentrations far below the corresponding PWQOs or CWQGs and do not currently present any threat to aquatic life or human health.

Table 7.1. Water Quality Monitoring Stations in the Balsam and Cameron Lakes Watershed

Station ID	Location	Number of Samples	Most Recent Sample
BC1	Martin Creek South at Hwy 35	73	June-2014
BC2	Pearns Creek at Pearns Road	76	June-2014
BC3	Balsam Lake outlet at Rosedale Dam	32	June-2014
BC4	Staples River at Fenel Road	69	June-2014
BC5	Gull River at Hwy 35	96	June-2014
BC6	Corben Creek at Hwy 35	71	June-2014
BC7	Burnt River at Northline Road	73	June-2014
BC8	Blanchards Creek at Blanchards Road	26	June-2014
ST2	Cameron Lake outlet in Fenelon Falls	95	June-2014
PR1	Precipitation sampler	91	June-2014
BL1	Balsam Lake, South Bay	16	Sept-2014
BL2	Balsam Lake, West Bay	16	Sept-2014
BL3	Balsam Lake, North Bay	16	Sept-2014
BL4	Balsam Lake, Gull River Bay (North-Eastern)	16	Sept-2014
BL5	Balsam Lake near Rosedale	16	Sept-2014
CL1	Cameron Lake near Burnt River Mouth	17	Sept-2014
CL2	Cameron Lake, McFarland Bay	17	Sept-2014
CL3	Cameron Lake, Sackett Bay (south end of the lake)	16	Sept-2014
CL4	Cameron Lake, central deep area of the lake	16	Sept-2014

** Stations ST2, BC3 and BC5 are monitored through the CKL LMP and PWQMN monitoring programs*

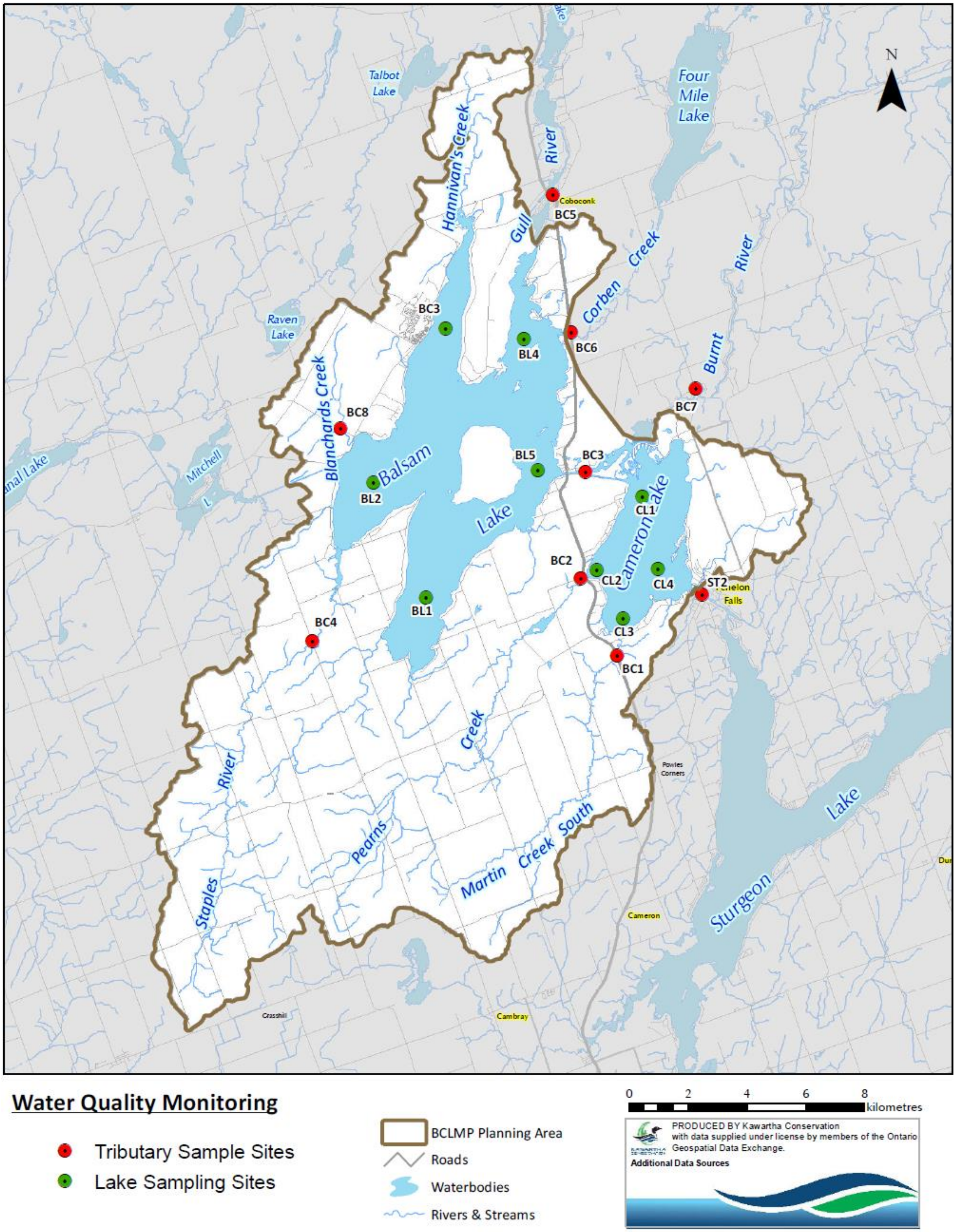

Figure 7.1. Water Quality Monitoring Stations in the Balsam and Cameron Lakes Watershed

Phosphorus

Phosphorus is one of the two primary nutrients required for the growth of aquatic plants and algae in streams and lakes. Even in elevated levels, phosphorus is not considered toxic to plants and animals. But high concentrations in water can cause the process of eutrophication, which results in excessive algae and aquatic plant development, and a corresponding depletion of dissolved oxygen in the water column. The PWQO for total phosphorus (TP) concentrations in watercourses is set at 0.030 mg/L in order to prevent nuisance algae and aquatic plant growth. The PWQO for TP concentrations in lakes is 0.020 mg/L and/or 0.010 mg/L for those lakes with a natural TP level below this value (MOE, 1994). Taking into consideration that phosphorus concentrations in the water of the major inflows into the lakes - the Gull River and Burnt River - is below (Gull River) or around (Burnt River) 0.010 mg/L, it seems reasonable to assume that Balsam and Cameron lakes historically had TP concentrations below 0.010 mg/L.

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

In the Balsam and Cameron lakes watershed, phosphorus concentrations sometimes exceed the PWQO in the three small southern tributaries (Martin Creek South, Pearns Creek and Staples River). As a result, TP averages were above the provincial objective in the waters of Martin Creek South and Pearns Creek during the 2011-2012 hydrologic year. In the northern streams of the watershed, TP levels are considerably lower and very seldom exceed the PWQO. As a result, phosphorus averages in the Gull River, Burnt River, Corben Creek and Blanchards Creek have always been below 0.015 mg/L ***(Figure 7.2).***

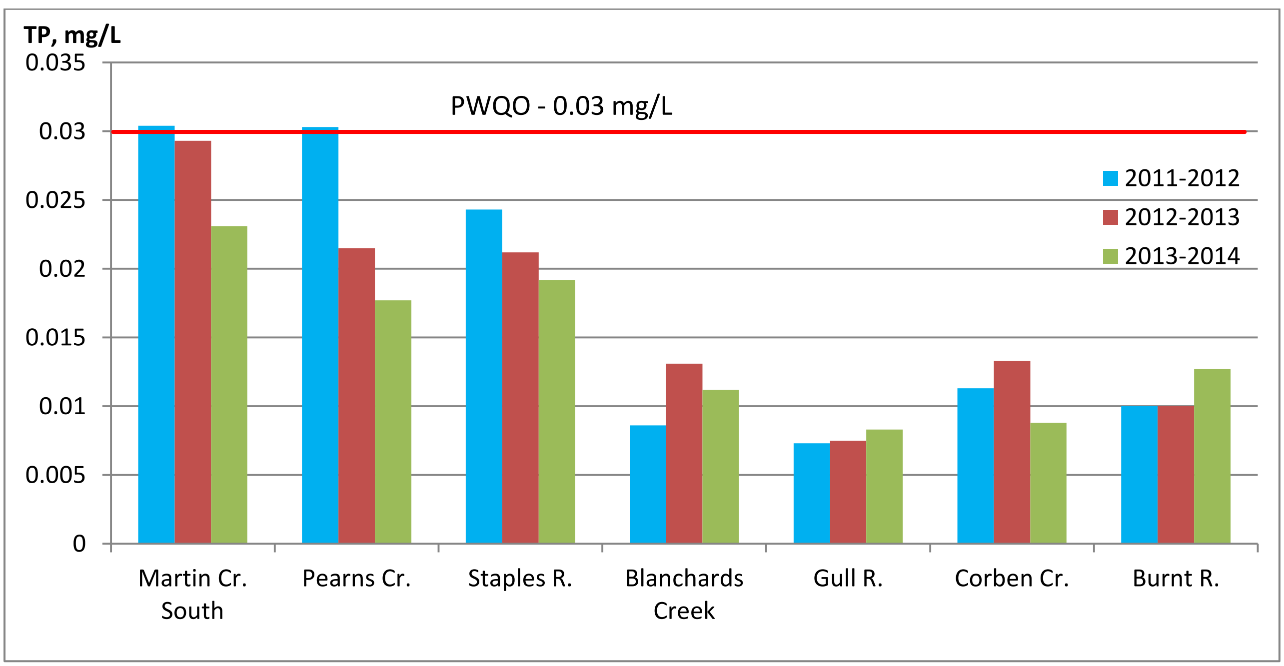

Figure 7.2. Average Phosphorus Concentrations in the Balsam and Cameron Lake Tributaries in 2011-2014

Martin Creek South begins in a large wetland west of the Hamlet of Cameron and flows among wetlands and treed wetlands into the southern portion of Cameron Lake. Phosphorus levels over the period of monitoring (2011-2014) varied from 0.007 mg/L to 0.102 mg/L ***(Table 7.2).*** The average TP concentration in the creek over the three-year period is 0.028 mg/L which is just below the PWQO. The annual averages ranged from 0.023 mg/L in 2013-2014, to 0.029 mg/L in 2012-2013 and to 0.030 mg/L in 2011-2012 ***(Figure 7.2).***

Current water quality in the creek is characterized by considerably elevated phosphorus concentrations during summer (0.032-0.102 mg/L), but throughout the rest of year, phosphorus levels are usually low (0.007-0.031 mg/L). Most exceedences were also detected in the summertime. The lowest TP concentrations are usually observed from late autumn into early spring. The highest phosphorus readings were observed in the summer months under both high and low flow conditions. This can indicate that phosphorus is entering the watercourse with stormwater runoff and as a result of release from wetlands during prolonged dry periods.

Table 7.2. Results of Statistical Analysis of Total Phosphorus Concentrations in Martin Creek South for the Period of 2011-2014

Statistical Parameters	2011-2012	2012-2013	2013-2014	Total 2011-2014
Maximum	0.102	0.072	0.045	0.102
75^{th} percentile	0.033	0.040	0.030	0.033
25^{th} percentile	0.018	0.012	0.015	0.016
Minimum	0.010	0.007	0.005	0.005
Average	0.030	0.029	0.023	0.028
Median (50^{th} percentile)	0.023	0.023	0.024	0.024
Exceedences, %	35	35	29	33
Number of samples	26	23	21	70

Phosphorus concentrations in the creek varied slightly between years, with median concentrations being identical in 2011-2012 and 2012-2013 at 0.023 mg/L, and a little bit higher in 2013-2014 when it reached 0.024 mg/L (***Table 7.2***). This may reflect increased flow in the stream during the last year of monitoring. However, more samples exceeded the PWQO in 2011-2012 and 2012-2013, than in 2013-2014. During the first two years of monitoring, 35% of samples exceeded the objective, while only 29% did during the third year of monitoring.

Pearns Creek is another small southern tributary of Cameron Lake. Its watershed is located just west of the Martin Creek South subwatershed. Most of the Pearns Creek subwatershed is occupied by agricultural lands. As a result, water quality in the creek varies considerably throughout the year. Phosphorus concentrations are much higher during summer (0.027-0.074 mg/L) and especially after rain events (0.042-0.074 mg/L). During late autumn, winter and spring, they vary from 0.006 to 0.024 mg/L which is far below the PWQO. At the same time, the percent of exceedences was quite high in 2011-2012 (35%) and in 2012-2013 (23%), but only 8% in 2013-2014 ***(Table 7.3)***. Over the three-year period, TP concentrations exceeded the PWQO in 24% of all collected samples. The average phosphorus concentration is 0.024 mg/L, with results ranging between 0.004 and 0.074 mg/L.

The Staples River occupies the south-western corner of the Balsam Lake watershed and is located west of the Pearns Creek subwatershed. Agricultural lands comprise a considerable portion (67%) of the Staples River subwatershed. Results of the water quality monitoring from the 2011-2014 period show a decreasing trend in total phosphorus levels in this stream. Whether this is a real trend or just variations between years needs to be determined by means of long-term monitoring.

Table 7.3. Results of Statistical Analysis of Total Phosphorus Concentrations in Pearns Creek for the Period of 2011-2014

Statistical Parameters	2011-2012	2012-2013	2013-2014	Total 2011-2014
Maximum	0.074	0.048	0.033	0.074
75th percentile	0.046	0.029	0.024	0.030
25th percentile	0.016	0.008	0.011	0.012
Minimum	0.009	0.004	0.005	0.004
Average	0.030	0.021	0.018	0.024
Median (50th percentile)	0.022	0.021	0.017	0.020
Exceedences, %	35	23	8	24
Number of samples	26	22	24	72

The average phosphorus concentration in the river is 0.022 mg/L (***Table 7.4***). The annual average concentrations during the three-year period fluctuated from 0.019 mg/L in 2013-2014, to 0.024 in 2011-2012 which is well below the PWQO. The highest phosphorus concentrations (0.048-0.075 mg/L) occurred in summer time under both dry and wet conditions. The lowest TP concentrations - in the range of 0.005-0.014 mg/L - have usually been observed from late autumn to early spring. Phosphorus levels exceeded the PWQO in 25% of all samples ***(Table 7.4).*** More samples exceeded the PWQO in 2011-2012 and 2012-2013, than in 2013-2014. During the first and second year respectively, 27% and 25% of samples exceeded the objective, and only 20% during the last year of monitoring.

Table 7.4. Results of Statistical Analysis of Total Phosphorus Concentrations in the Staples River for the Period of 2011-2014

Statistical Parameters	2011-2012	2012-2013	2013-2014	Total 2011-2014
Maximum	0.075	0.053	0.036	0.075
75th percentile	0.035	0.028	0.026	0.030
25th percentile	0.012	0.010	0.014	0.012
Minimum	0.006	0.005	0.006	0.005
Average	0.024	0.021	0.019	0.022
Median (50th percentile)	0.019	0.018	0.017	0.018
Exceedences, %	27	25	20	25
Number of samples	26	20	20	66

The Gull River is the largest Balsam Lake tributary with a drainage area of 1,347 km^2 extending far north from the lake. The river water quality is largely what determines the quality of the water in Balsam Lake. Over the period of observation, water quality in the river was very good with phosphorus concentrations far below the PWQO. As the river headwaters are located on the Canadian Shield in a scarcely populated watershed, the water of the Gull River has very low concentrations of all chemicals, including phosphorus. Since the beginning of the intensive monitoring activities in 2011, phosphorus concentrations in the Gull River have always been below the PWQO set for total phosphorus ***(Figure 7.2).*** The average phosphorus concentration in the river at the Coboconk monitoring location is 0.007 mg/L, with results ranging from 0.003 to 0.020 mg/L ***(Table 7.5)***. That is the lowest among monitored streams in this report.

Table 7.5. Results of Statistical Analysis of Total Phosphorus Concentrations in the Gull River for the Period of 1966-2014

Statistical Parameters	1966-1970	1971-1975	1976-1980	1981-1985	1986-1990	1996-2000	2001-2010	2011-2014
Maximum	0.042	0.038	0.034	0.040	0.021	0.020	0.018	0.020
75th percentile	0.020	0.016	0.011	0.011	0.009	0.010	0.010	0.009
25th percentile	0.010	0.009	0.006	0.007	0.005	0.006	0.006	0.005
Minimum	0.002	0.005	0.002	0.002	0.002	0.004	0.002	0.003
Average	0.016	0.014	0.010	0.011	0.008	0.008	0.008	0.008
Median (50th percentile)	0.013	0.012	0.009	0.009	0.007	0.008	0.008	0.007
Exceedences, %	11	6	2	4	0	0	0	0
Number of samples	46	62	46	56	53	50	78	96

Seasonal distribution of total phosphorus in the Gull River is characterized by the highest readings in summer months during both high and low flow conditions (0.011-0.020 mg/L). In spring months, TP concentrations can be quite high also, up to 0.011 mg/L, as a result of snowmelt and the corresponding freshet. The lowest TP concentrations are usually observed from late autumn to early spring.

Over the three-year monitoring period there were no PWQO exceedances (***Table 7.5*).** Actually, the Gull River has not had phosphorus concentrations exceeding 0.03 mg/L since 1984. The highest phosphorus levels in the Gull River in the past were observed at the end of 1960s and beginning of 1970s when waste water treatment plants were in a rudimentary state, and the amount of phosphorus in laundry detergents, soaps, shampoos was much higher.

Corben Creek is the second largest tributary of Balsam Lake, after the Gull River. It carries water from Four Mile Lake into Balsam Lake and flows through unpopulated forested areas with abundant wildlife. Similar to the Gull River watershed, the Corben Creek subwatershed is located outside of the Kawartha Conservation jurisdictional boundary. The Corben Creek subwatershed begins approximately 20 km north of Balsam Lake and includes Four Mile Lake, which is situated in the middle of the subwatershed. Corben Creek also receives flow from Merrett Creek, which empties into Four Mile Lake east from the Upper Corben Creek mouth. Most of its subwatershed is occupied by forests and wetlands. As a result, the creek has very good water quality with low phosphorus and nitrogen concentrations.

Since the beginning of monitoring activities, phosphorus concentrations in Corben Creek have usually been below the PWQO. Phosphorus levels in the creek near its mouth (Corben Creek at Hwy 35) varied from 0.003 to 0.031 mg/L, with an average of 0.012 mg/L (***Table 7.6***). The average annual phosphorus concentrations varied from 0.009 mg/L in 2013-2014, to 0.013 mg/L in 2012-2013.

Maximum values of 0.031 and 0.030 mg/L were observed in May of 2012 and August of 2011 respectively under dry weather conditions. It is possible to suggest that high phosphorus concentrations in Corben Creek during dry hot weather are the result of phosphorus input (desorption) from sediments in the lower reaches of the creek, where it is flowing through a large wetland. Consequently, seasonal distribution of total phosphorus in Corben Creek is characterized by the highest readings in summer time during both high and low flow conditions. The lowest TP concentrations are usually observed throughout late autumn, winter and early spring before snowmelt.

Table 7.6. Results of Statistical Analysis of Total Phosphorus Concentrations in Corben Creek for the Period of 2011-2014

Statistical Parameters	2011-2012	2012-2013	2013-2014	Total 2011-2014
Maximum	0.031	0.030	0.016	0.031
75th percentile	0.015	0.018	0.012	0.015
25th percentile	0.006	0.007	0.006	0.006
Minimum	0.003	0.003	0.003	0.003
Average	0.011	0.013	0.009	0.012
Median (50th percentile)	0.008	0.011	0.010	0.010
Exceedences, %	4	4	0	3
Number of samples	24	24	18	66

The Burnt River is the largest watercourse flowing into Cameron Lake. It drains a very large watershed which occupies 1,489 km^2 and extends from Cameron Lake almost to Algonquin Provincial Park. The monitoring station on the Burnt River is located outside the study area ***(Figure 7.1).*** The average annual TP concentrations in the Burnt River fluctuated from 0.010 mg/L (in 2011-2012 and 2012-2013) to 0.013 mg/L (in 2013-2014) ***(Figure 7.2)***, with a range of individual results from 0.004 to 0.035 mg/L ***(Table 7.7).*** Phosphorus concentrations exceeded the PWQO only once in 2012-2013.

Table 7.7. Results of Statistical Analysis of Total Phosphorus Concentrations in the Burnt River for the Periods of 1971-1973 and 2011-2014

Statistical Parameters	1971-1973	2011-2012	2012-2013	2013-2014	Total 2011-2014
Maximum	0.089	0.022	0.035	0.029	0.035
75th percentile	0.021	0.013	0.012	0.016	0.014
25th percentile	0.014	0.006	0.006	0.008	0.006
Minimum	0.009	0.004	0.004	0.005	0.004
Average	0.020	0.010	0.010	0.013	0.011
Median (50th percentile)	0.016	0.008	0.009	0.010	0.009
Exceedences, %	10	0	4	0	1
Number of samples	31	25	23	23	71

The highest readings were observed during spring freshet (0.029-0.035 mg/L), and in the summer during extended periods of dry and hot weather (0.016-0.022 mg/L). Similar to other watercourses in the study area, the lowest TP concentrations were usually observed throughout late autumn to early spring (0.004-0.012 mg/L).

Comparison of the current data with historical monitoring data demonstrates an impressive decreasing trend in phosphorus concentrations in the Burnt River since the early 1970s ***(Table 7.7)***. While average and median phosphorus concentrations were 0.020 and 0.016mg/L respectively in 1971-1973, they were only 0.011 and 0.009mg/L forty years later during the 2011-2014 monitoring period.

Nitrogen

Nitrogen is another key nutrient vital for the development of algae and aquatic plants. Nitrogen is present in surface water in several chemical forms such as free ammonia and ammonium, nitrite, nitrate and organic nitrogen. For the purpose of analytical and/or statistical analysis, the nitrite values are often combined with the nitrate concentrations, as nitrite-ions are the transitional form of nitrogen from ammonia to nitrate-ions and are usually present in surface water in very low concentrations. All nitrites in lake or river water are transformed into nitrates in a very short time. The combined concentrations of nitrate and nitrite are usually called total nitrates and consist typically of 98.0-99.9% of nitrates and 0.1-2.0% of nitrites. In streams, nitrates often compose most of the total nitrogen amount, which comprises all the above-mentioned chemical forms of nitrogen in water. Nitrates are essential for plant growth in both terrestrial and aquatic ecosystems because they are highly soluble and mobile in water solutions and are the most-available for plant consumption. Anthropogenic sources of nitrates include inorganic fertilizers, septic systems and wastewater treatment plants. Concentrations of total nitrates in surface water reflect general land use and anthropogenic pressure within the various parts of the watershed.

Total Kjeldahl nitrogen is a measure of total organic nitrogen plus total ammonia. In some cases, it can show the presence of fresh organic pollution in a water body or the level of phytoplankton development in lake water.

Total nitrogen (TN) includes both inorganic and organic forms of nitrogen. There is no provincial or federal guideline for total nitrogen concentrations in surface water. At the same time, Alberta Environment has established the surface water quality guideline for total nitrogen at 1.0 mg/L (Alberta Environment, 1999). This guideline was used by Environment Canada for reporting on water quality in Lake Winnipeg (Environment Canada, 2013a, 2013b). It provides us with an opportunity to use the above-mentioned guideline as an interim nitrogen guideline for streams and lakes in the Kawartha Conservation watershed. As well, the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQGs) set the guideline for one of the chemical forms of nitrogen in natural water, namely nitrates, at 2.93 mg/L (CCME, 2003). This guideline was developed in order to protect freshwater life from the direct toxic effects of elevated nitrate levels which often are the result of anthropogenic contamination. Indirect toxic effects resulting from eutrophication may still occur at nitrate concentrations below the guideline value, depending on the total amount of nitrogen in water (CCME, 2003).

Within the Balsam and Cameron lakes watershed, nitrogen occasionally exceeded 1.0 mg/L in the water of several tributaries, namely Martin Creek South (BC1), Pearns Creek (BC2) and the Staples River (BC4) (***Table 7.8***)**.** At the same time, average and median nitrogen levels in these streams - as well as in other tributaries - are well below the interim guideline ***(Figure 7.3).***

Table 7.8. Results of Statistical Analysis of Total Nitrogen Concentrations in the Balsam and Cameron Lakes Tributaries for the Period of 2011-2014

Statistical Parameters	BC1	BC2	BC4	BC5	BC6	BC7	BC8
Maximum	1.76	1.59	1.21	0.70	0.66	0.81	0.85
75^{th} percentile	0.86	0.78	0.88	0.33	0.36	0.40	0.64
25^{th} percentile	0.62	0.45	0.51	0.23	0.23	0.30	0.37
Minimum	0.39	0.23	0.28	0.11	0.12	0.18	0.21
Average	0.75	0.64	0.70	0.28	0.30	0.36	0.50
Median (50^{th} percentile)	0.77	0.63	0.71	0.26	0.29	0.35	0.52
Exceedences, %	5.5	3.9	8.7	0	0	0	0
Number of samples	73	76	69	96	68	74	26

The frequency of exceedences was the highest in the Staples River, where almost 9% of all samples exceeded the guideline (***Table 7.8***). In Martin Creek South, total nitrogen concentration was above the 1.0 mg/L in more than 5% of collected samples. The highest nitrogen levels in the watershed, which are somewhat elevated in comparison with background concentrations, were also observed in the water of that tributary. Over the three-year period of monitoring, average nitrogen concentrations in the creek varied from 0.72 mg/L in 2012-2013 to

0.81 mg/L in 2013-2014 ***(Figure 7.3)***. The maximum nitrogen concentration in the watershed (1.76 mg/L) was also observed in Martin Creek South in June 2013 ***(Table 7.8)***.

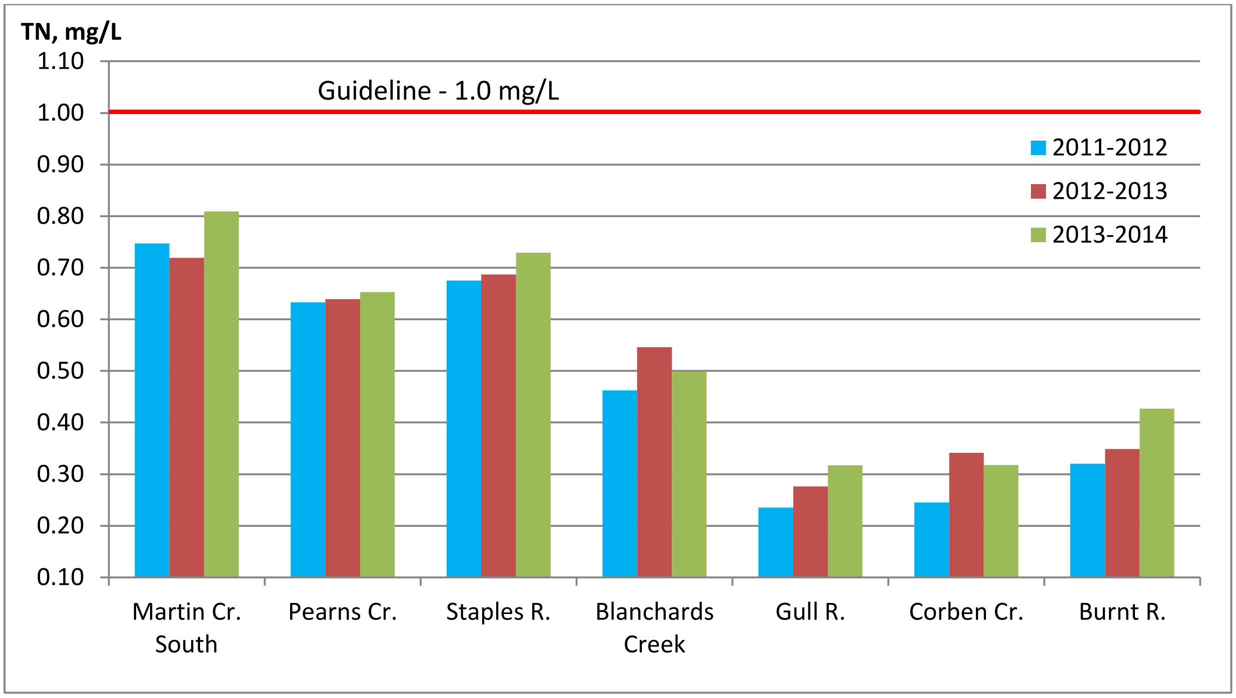

Figure 7.3. Average Total Nitrogen Concentrations in the Balsam and Cameron Lakes Tributaries in 2011-2014

Seasonal distribution of total nitrogen in streams of the watershed is characterized by higher concentrations during summer due to increasing levels of organic forms of nitrogen as determined by the TKN analysis. TKN values are always higher in summertime as a result of increased biomass of phytoplankton in water. Another reason is that more organic matter is entering streams from wetlands.

At the same time, the highest levels of nitrates in surface waters of the watershed were usually detected in the middle of winter (January), when groundwater contributes the most to the flow in tributaries and natural processes of nitrate assimilation are very slow.

Looking at the watershed-wide scale, one can see that the highest nitrogen levels are detected in the three southern streams, namely Martin Creek South, Pearns Creek and the Staples River. Analysis of water quality data suggests that increase in total nitrogen levels is correlated with higher TKN concentrations in these streams, which, in turn, can be the result of both agricultural activities and, very often, natural processes in wetlands.

Total Suspended Solids

Total suspended solids (TSS) may have significant effects on aquatic organisms because of shading, abrasive action, habitat alteration and sedimentation (CCME, 2002). Suspended solids or sediments have a significant effect on community dynamics when they interfere with light transmission. Most flowing waters have considerable variation in suspended solids from day to day. Because this natural variation is so great, it is not desirable to establish a fixed rigid guideline (CCME, 2002). Therefore, more flexible guidelines have been established. They state: the concentration of suspended solids in stream water should not be increased by more than 25 mg/L over background levels during any short-term exposure period, and no more than 5 mg/L over background levels for long-term exposure (30 days and more) (CCME, 2002).

Background concentrations of total suspended solids in streams of the study area are usually 0.5-1 mg/L. After significant rain events, TSS concentrations can increase quite substantially at several monitoring stations ***(Table 7.9).*** For example, from time to time, high TSS levels have been observed in Martin Creek South (station BC1) as a result of a sharp increase in flow volume after storm events. The maximum TSS concentration detected in this watercourse is 16 mg/L, while the average is 3.3 mg/L. That's three times more than in the Gull River, double more than in Corben Creek and much higher than in other streams of the watershed ***(Table 7.9).*** The Staples River has the second-highest average and median TSS concentrations after Martin Creek South, but a much lower maximum concentration ***(Table 7.9).*** The highest observed TSS reading of 34 mg/L in the Burnt River was detected once on the peak of flow during the 2014 spring freshet. This result was a single exceedence among all monitored streams. Average and median TSS concentrations in all monitored streams are well below the CCME guideline. The lowest TSS concentrations, as anticipated, were detected in the water of the Gull River, which drains forested areas with numerous lakes on Canadian Shield (station BC5).

Table 7.9. Results of Statistical Analysis of TSS Concentrations in the Balsam and Cameron Lakes Tributaries for the Period of 2011-2014

Statistical Parameters	BC1	BC2	BC4	BC5	BC6	BC7	BC8
Maximum	16.0	9.0	8.0	2.5	9.0	34.0	9.0
75th percentile	4.0	3.0	3.0	1.4	2.3	2.0	3.0
25th percentile	1.0	1.0	1.0	0.5	1.0	1.0	1.0
Minimum	1.0	1.0	1.0	0.3	1.0	0.6	1.0
Average	3.2	2.0	2.4	1.0	2.1	3.1	2.4
Median (50th percentile)	3.0	1.0	2.0	1.0	1.0	1.0	1.0
Exceedences, %	0	0	0	0	0	3.6	0
Number of samples	60	60	57	33	24	28	11

Escherichia Coli

The Provincial Water Quality Objective for Escherichia coli ***(E.coli)*** is based on the recreational water quality guideline established by the Ontario Ministry of Health for swimming and bathing beaches (MOEE, 1994). E.coli characterizes bacteriological contamination of surface or ground water. E.coli was selected for the guideline because E.coli is the most suitable and specific indicator of fecal contamination (MOEE, 1994). The PWQO is set at 100 colony forming units per 100 mL (cfu/100 mL), and based on a geometric mean of at least five samples (MOEE, 1994).

E.coli monitoring results from 2011-2013 have revealed that three monitored streams in the watershed mostly had E.coli levels below the PWQO. In the Staples River and Pearns Creek, E.coli concentrations may be a concern. In the Staples River, the geomean E.coli concentration was 37 cfu/100 mL in 2011, 112 in 2012 and 58 in 2013 ***(Figure 7.4).*** Furthermore, E.coli concentrations exceeded the PWQO in 12.5% of water samples collected from the creek in 2011, in 43% of samples in 2012 and in 25% of samples in 2013. In 2012, the maximum E. coli concentration reached 800 cfu/100 mL; that being the highest value observed in three years in the three monitored streams. In Pearns Creek, E.coli concentrations exceeded the PWQO only in 12.5% of samples in 2011 and 2012, but in 38% of samples in 2013 under both dry and wet weather conditions.

Generally speaking, E.coli concentrations occasionally exceeded the PWQO in all three monitored streams, largely following intensive rain events. In 2012, dry weather samples from Martin Creek South and Pearns Creek in some instances have shown E.coli concentrations in excess of the PWQO that may be the result of low water volumes that summer and, consequently, increased stream vulnerability to contamination from natural and human-induced sources.

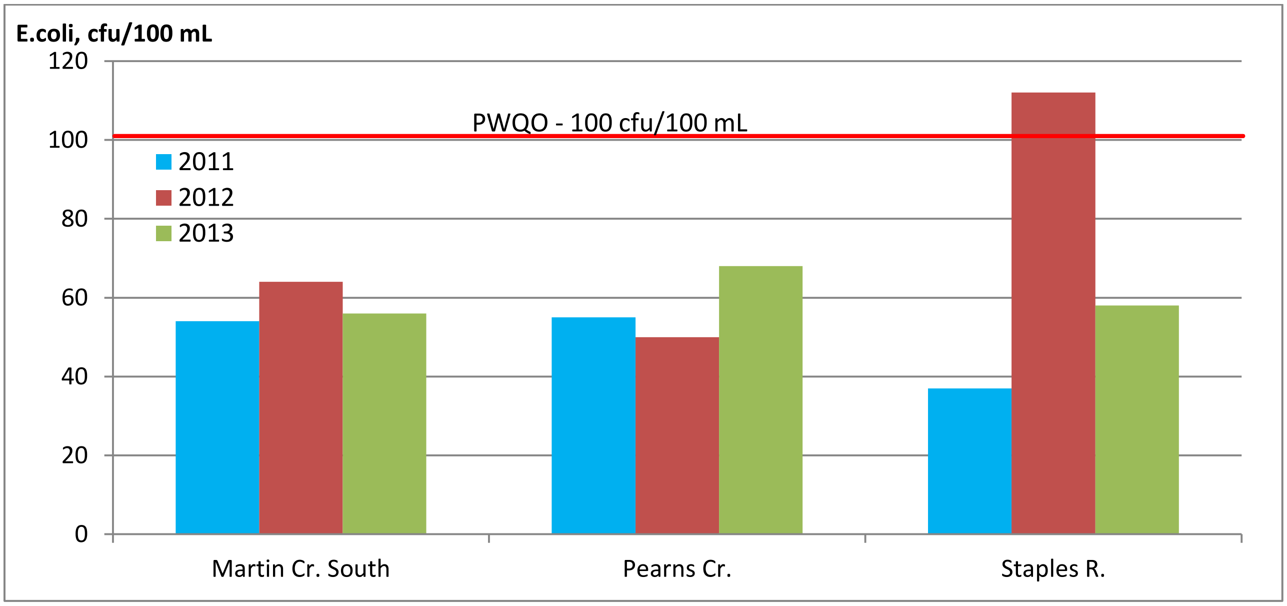

Figure 7.4. Geomean E. coli Concentrations in Balsam and Cameron Lake Tributaries in 2011, 2012 and 2013

7.5 Lake Water Quality

Water quality in lakes is determined by a number of abiotic and biotic factors. Among abiotic factors it is necessary to mention the hydrological regime, lake water levels, shoreline development and population density along the shoreline. As well, meteorological conditions in any given year play an important role in water quality. The amount of precipitation, solar radiation, numbers of sunny and cloudy days, wind conditions and average annual air temperature all have a significant effect on water quality in lakes.

Biotic factors are also very important for water quality in lakes. Those factors include bottom sediments and conditions at the water-sediment interface, the amount and consumption rates of dissolved oxygen in different layers of water, the amount of macrophytes, algae and phytoplankton in a lake and competition between them for nutrients, light and oxygen. The lake depth can have a considerable effect on the amounts of phosphorus and nitrogen in the water and their movement through the water column.

7.5.1 Balsam Lake

Overall, Balsam Lake can be characterized as an oligotrophic water body. This conclusion is based on phosphorus concentrations in the lake water in recent years and Secchi disk depth readings. According to the Canadian Council of Ministers of the Environment (CCME) classification, a lake can be defined as an oligotrophic water body if it has total phosphorus concentration less than 10 µg/L (0.01 mg/L) during the open water period (CCME, 2007*)*. During the 2011-2014 monitoring period, phosphorus levels in Balsam Lake at all monitoring locations were generally below the above-mentioned limit ***(Figure 7.5).*** Average Secchi disk depth readings usually exceeded 3.2 m, and even reached 4.8-5.6 m in 2012 and 2013.

Balsam Lake has four distinct parts: South Bay, West Bay, North Bay and Gull River Bay. Water quality in those bays is monitored by means of water sampling at four monitoring stations (BL1, BL2, BL3 and BL4 respectively) ***(Figure 7.1)***. The fifth station (BL5) is situated in the middle of the lake east of Grand Island and closer to the lake outlet. Another station (BC3) is located at the lake outlet on the Rosedale River and sampled as part of the PWQMN program ***(Figure 7.1).***

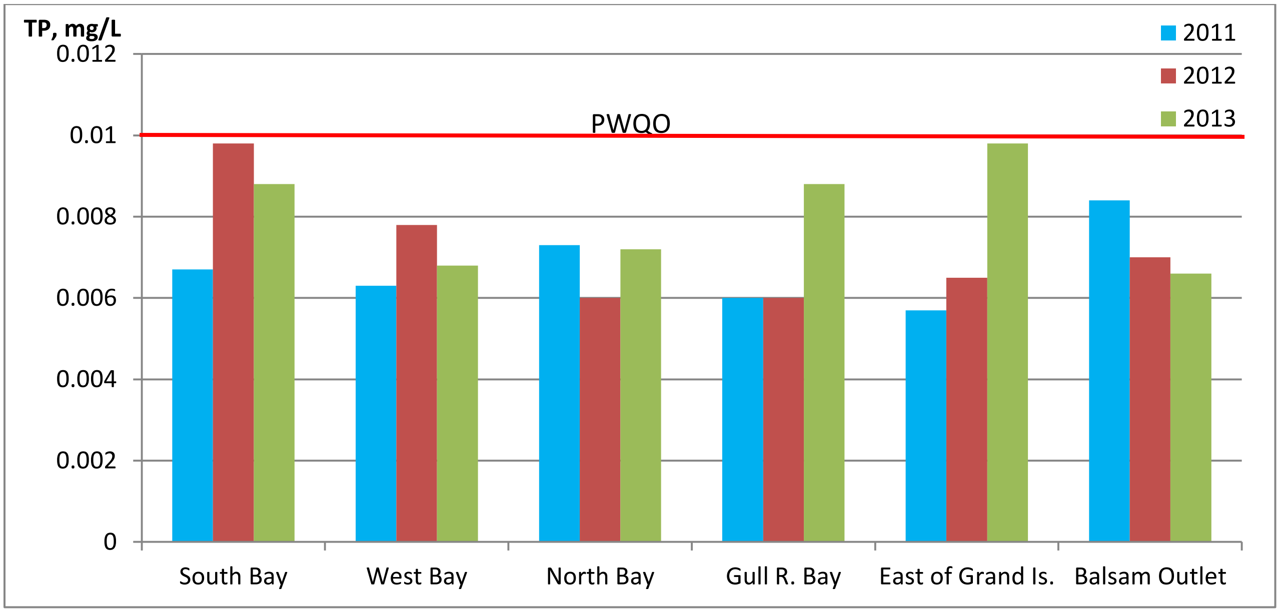

Figure 7.5. Average Phosphorus Concentrations in Balsam Lake During the May-September Period in 2011-2013 in Comparison with the PWQO

All four parts of the lake have rather different hydrographic features and hydrological regimes. As a result, the hydrochemical regime in each bay is influenced by the local hydrography and hydrology. The hydrochemical regime is also influenced to some degree by abiotic anthropogenic factors including the urban area of Coboconk, which is situated on the Gull River upstream of the north-eastern bay (Gull River Bay) and private septic systems along the shores.

South Bay on Balsam Lake is located to the south of Grand Island. The monitoring station BL1 is situated in the middle of the bay. This shallow bay usually has higher phosphorus and nitrogen concentrations when compared to the other parts of the lake. Average annual phosphorus concentrations in the bay ranged from 0.007 mg/L during the summer of 2011 to almost 0.010 mg/L in the summer of 2012.

Over the monitoring period, phosphorus levels in South Bay fluctuated from as low as 0.005 mg/L in May and September of 2013, to as high as 0.012 mg/L in June of 2012 and 0.014 mg/L in June of 2013. Phosphorus levels in this part of the lake appear to be highest at the beginning of summer (June) as a result of spring turnover. The lowest TP concentrations were observed every year in May and September.

The monitoring station BL2 is situated in the West Bay. Average annual phosphorus concentrations in the bay ranged from 0.006 mg/L during the summer of 2011 to almost 0.008 mg/L in the summer of 2012. Over the three-year period, phosphorus levels in the West Bay fluctuated from as low as 0.003 mg/L in May of 2013 and

0.005 mg/L in May and June of 2011, to as high as 0.010 mg/L in June of 2012 and 2013. Phosphorus levels in the West Bay appear to be usually the highest at the beginning of summer (June) as a result of the spring turnover. The lowest TP concentrations were usually observed in May.

The northern part of the lake includes the deeper North Bay and the Gull River Bay (the north-eastern bay). Both bays, which are represented by the monitoring stations BL3 and BL4 respectively, have the lowest phosphorus concentrations ***(Figure 7.5).*** The three-year average phosphorus concentration is 0.007 mg/L in both locations. The annual averages vary from 0.006 to 0.0073 mg/L in North Bay, and from 0.006 to 0.009 mg/L in Gull River Bay. In the latter, the highest TP levels (with an annual average of 0.009 mg/L) were observed in 2013 as a result of the very high spring inflow from the Gull River during May and June.

The eastern part of Balsam Lake is represented by two monitoring stations, namely BL5 and BC3. Phosphorus concentrations in the eastern portion of the lake fluctuated from 0.004 and 0.016 mg/L between the two locations during the summers of 2011-2013. The average phosphorus level near Grand Island was the highest in 2013 (0.010 mg/L), and the lowest in 2012 (0.007 mg/L). Near the lake outlet, the average TP concentration was the highest in 2011 (0.008 mg/L), while in 2013 phosphorus levels fluctuated from 0.004 to 0.010 mg/L, averaging at 0.007 mg/L. Generally speaking, phosphorus concentrations across the entire lake were the highest in 2013 ***(Figure 7.5).*** It appears that the extremely high spring inflow from the Gull River resulted in a considerable influx of phosphorus into the lake during April – June and caused elevated TP levels during the summer of 2013.

The available data demonstrate that the lowest phosphorus concentrations in Balsam Lake were usually detected in May, just before or during the spring turnover ***(Figure 7.6).*** After that, TP levels increase and reach the highest values in June-July, depending on the weather conditions each given year. During August-September, phosphorus concentrations decrease and typically reach lower levels in October-November that are comparable with values in May.

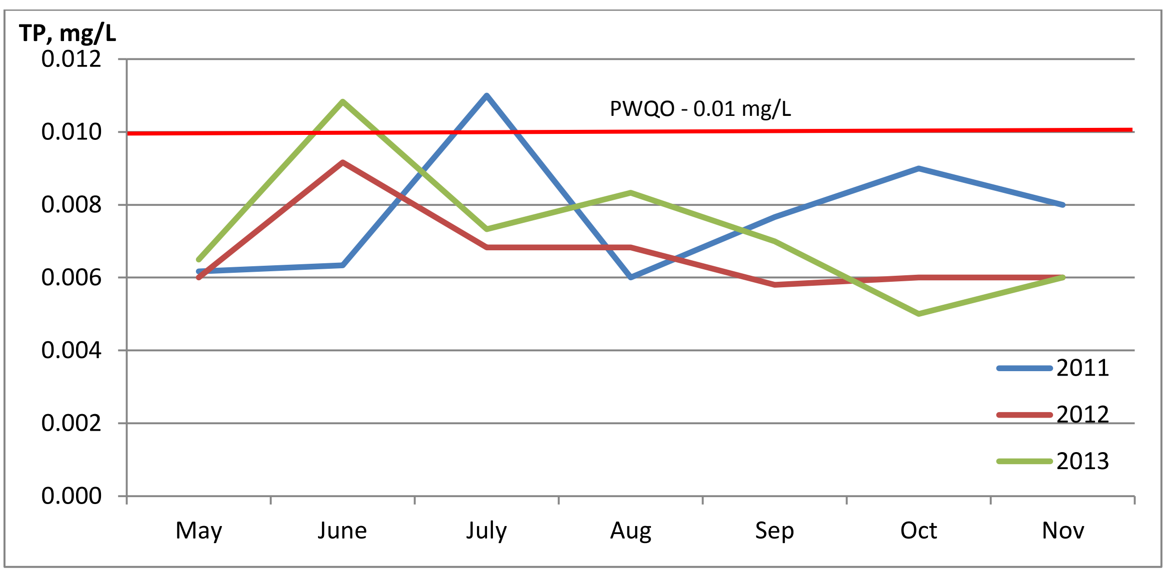

Figure 7.6. Average Monthly Phosphorus Concentrations in Balsam Lake in 2011, 2012 and 2013

The long-term data collected through the PWQMN program at the Balsam Lake outlet in Rosedale demonstrate that phosphorus concentrations in the lake were steadily decreasing from the 1970s until the 1990s ***(Table 7.10)***. Since the 1990s, TP concentrations have been quite stable and the number of exceedences has continued to decrease from 43% in 1996-2000 to 26% in 2006-2010. During the most recent 2011-2014 monitoring period, it seems that phosphorus levels resumed their declining trend ***(Table 7.10, Figure 7.7)***. During this period, only two samples exceeded the provincial objective and both average and median concentrations considerably decreased. More monitoring data are needed in order to sustain or reject this assumption.

Table 7.10. Results of Statistical Analysis of Total Phosphorus Concentrations at the Balsam Lake Outlet During May-October for the 1971-2014 Monitoring Period

Statistical Parameters	1971-1975	1976-1980	1981-1985	1986-1990	1996-2000	2001-2005	2006-2010	2011-2014
Maximum	0.028	0.025	0.020	0.022	0.020	0.024	0.019	0.016
75th percentile	0.018	0.016	0.014	0.011	0.012	0.012	0.011	0.010
25th percentile	0.010	0.009	0.010	0.007	0.008	0.008	0.008	0.006
Minimum	0.005	0.003	0.004	0.004	0.004	0.004	0.004	0.004
Average	0.014	0.013	0.012	0.010	0.011	0.011	0.010	0.008
Median (50th percentile)	0.012	0.014	0.012	0.009	0.010	0.010	0.010	0.008
Exceedences, %	73	63	65	41	43	33	26	17
Number of samples	33	27	26	29	28	30	27	23

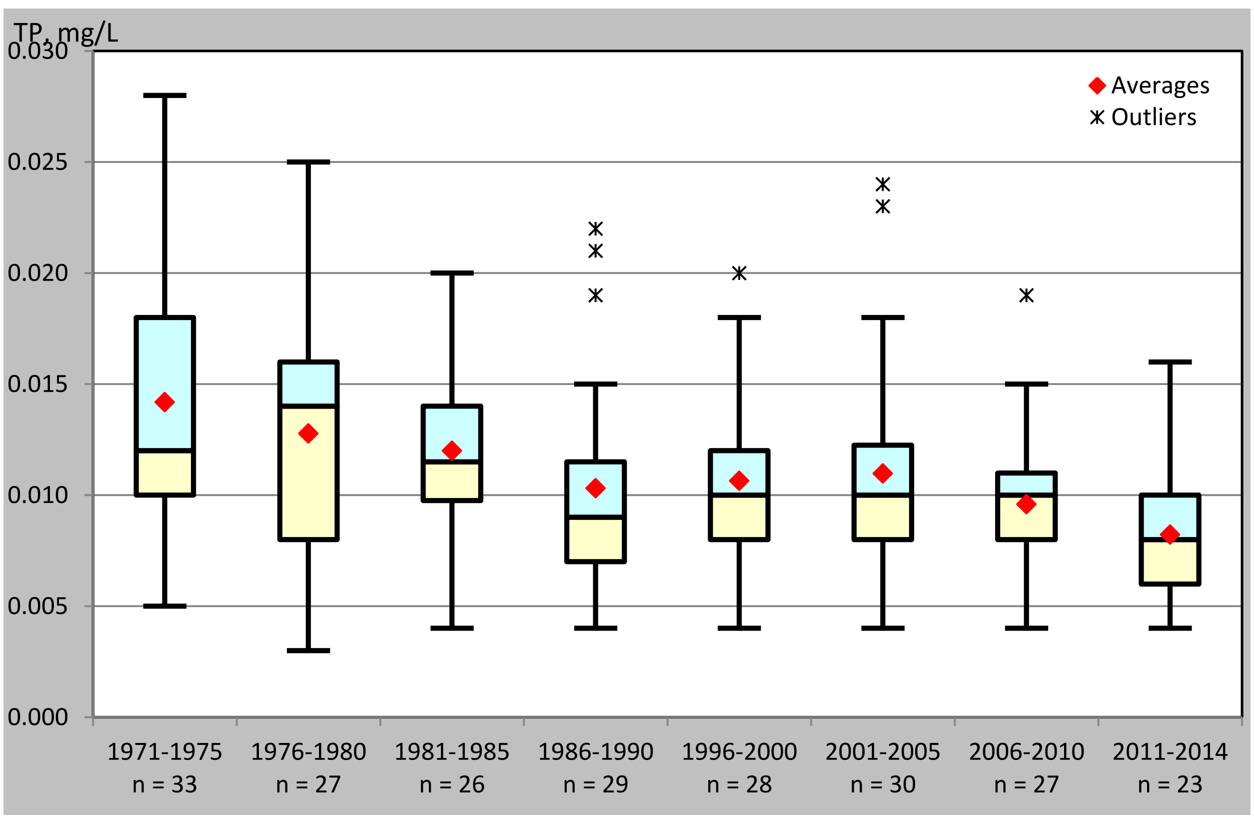

Figure 7.7. Phosphorus Concentrations in Balsam Lake over the Entire Period of Monitoring

Total nitrogen concentrations are quite low across the entire lake ***(Figure 7.8).*** They are a little bit higher in South Bay (station B1) - which is influenced by runoff from agricultural fields south of the lake - and at the lake outlet (station BC3). At station BC3, nitrogen concentrations were the highest with average and median concentrations being 0.27 mg/L. This may be a result of influence from a small urban area (Rosedale) just upstream of the sampling station ***(Table 7.11)***. Among the open water stations, BL1 had the highest nitrogen concentrations. These ranged from 0.18 mg/L in August 2012 to 0.37 mg/L in August 2013, with an average of 0.26 mg/L. The lowest TN levels among five stations were observed at station BL3 (0.16-0.33 mg/L with an average of 0.23 mg/L), and at station BL4 (0.13-0.32 mg/L) which also had an average of 0.23 mg/L ***(Table 7.11)***.

Table 7.11. Results of Statistical Analysis of Total Nitrogen Concentrations in Balsam Lake for the Period of 2011-2013

Statistical Parameters	BL1	BL2	BL3	BL4	BL5	BC3
Maximum	0.37	0.36	0.33	0.32	0.30	0.32
75th percentile	0.29	0.27	0.27	0.27	0.26	0.28
25th percentile	0.23	0.21	0.20	0.19	0.21	0.24
Minimum	0.18	0.19	0.16	0.13	0.15	0.22
Average	0.26	0.25	0.23	0.23	0.24	0.27
Median (50th percentile)	0.26	0.24	0.23	0.25	0.25	0.27
Exceedences, %	0	0	0	0	0	0
Number of samples	12	12	12	12	12	17

The lowest total nitrogen concentrations in the lake were observed in 2012 (when levels at the five stations ranged from 0.13-0.17 mg/L in August to 0.24-0.31 mg/L in July. In 2011 and 2013, nitrogen concentrations were higher, ranging from 0.18-0.23 mg/L to 0.27-0.37 mg/L. There is no apparent seasonal pattern in total nitrogen levels.

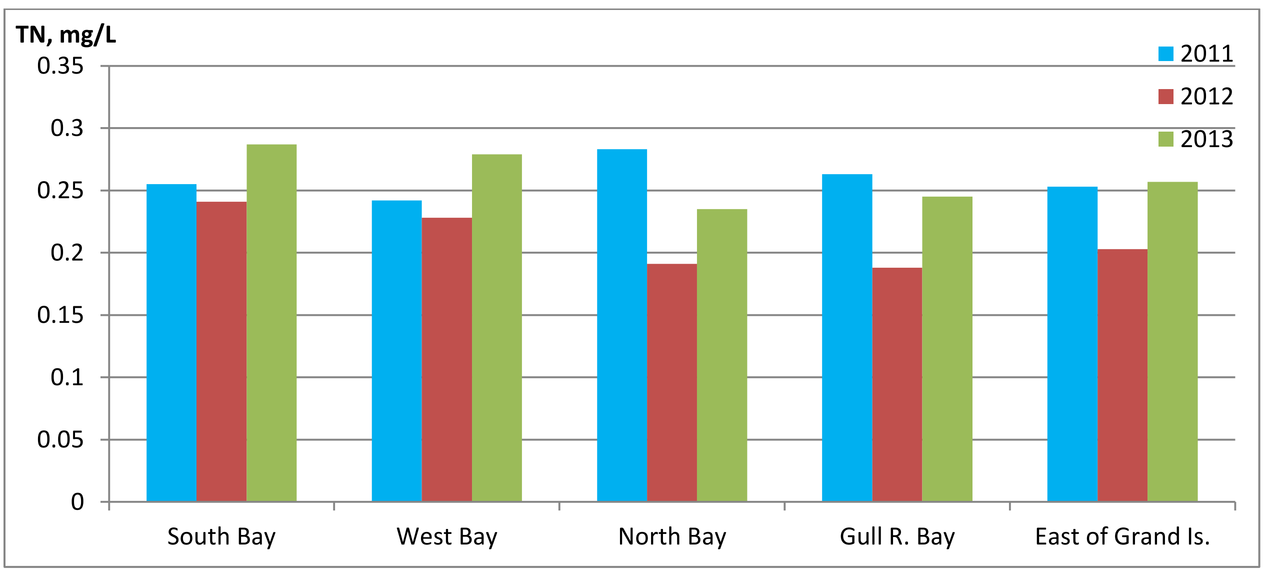

Figure 7.8. Average Total Nitrogen Concentrations in Balsam Lake During the May-September Period in 2011-2013

Organic nitrogen (total Kjeldahl nitrogen minus ammonia) constitutes most of the total nitrogen amount in the lake water, ranging from 64% to 94% of TN amount, with an average of 83-87%. Nitrate levels tend to be higher in early spring (March-April), up to 0.37 mg/L. During summer and autumn, nitrate concentrations are often below the laboratory detection limit (0.02 mg/L) or in the range just above the limit – 0.02-0.05 mg/L.

Dissolved oxygen (DO) is one of the most important parameters in natural water. It is extremely vital for fish and other forms of aquatic life. Major sources of dissolved oxygen in water are the atmosphere and photosynthesis by aquatic vegetation and algae (CCME, 1999). DO in lakes is consumed mainly for oxidation of organic matter at the sediment-water interface, and within the water column for bacterial, plant and animal respiration (CCME, 1999). An excessive input of phosphorus and nitrogen into lakes can lead to an over-abundance of aquatic vegetation and/or algae. The resulting plant die-off and decomposition causes an accelerated depletion of DO levels in the hypolimnion (deep water layers) affecting the well-being of aquatic organisms.

Extremely low DO levels have another negative effect on lake ecosystems. When deficits of dissolved oxygen in the near-bottom layers of lake water occur, phosphorus may begin desorbing from lake sediments. This can have a significant effect on phosphorus concentrations in water. An acute deficit of dissolved oxygen in combination with low pH values creates a reducing environment (negative Eh values) in both bottom sediments and the water/sediment interface. This causes the intensive process of desorption of previously adsorbed phosphorus from sediments. As well, low redox potential can lead to mineral dissolution of iron-phosphorous, manganese-phosphorous and aluminum-iron-phosphorous minerals present in the lake sediments. As a result, elevated concentrations of phosphorus as well as iron and manganese can be observed in the bottom layer of the lake water.

The PWQOs have several numerical limits for the dissolved oxygen which depend on type of water biota and temperature of water. For the warm water biota, the objective varies from 4 mg/L at 25°C to 7 mg/L at 0°C and the percent of DO saturation stays at 47% (MOE, 1994). For the cold water biota, the objective varies from 5 mg/L at 25°C to 8 mg/L at 0°C, and the percent of DO saturation varies from 54 to 63% (MOE, 1994). The CWQGs for the Protection of Aquatic Life have somewhat more stringent DO limits. For the warm water organisms the lowest acceptable DO concentration is 5.5 mg/L, and for the cold water organisms the lowest acceptable concentration is 6.5 mg/L (CCME, 1999).

A regime of dissolved oxygen in Balsam Lake is characterized by predominantly high DO concentrations during both the spring – summer and autumn periods ***(Figure 7.9)***. In the surface layer of water, oxygen levels have primarily varied within a quite narrow range of concentrations (7.6 – 9.8 mg/L or 89 – 102% of saturation).

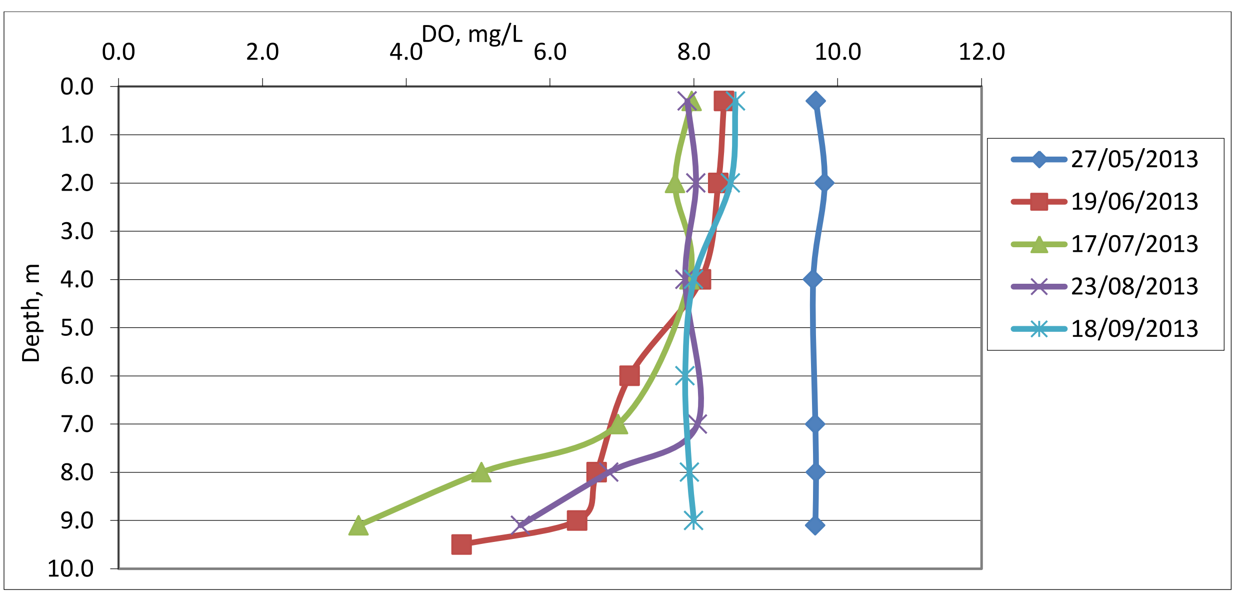

Figure 7.9. Dissolved Oxygen Profiles in Balsam Lake (Station BL3) in May-September 2013

In the hypolimnion (bottom layers of water), DO levels were usually lower (6.0 – 9.5 mg/L or 65 – 92%), but still above the PWQO and CWQG. During July each year, DO levels in the bottom water of some stations (BL2, BL3, and BL5) were even lower - 2.9 – 5.8 mg/L. The lowest oxygen concentration of 2.92 mg/L (32% of saturation) was observed at the station BL2 in July 2014 at the depth of 8.8 m. At the station BL3, the lowest DO level of 3.3 mg/L (37% of saturation) was observed in July 2013 at the depth of 9.1 m. Monthly dissolved oxygen profiles at the station BL3 water in 2013 are presented in ***Figure 7.9***.

7.5.2 Cameron Lake

Similar to Balsam Lake, Cameron Lake is an oligotrophic water body. While phosphorus concentrations in the lake are a little bit higher than in Balsam Lake, mostly they are below 10 µg/L or 0.01 mg/L. During the 2011-2014 monitoring period, average phosphorus levels in Cameron Lake at all monitoring locations fluctuated from 0.006 to 0.014 mg/L ***(Figure 7.10).*** Average Secchi disk depth readings usually exceeded 2.9 m and even reached 4.1-4.4 m in 2012.

Cameron Lake is a small water body and does not have distinct separated parts. While it is possible to distinguish several small bays, they are wide open to other parts of the lake; water is mostly homogeneous across the lake with only small variations in TP and TN concentrations between the northern and southern portions of the lake.

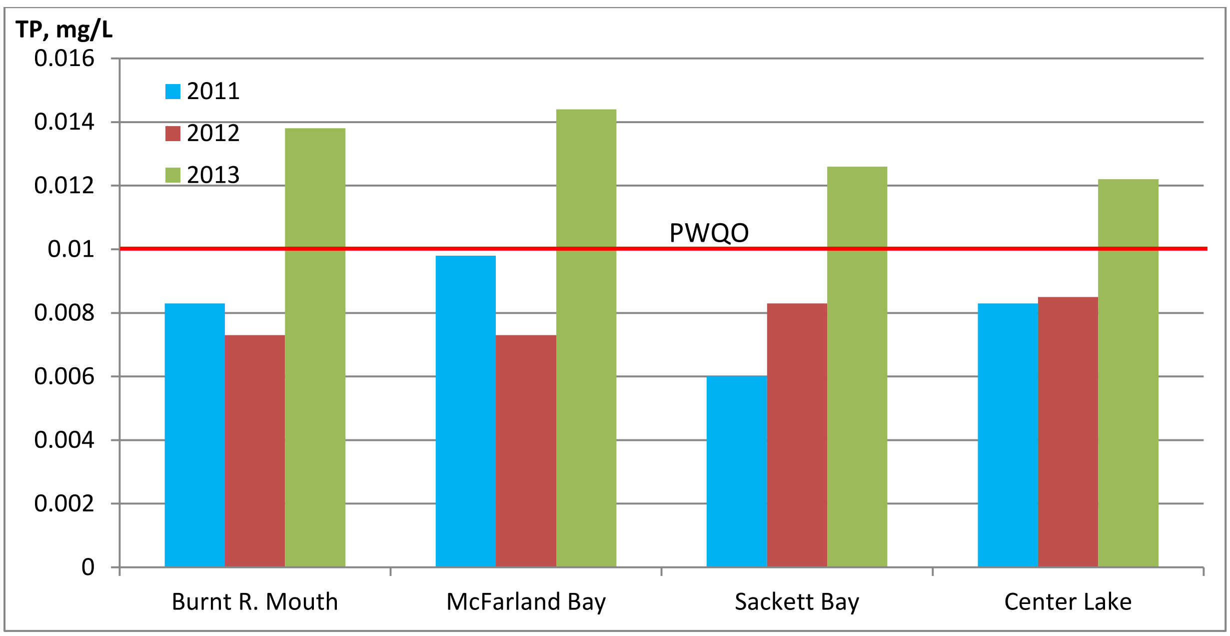

Figure 7.10. Average Phosphorus Concentrations in Cameron Lake during the May-September Period in 2011-2013 in Comparison with the PWQO

Water quality in the lake is monitored by means of water sampling at five monitoring stations (CL1, CL2, CL3, CL4 and ST2) ***(Figure 7.1)***. The station CL1 is situated in the northern part of the lake in close proximity to the Burnt River mouth and the Rosedale River. Water flow from the Burnt River and from Balsam Lake via the Rosedale River has a significant effect on water quality in Cameron Lake. The stations CL2 and CL3 represent the southern portion of Cameron Lake and are located near the Pearns Creek mouth (McFarland Bay) and in Sackett Bay respectively. The water quality in the southern part of the lake is influenced by anthropogenic factors such as agricultural runoff, urban runoff from some nearshore urban areas and private septic systems along the shore. Station CL4 is situated in the middle of the lake, over the deepest area of the water body. The fifth station (ST2), is located at the lake outlet in Fenelon Falls on the Fenelon River (Channel). It is sampled not only in the framework of the lake management plan, but also as part of the PWQMN program.

As noted, monitoring station CL1 is situated in the northern portion of the lake. Average annual phosphorus concentrations in this area ranged from 0.007 mg/L during the summer of 2012 to almost 0.014 mg/L in the summer of 2013 ***(Figure 7.10)***.

Over the three-year period, phosphorus levels in the northern part of the lake fluctuated from as low as 0.005 mg/L in August of 2012 and 0.006 mg/L in May and June of 2011, to as high as 0.024 mg/L in June of 2013. Phosphorus levels appear to be usually the highest during hot months (June-August), probably reflecting the increasing algae population in summer time. The lowest TP concentrations were observed during different months depending on the year. For instance, 2012 was a very dry year with a small amount of flow moving into and through the lake. Phosphorus concentrations that year were very low. The next year, 2013, was a wet year with extremely high flow entering the lake from the Burnt River that resulted in elevated phosphorus concentrations across the entire lake ***(Figure 7.10)***. It appears that during dry years, phosphorus levels are low, while during wet years with high inflows, TP concentrations are much higher.

Phosphorus concentrations in the southern portion of Cameron Lake varied between 0.003 and 0.031 mg/L at two stations during the summers of 2011-2013. The average phosphorus level at McFarland Bay near the Pearns Creek mouth (station CL2) was the highest in 2013 (0.014 mg/L). At Sackett Bay (station CL3) the average TP concentration was the also highest in 2013 (0.013 mg/L). During the summer of 2012, as a result of very dry spring and summer, phosphorus levels fluctuated in a lower range from as low as 0.003 mg/L in the middle of August, to 0.010 mg/L in June-July. Generally speaking, phosphorus concentrations were much higher in 2013 compared to 2012 ***(Figure 7.10).*** In the central area of Cameron Lake, phosphorus concentrations generally followed a pattern similar to other parts of the lake.

The collected data demonstrate that the lowest phosphorus concentrations in Cameron Lake were usually detected in May, just before or during the spring turnover ***(Figure 7.11).***

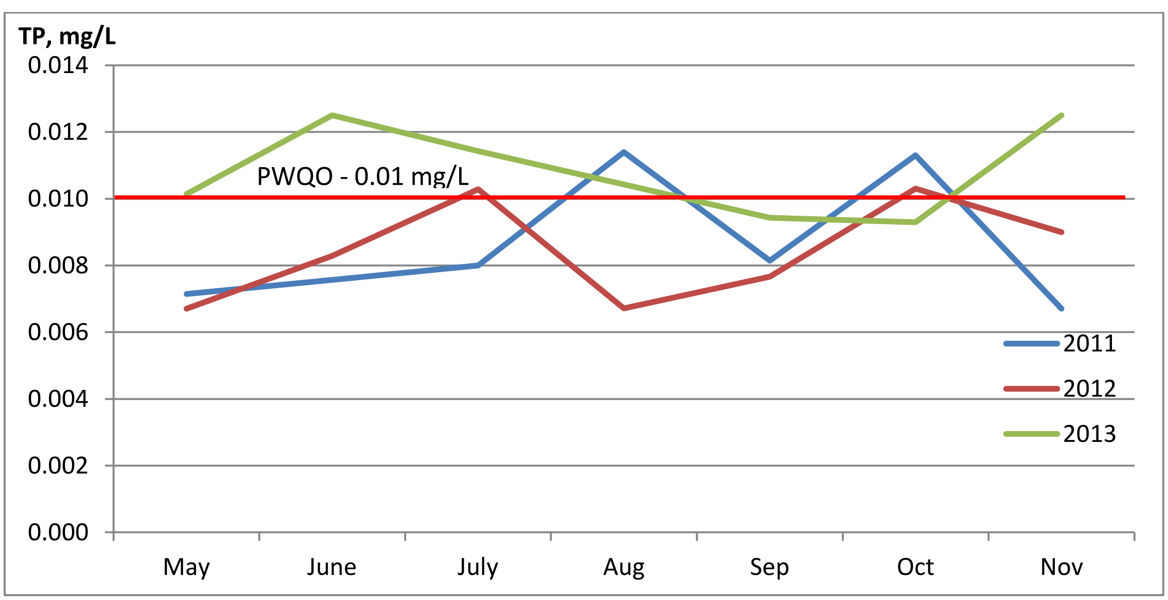

Figure 7.11. Average Monthly Phosphorus Concentrations in Cameron Lake in 2011, 2012 and 2013

In June, TP levels always increase and can reach the highest values in July or August depending on the weather conditions each year. In September, phosphorus concentrations are typically lower and comparable with the May values. In October they are increasing again, reaching, on average, the highest values. In November, during the three-year monitoring period, average TP levels varied from 0.007 to 0.013 mg/L.

The long-term data collected through the PWQMN program at the Cameron Lake outlet in Fenelon Falls demonstrate that phosphorus concentrations in the lake have shown a similar trend as in Balsam Lake. They were steadily decreasing from the 1970s until the 1990s ***(Table 7.12, Figure 7.12)***. Over that 20-year period, average concentration decreased by 50% from 0.015 mg/L to 0.010 mg/L. The number of exceedences dropped from 85% in 1971-1975 to 34% in 1986-1990. During the next 30 years, average and median phosphorus levels remained within the same narrow range of 0.009-0.011 mg/L ***(Table 7.12)***. The number of exceedences was approximately the same (34-35%), except for the 2001-2005 period when it jumped to 50%. It then decreased to 34% during the following period.

Table 7.12. Results of Statistical Analysis of Total Phosphorus Concentrations at the Cameron Lake Outlet During May-October for the 1971-2014 Monitoring Period

Statistical Parameters	1971-1975	1976-1980	1981-1985	1986-1990	1996-2000	2001-2005	2006-2010	2011-2014
Maximum	0.037	0.030	0.046	0.021	0.016	0.022	0.025	0.017
75th percentile	0.017	0.017	0.014	0.011	0.012	0.012	0.012	0.011
25th percentile	0.012	0.009	0.008	0.007	0.008	0.008	0.008	0.007
Minimum	0.005	0.003	0.003	0.002	0.004	0.005	0.002	0.003
Average	0.015	0.014	0.013	0.010	0.010	0.011	0.010	0.009
Median (50th percentile)	0.014	0.012	0.011	0.009	0.010	0.011	0.009	0.010
Exceedences, %	85	68	56	34	35	50	34	35
Number of samples	34	28	36	29	26	30	38	60

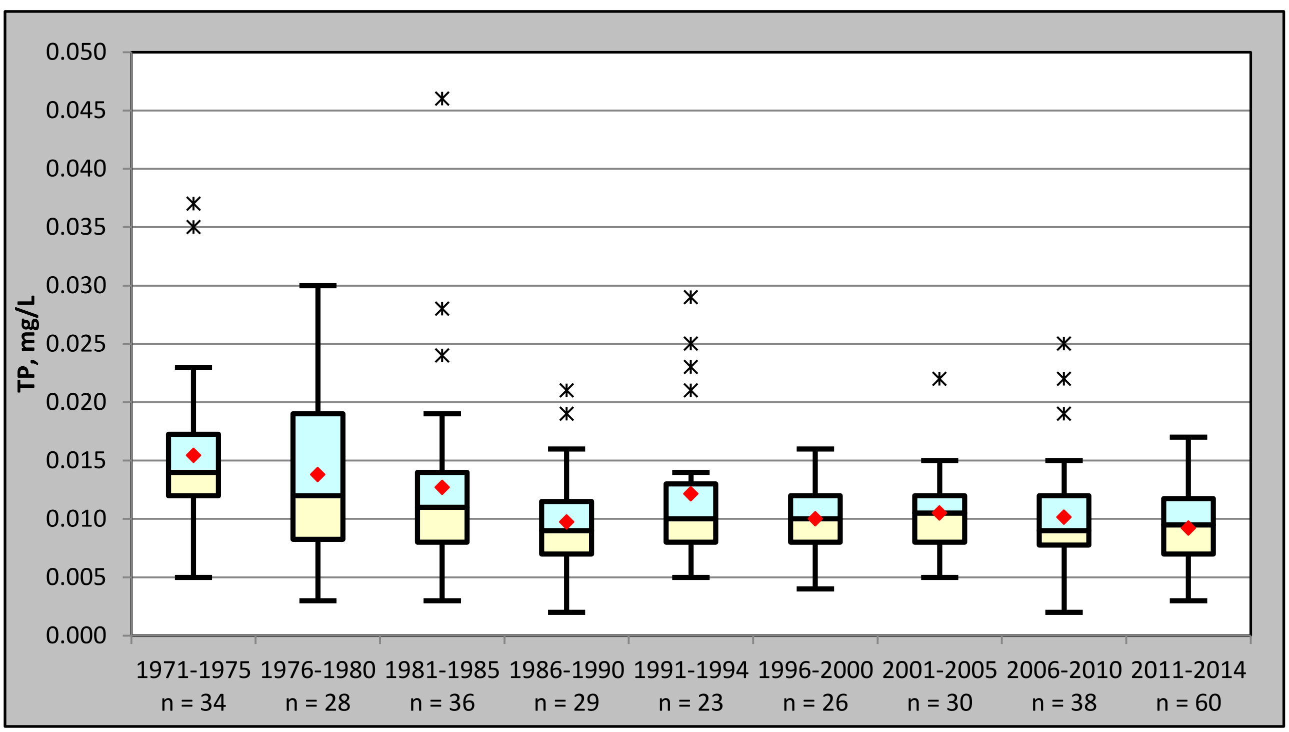

Figure 7.12. Phosphorus Concentrations in Cameron Lake over the Entire Period of Monitoring

Looking at the data in ***Table 7.12*** and ***Figure 7.12*** one can see that phosphorus concentrations in Cameron Lake have not changed much since the end of 1980s. The objective of the Lake Management Plan would be to maintain current water quality in the lake and prevent any possible deterioration as a result of increasing human activities in the watershed.

In Cameron Lake total nitrogen concentrations fluctuated in the range of 0.12 – 0.54 mg/L ***(Table 7.13).*** The highest concentrations were observed in 2013 resulting in average concentrations 0.31 – 0.35 mg/L ***(Figure 7.13).*** In 2012, nitrogen concentrations were the lowest, ranging from 0.12 to 0.31 mg/L and averaging at 0.21 – 0.22 mg/L.

Organic nitrogen also constituted most of the total nitrogen amount in the water, ranging from 63 – 95% of TN amount and averaging at 88 – 91%. Similar to Balsam Lake, nitrate concentrations were much higher in winter and spring (0.07 – 0.26 mg/L). During summer and autumn, nitrate levels usually fluctuated in the range of 0.02 – 0.08 mg/L, or below the laboratory detection limit (0.02 mg/L).

Table 7.13. Results of Statistical Analysis of Total Nitrogen Concentrations in Cameron Lake for the Period of 2011-2014

Statistical Parameters	CL1	CL2	CL3	CL4	ST2
Maximum	0.48	0.54	0.46	0.43	0.46
75th percentile	0.34	0.31	0.32	0.32	0.33
25th percentile	0.25	0.24	0.25	0.25	0.27
Minimum	0.16	0.12	0.13	0.15	0.15
Average	0.30	0.28	0.29	0.28	0.30
Median (50th percentile)	0.30	0.27	0.29	0.28	0.30
Exceedences, %	0	0	0	0	0
Number of samples	15	15	15	14	60

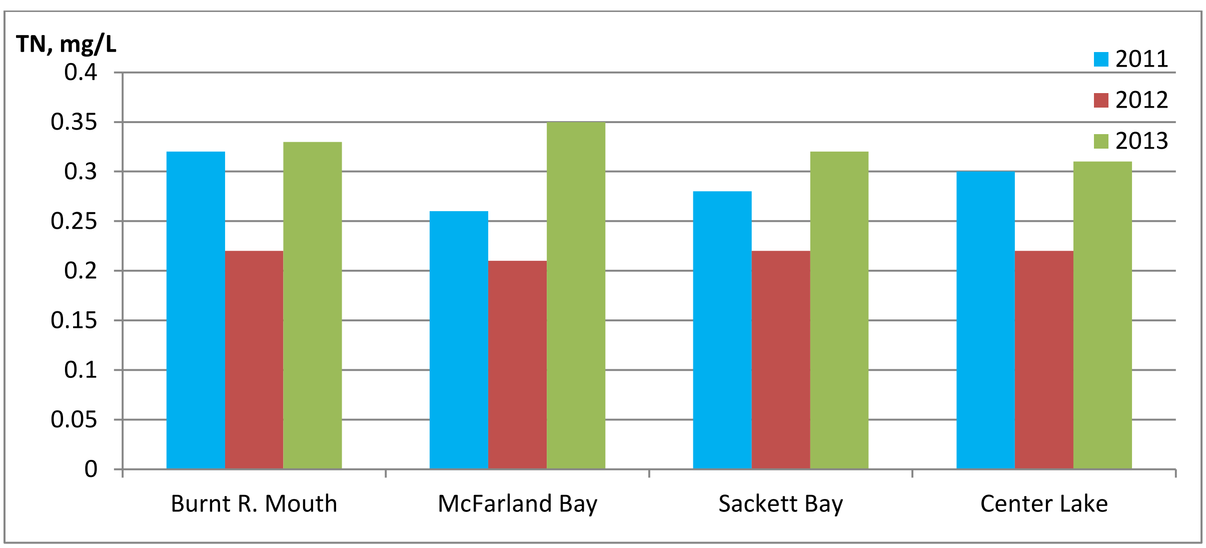

Figure 7.13. Average Total Nitrogen Concentrations in Cameron Lake during the May-September Period in 2011-2013

The regime of dissolved oxygen in Cameron Lake is generally good, with DO concentrations in the surface layer of water being mainly above 90% of saturation (7.53 – 9.89 mg/L and 82 – 116%). In the bottom layers of water at three stations (CL1, CL2 and CL3) with the water depths from 3.0 to 7.0 m, oxygen levels were often lower (5.5 – 8.8 mg/L) in summer months, but never dropped below the PWQO. At station CL4, which has a water depth of 15.5 m, a severe deficit of oxygen in the hypolimnion was often observed during July – August and once in September of 2012. In July of each year, DO concentrations in the near bottom layers of water from the depth of 10.0 m and deeper were in the range of 0.95 – 3.6 mg/L or 9.7 – 39% of saturation. In August of each year, the situation was worsening with dissolved oxygen being virtually absent in the near bottom layers of water. For example, in August 2012 and August 2013, DO readings were as low as 0.1 and 0.02 mg/L respectively which is just 0.3 – 0.9% of saturation ***(Figure 7.14).*** During August 2014, oxygen concentrations at depths below 10.0 m varied from 0.14 to 0.70 mg/L. Similar severe dissolved oxygen depletions in the deep water area were observed during July – August in 1971, when DO concentrations were close to 0.0 mg/L below the water depth of 12.0 m (OWRC, 1971).

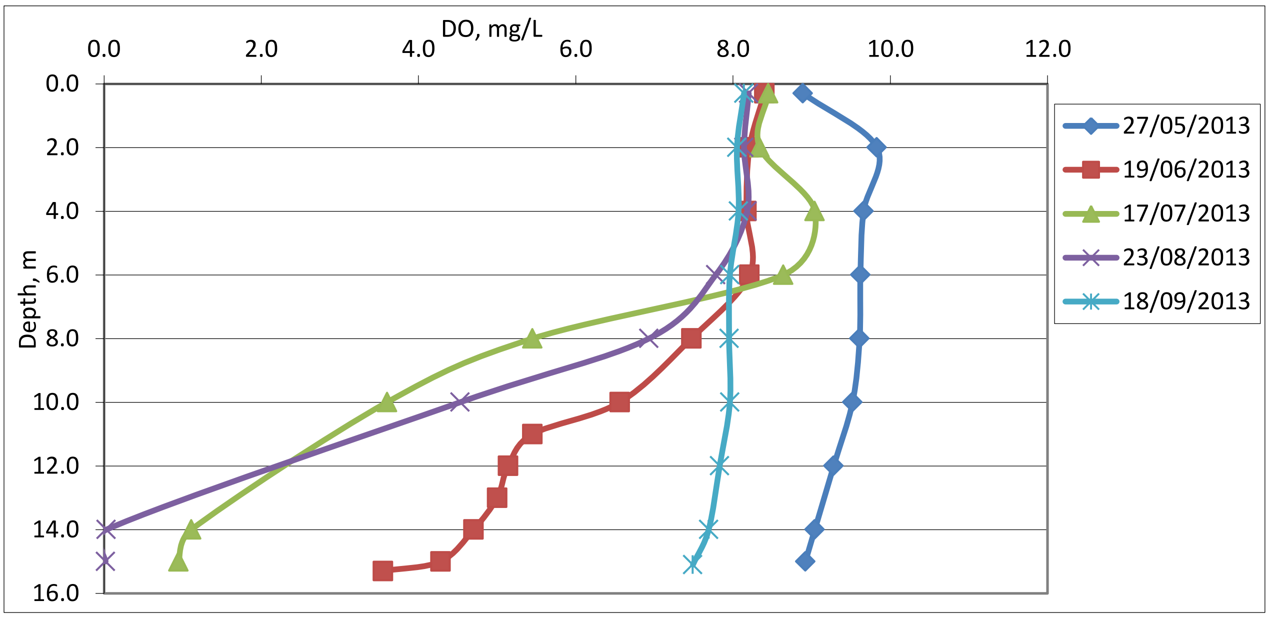

Figure 7.14. Dissolved Oxygen Profiles in Cameron Lake (Station CL4) in May-September 2013

7.5.3 Public Beaches

The Haliburton, Kawartha, Pine Ridge (HKPR) District Health Unit monitors bacteriological contamination at three beaches on Balsam Lake and at one beach on Cameron Lake ***(Figure 7.15).*** Another public beach, namely Lions Park Beach, is located on the Gull River in Coboconk, several kilometers upstream of Balsam Lake. In order to ensure that the lake beaches are safe for swimming, health unit inspectors collect water samples for Escherichia coli analysis every week from the beginning of June until the end of August.

The health unit's E.coli data for 2011-2013 demonstrate that three out of five beaches usually have good bacteriological water quality. Two beaches with serious concerns about water quality and swimming safety are the Bond Street beach in Fenelon Falls and Lions Park beach in Coboconk ***(Table 7.14).***

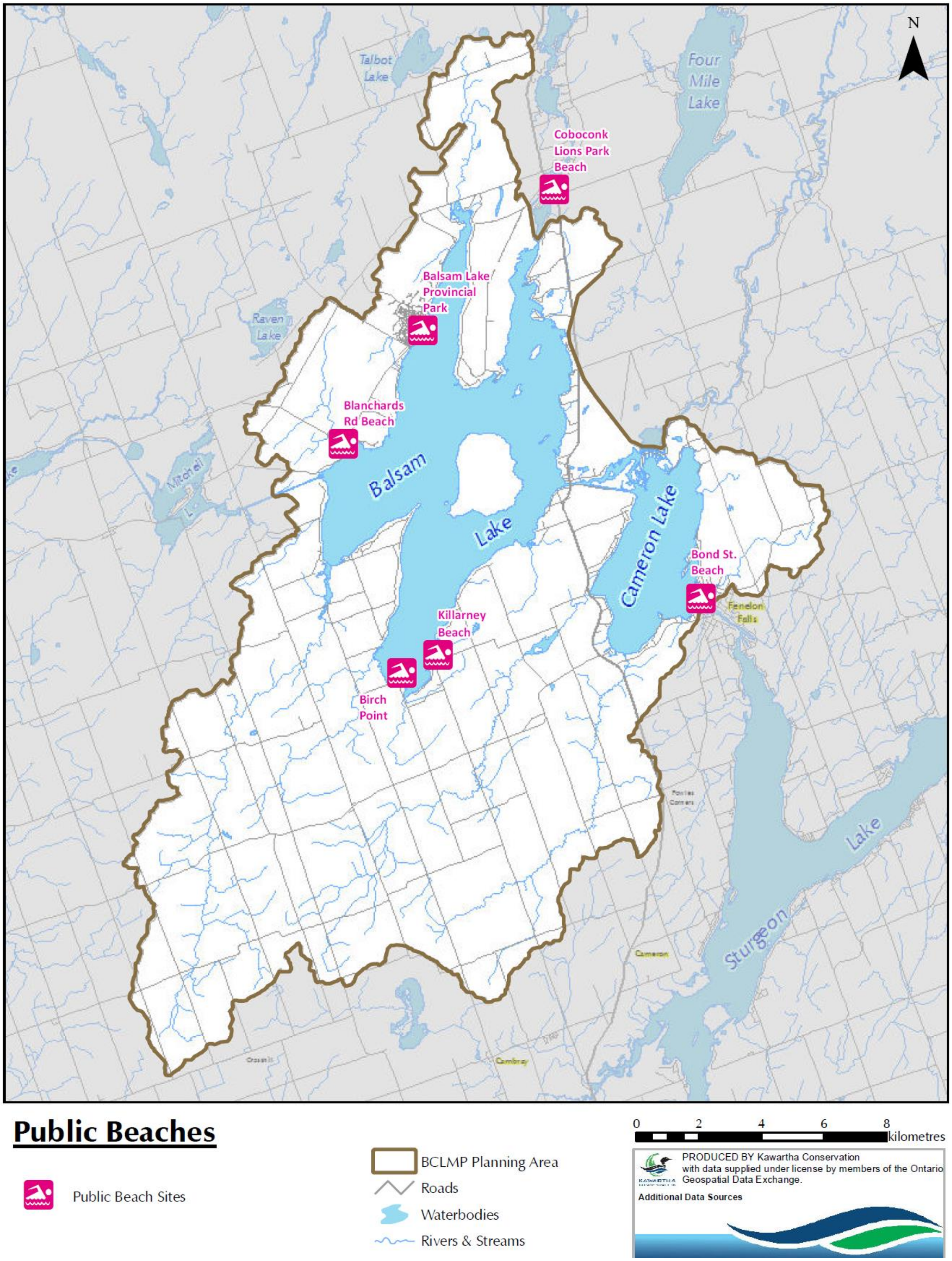

Figure 7.15. Public Beach Locations Around Balsam and Cameron Lakes

Table 7.14. E.coli Concentrations at the Balsam and Cameron Lakes Beaches in 2011 - 2013

Beach	Lake/River	2011		2012		2013	
		Geomean, cfu/100mL	Exceed-ences, %	Geomean, cfu/100mL	Exceed-ences, %	Geomean, cfu/100mL	Exceed-ences, %
Blanchards Rd.	Balsam	27	0	20	8	31	17
Birch Point	Balsam	18	10	18	8	17	9
Bond Street	Cameron	25	10	71	46	146	58
Kilarney Bay	Balsam	13	0	19	15	17	11
Lions Park	Gull R.	62	42	27	8	267	75

During recent years, the Bond Street beach has had the worst water quality among the five beaches ***(Figure 7.16).*** The earlier health unit E.coli data from the 2007-2010 period show the same trend ***(Table 7.15)***. E.coli concentrations at the Bond Street beach exceeded the PWQO (100 cfu/100 mL) in 54% of samples in 2010, in 46% of samples in 2012 and in 58% of samples in 2013 which often resulted in beach posting ***(Table 7.14 and 7.15).*** As a result, the annual geometric mean exceeded 100 cfu/100 mL in 2010 and 2013, and was as high as 71 cfu/100 mL in 2012. The most likely source of contamination in this location is the local Canada goose population. At the same time, the Lions Park beach in Coboconk had even worse bacteriological water quality in 2013 when the geometric mean was 267 cfu/100 mL and 75% of samples exceeded the PWQO. The other three beaches had low E.coli levels that only occasionally exceeded the provincial objective ***(Table 7.14).***

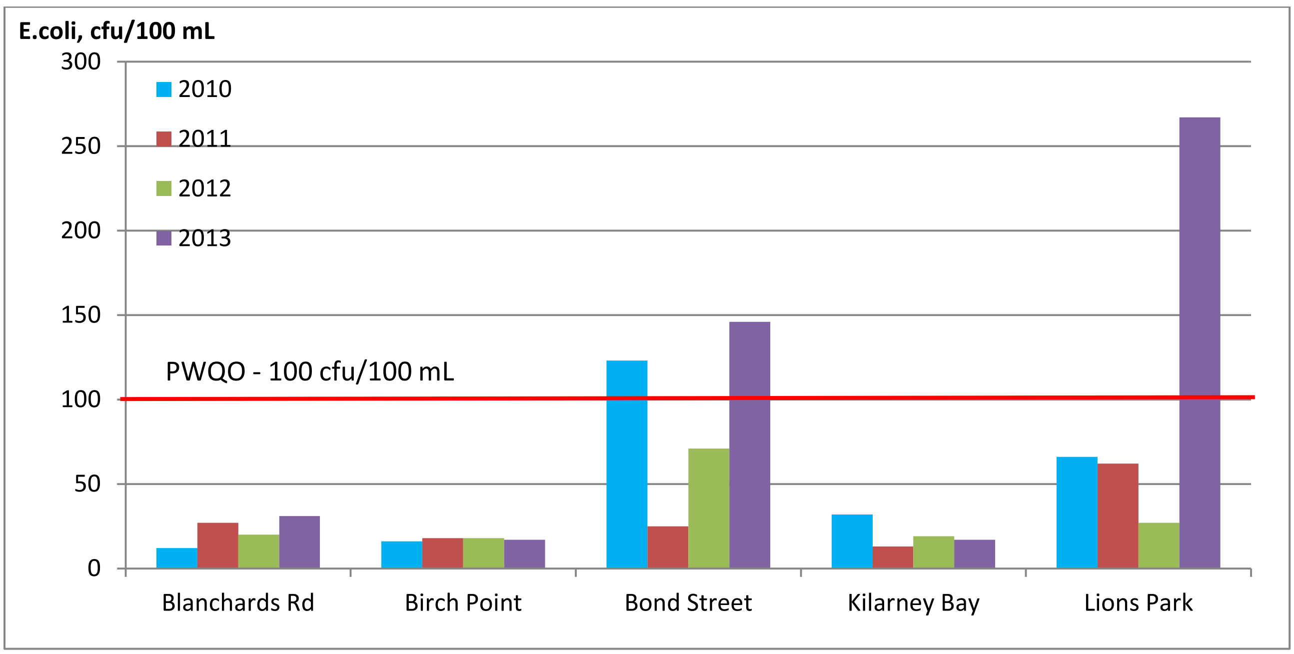

Figure 7.16. Annual Geometric Mean E.coli Concentrations at the Balsam and Cameron Lakes Beaches

While E.coli concentrations can be quite high at some beaches, they are usually very low at open water sampling locations according to the Kawartha Lake Stewards Association (KLSA) data (KLSA, 2012, 2013, 2014). On Balsam Lake, KLSA volunteers have collected water samples for E.coli analysis since 2009. They monitor 12 sites across the lake and take samples usually 6 times per season.

During seven years of monitoring, E.coli concentrations exceeded the PWQO only in three samples from three different stations in 2009 and 2010. All other samples were far below the PWQO, mainly in the range of 3 – 30 cfu/100 mL. Many samples have returned results below the method detection limit. The annual geometric mean varied from 3 – 15 cfu/100 mL at different stations (KLSA, 2012, 2013, 2014).

Table 7.15. E.coli Concentrations at the Balsam and Cameron Lakes Beaches in 2007 - 2010

Beach	Lake/ River	2007		2008		2009		2010	
		Geomean, cfu/100mL	Exceed-ences, %	Geomean, cfu/100mL	Exceed-ences, %	Geomean, cfu/100mL	Exceed-ences, %	Geomean, cfu/100mL	Exceed-ences, %
Blanchards Rd.	Balsam	34	23	24	17	12	0	12	0
Birch Point	Balsam	17	8	15	0	29	17	16	0
Bond Street	Cameron	46	15	98	50	134	64	123	54
Kilarney Bay	Balsam	18	9	24	9	30	20	32	23
Lions Park	Gull R.	142	62	29	8	52	11	66	46

7.6 Sources of Phosphorus and Nitrogen

Phosphorus and nitrogen are the two most significant nutrients in aquatic ecosystems. Without nutrients, there would be no aquatic life in watercourses and lakes. However, because of increasingly intensive human activities during the last century, nutrients have been entering natural water bodies in excessive amounts. As a result, phosphorus and nitrogen have become responsible for the process of eutrophication and overabundant development of macrophytes, multi-cellular algae and phytoplankton in many lakes and rivers across Canada, including Cameron Lake. Other chemical elements (such as copper, iron, manganese, molybdenum, zinc and some others called micronutrients) are also vital for the development of aquatic vegetation. They are usually present in small yet sufficient quantities. Only phosphorus and nitrogen concentrations, however, affect the rate of algae and vegetation growth and, consequently, the rate of eutrophication.

As explained, phosphorus and nitrogen enter Balsam and Cameron lakes from various sources. It can be runoff from agricultural fields and urban areas, shoreline development and recreational activities, wastewater from the treatment plant and industrial discharges, and atmospheric deposition. It is impossible to determine a single source of nutrients that is responsible for the entire process of eutrophication. This process is a consequence of many factors and causes, most of them having a human origin.

All nutrient sources can be separated into two large groups: point sources and non-point sources. Point sources of nutrients include industrial and municipal sewage outflows, individual septic tanks, single wastewater discharge pipes from farms, other businesses, etc. Non-point sources include nutrients that are entering water bodies with urban runoff, agricultural runoff, and atmospheric deposition (wet and dry). Natural sources include shoreline and riverbank erosion, groundwater discharges, wild waterfowl, local geology and soil conditions, etc.

Balsam Lake and Cameron Lake receive nutrient input from many of the above-mentioned sources. In order to quantify nutrient load into the lakes, all sources have been separated into five major categories:

1) River flow and surface water runoff including:

    1a) Gull River flow;
    1b) Burnt River flow;
    1c) Corben Creek flow;
    1d) Local stream and surface water flow;
2) Atmospheric deposition on water surface of the lakes;
3) Direct urban runoff into the lakes;
4) Septic systems along the shoreline; and
5) Municipal point source.

A detailed description and characteristics of the above-mentioned categories of phosphorus and nitrogen sources are provided below.

River Flow and Surface Water Runoff

More than 96% of the total volume of water entering Balsam and Cameron lakes is surface or river flow ***(Tables 6.6 and 6.7).*** The river flow is a derivative of precipitation, which is the main and determinative source of water in our physiographical zone. Approximately 33% of the total annual precipitation amount is entering the lakes as surface runoff. This 33% can be separated into two components: instantaneous surface runoff and shallow groundwater runoff. Groundwater runoff or discharge includes precipitation infiltrated into shallow aquifers as well as water from deeper aquifers. Approximately 67% of the precipitation amount eventually returns to the atmosphere through the processes of evaporation and evapotranspiration.

Rivers and streams collect runoff from their corresponding drainage basins and eventually deliver all of their water into the lakes. Watercourses in the Balsam and Cameron lakes watershed have a distinct seasonal distribution of flow volume as can be seen from the annual hydrographs ***(Figures 6.6 and 6.7).*** Even a quick analysis of a typical annual hydrograph demonstrates that the largest portion of flow enters the lake during the spring period (40 – 55% of the total annual flow) followed by winter (30 – 35%) and finally by the summer-autumn period (15 – 25%). Consequently, the highest concentration of phosphorus and nitrogen in rivers is usually observed during periods of high water levels and discharges that occur during spring freshet, winter thaws and after intensive rain events in spring, summer and fall. Due to these hydrological factors, the largest portion of the nutrient load is delivered into the lakes during the springtime. Under high flow conditions, phosphorus concentrations in the stream water within the study area have been observed as high as 0.060-0.075 mg/L or 2-2.5 times above the PWQO.

River flow incorporates phosphorus from both natural and anthropogenic sources. As a result, natural surface water always has some amount of phosphorus, even in the most pristine natural environments.

Natural sources of phosphorus and nitrogen include shoreline and riverbank erosion, groundwater discharges, lake sediments, local bedrocks and soils, wild waterfowl, fallen tree branches and leaves, and remnants of other organic materials.

Anthropogenic sources of nutrients in surface water include urban runoff and agricultural runoff. Urban areas are the source of a significant amount of nutrients that can substantially pollute local watercourses. As a result of a high percentage of impervious surfaces in urban areas, and, consequently, low infiltration rates, rainfall and water from snowmelt enter adjacent streams and lakes faster and in larger volumes, thus transporting larger amounts of the pollutants found in an urban environment.

Agricultural sources of nutrients in surface water include manure, chemical fertilizers, milkhouse wastewater, cropland erosion and livestock operations. Manure and chemical fertilizer field applications, along with soil erosion, are probably the most significant sources of phosphorus and nitrogen among the above-mentioned agricultural activities. It is very important to promote and apply advanced techniques in modern agricultural land management.

Unrestricted access of livestock to watercourses is another source of nutrients. It can also increase bacteriological contamination of surface water (E.coli, Total coliform, fecal coliform etc.) and cause erosion along riverbanks.

Atmospheric Deposition

Atmospheric deposition of phosphorus and nitrogen includes wet deposition (rain, snow, dew) and dry deposition (dust, etc.). Air circulation and precipitation can bring nutrients into the lake from both local sources (such as wind erosion of bare ground, construction sites and local industrial emissions) and locations thousands of kilometers away.

Concentrations of phosphorus and nitrogen in precipitation samples vary significantly during the year. Usually the highest concentrations are observed in the spring season and the lowest during late fall-winter. Atmospheric deposition of phosphorus and nitrogen was calculated as a sum of the number of precipitation volumes collected in two-week periods multiplied by phosphorus or nitrogen concentrations in the corresponding rain and snow samples.

Urban Runoff

Urban runoff is one of the main human-generated sources of phosphorus, nitrogen and other contaminants found in Balsam and Cameron lakes. Urban centers have large impervious areas paved with asphalt and concrete as well as plenty of building roofs. Due to the high percentage of impervious surfaces, urban areas have higher runoff coefficients and, as a result, generate much larger volumes of stormwater runoff into adjacent streams and lakes. The rapid rainwater or snowmelt runoff carries large quantities of phosphorus and nitrogen, as well as other pollutants which can easily contaminate water in nearby streams and lakes. According to multiple research data, high-density urban areas generate nutrients and other pollutants at a much higher rate per unit area than agricultural lands. In order to mitigate this, all new urban developments are required to be serviced by stormwater management facilities such as stormwater ponds, constructed wetlands or other SWM controls. Yet, a substantial portion of urban areas around both lakes do not have stormwater treatment facilities, thus making them a significant source of pollutants including phosphorus and nitrogen.

To calculate phosphorus loading from urban areas, a phosphorus export coefficient of 132 kg/km^2/year, based on the MOE research data from 2006 SWAMP studies, has been accepted (Hutchinson Environmental Sciences, 2012, MOE, unpublished data). This value is very close to our own data obtained during the urban stormwater monitoring program in the Port Perry urban area, when an average TP export coefficient of 133 kg/km^2/year was derived from water quality data collected in 2006-2009. This value can be slightly adjusted annually depending on the amount of precipitation in each hydrologic year.

Urban areas intersecting the Balsam Lake shoreline occupy 0.25 km^2 of the watershed. As well, rural or semi-urban developments intersecting the lake's shoreline occupy 3.72 km^2. Urban and semi-urban areas around Cameron Lake occupy 0.66 and 1.36 km^2 correspondingly. These areas include Fenelon Falls, Rosedale and a number of other urban and semi-urban subdivisions and hamlets adjacent to the lakes' shorelines. They generate direct urban runoff into the lakes.

Septic Systems

Nearshore septic systems can be a significant source of phosphorus and nitrogen loading to the adjacent water bodies. There has been considerable scientific discussion in recent decades about phosphorus loading from septic systems and whether some portion of it can be retained in soils. While the Ontario Ministry of the Environment has recognized that the degree of retention may vary with soil type and particle size, it has consistently held the position that all of the phosphorus deposited in septic systems within 100 m of a water body eventually migrates to lake ecosystems. Specifically, it relates to the Canadian Shield areas. Given that the ecological state of Canadian Shield lakes was a high priority for the Ministry, it recommended a cautious approach, adhering to the "precautionary principle" and assumed that 100% of phosphorus from septic systems within 100 m from the shoreline will reach the nearest water body (Paterson et al., 2006). This approach reflects the predominance of thin, organic or sandy soils and tills on the Precambrian Shield, the fractured nature of the bedrock, and the predominance of aging septic systems that were designed for hydraulic purposes (*i.e.,* to ensure fast infiltration) rather than for nutrient retention (MOE, MNR, MMAH, 2010).

At the same time, there is a considerable list of scientific literature on septic systems and phosphorus behaviour in/under leaching beds and in septic plumes. According to multiple studies, there is clear evidence that phosphorus concentrations in plumes from septic tile beds are usually much lower than in effluent from septic tanks. The percent of phosphorus retention can vary from 23-99% (Robertson et al., 1998). It was shown that the movement of phosphorus from septic tank tile bed systems may be retained to some degree depending on soil type and thickness. It was also shown that phosphorus retention in the vadose zone (the layer of soil between the land surface and the groundwater table) is mostly achieved due to reactions of chemical precipitation (Zanini et al., 1998).

It was also shown that phosphorus from a nearshore septic system can and will reach an adjacent water body (Robertson W.D., 1995; Harman J., 1996; Zurawsky M.A., 2004; Zanini L., 1998). The question is how far and how fast the phosphorus plume can travel and what is the possible average/maximum phosphorus concentration in the plume? That's why it is important to note that there is a substantial difference in degree of phosphorus retention in calcareous and non-calcareous soils. Phosphates have much higher mobility and form long, distinct plumes with higher phosphorus concentrations (0.5-5.0 mg/L) in shallow groundwater located under and down gradient of septic systems placed on calcareous soils (Robertson, 1998). Additional data have shown that percent of retention on calcareous soils in the vadose zone varies from 23-84%, with an average of 51%. On non-calcareous soils, such as those found on the Canadian Shield (Muskoka region), phosphorus retention in the vadose zone can be much higher, up to 75-99% under some specific conditions (Robertson, 2003).

In general, there are two approaches to determining septic system phosphorus loading into water bodies. The first assumes that 100% of phosphorus from septic systems near the lake shoreline eventually will reach the lake (MOE, MNR, MMAH, 2010). However, the Handbook's authors recognize that it is mainly related to Canadian Shield areas with very thin or no soils, and fractured bedrock underneath. Another approach is that some of the phosphorus from septic tanks, which can be quite substantial, is retained in the soil. The level of irreversible attenuation (retention) depends on many factors including soil type and thickness, chemical composition of soil, distance to the shore, depth of saturated zone, etc. (Robertson, 2003). As a result, it is very difficult to determine one single average percent of attenuation for the entire lake shoreline. Trent University researchers believe that it is unrealistic to assume that 100% of phosphorus from a septic tank can reach the lake or stream.

The coefficient of phosphorus retention will depend on the condition, size and maintenance of the septic system (Dr. Paul Frost, personal communications). As well, new septic systems do not immediately add phosphorus to a nearby waterbody; it may take years for the phosphorus plume to reach the lake or stream depending on the distance from the lakeshore or river bank.

Balsam and Cameron lakes are surrounded by predominantly calcareous soils underlined by limestone formations. As a result, and taking into consideration the above-mentioned information, it is reasonable to assume that phosphorus attenuation (retention) in septic systems around the lakes is somewhere near 50%. Therefore, until new data and methods of estimation become available, it has been recommended by the SLMP Science and Technical Committee to use a 50% retention rate in all future calculations of septic system phosphorus loading within the Balsam and Cameron lake watershed. It was also recognized that in cases where septic systems are malfunctioning for various reasons, then virtually all phosphorus and nitrogen from septic tank effluent can ultimately reach nearby water bodies.

According to the previous research data, a phosphate plume from a septic system can extend for 70-75 m (Harman et al., 1996). There are approximately 1,968 houses with private septic systems within 75 metres of the Balsam and Cameron lake shorelines, something to consider when phosphorus loading to the lake littoral zone is in question. Property usage values from ***Table 7.16*** have been used in phosphorus loading calculations. The water usage number of 200 L/day/capita was used for the septic phosphorus loading calculations (Paterson et al., 2006).

Table 7.16. Septic System Usage Values for Shoreline Properties
(Paterson et al. 2006)

Development Type	Usage (capita years·yr^{-1})
Permanent residence	2.56
Extended seasonal residence (cottage with winter access)	1.27
Seasonal residence (cottage – no winter access)	0.69
Resorts (serviced, housekeeping cabins)	1.18
Trailer parks	0.69
Campgrounds/tent trailers/RV parks	0.37
Youth Camps	125 grams of P·$capita^{-1}$·yr^{-1}

The average phosphorus concentration in septic tank effluent, according to the most recent data, is 8.2 mg/L based on 174 samples (Hutchinson, 2002, Paterson et al., 2006). Other researchers demonstrate similar data, 7.5 mg/L (weighted average from 64 samples) and 8.1 mg/L (average from five septic tanks) (Robertson et al., 1998). The Lakeshore Capacity Assessment Model uses 9.0 mg/L (MOE, MNR, MMAH, 2010). Applying a 50% retention factor to the value of 8.2 mg/L, we can calculate that 4.1 mg/L of phosphorus in the septic system effluent will reach Balsam and Cameron lakes.

The average nitrogen concentration in regular septic tank effluent is 45 mg/L (MOE, 1982). Approximately 25% of nitrogen can easily be attenuated while effluent is passing through soils and shallow aquifers on its way to the closest water body. The remaining nitrogen amount (in nitrate form), taking into consideration the possible extension of the plume from conventional septic systems (Harman et al., 1996, MPCA, 1999), will reach the lake.

As more accurate data from new studies for all components becomes available, it will be possible to refine current calculations. Meanwhile, Kawartha Conservation's *Blue Canoe Program* was initiated during summer of

2012. In the framework of this program, Kawartha Conservation staff conducts surveys among shoreline residents and collect information on septic systems, including type, age, distance from the lake, etc. These new endeavours can help to better understand septic system effects on water quality in Balsam and Cameron lakes.

Municipal Point Sources

One small municipal point source of phosphorus and nitrogen, namely the Coboconk Wastewater Treatment Plant and Collection System, releases final wastewater effluent into the Gull River approximately 2.5 km upstream of Balsam Lake.

The Coboconk Wastewater Treatment (WWTP) was built approximately 40 years ago, in the mid-1970s. The plant serves the Village of Coboconk with a total serviced population of approximately 480 people (Ontario Clean Water Agency, 2012).

The plant is situated just north of Coboconk on the west bank of the Gull River. The plant is a dual lagoon system with continuous phosphorus removal using aluminum sulphate, and seasonal effluent discharge. The discharge window in the spring is April 1 to May 31; in the fall it is November 1 to December 31 (Ontario Clean Water Agency, 2012). The spring & fall discharges usually take place within the specified time periods.

The Coboconk WWTP was designed and approved to treat wastewater at an annual average daily flow rate of 421 m^3/day (Ontario Clean Water Agency, 2012). The average daily flow in 2011 was 168 m^3/day or 40% of capacity. It was a 21% decrease in average flow from 2010. The effluent was released during five days in May, one day in November and six days in December. The average daily flow in 2012 was 120 m^3/day that was 48 m^3/day (28.5%) less than the previous year or just 29% of designed capacity. The effluent was released during two days in May and three days in October. In 2013, the average daily flow was 204 m^3/day or 48% of capacity. The effluent was released during five days in May, five days in November and one day in December. The Coboconk WWTP treated a total of 61,323 m^3 of raw sewage in 2011, 43,971 m^3 in 2012 and 74,395 m^3 in 2013 (Ontario Clean Water Agency, 2012, 2013, 2014).

The MOE Certificate of Approval objective requires that phosphorus concentrations in the effluent have to be less than 0.5 mg/L. The Certificate of Approval limit is 0.5 mg/L (Ontario Clean Water Agency, 2012). The average phosphorus concentrations in the plant's final effluent was 0.068 mg/L in 2011 and translates into TP loading of 0.223 kg/day, 0.030 mg/L or 0.26 kg/day in 2012, and 0.056 mg/L or 0.327 kg/day in 2013 (Ontario Clean Water Agency, 2012, 2013, 2014).

The MOE Certificate of Approval objective for total ammonia concentrations in the effluent is 10 mg/L for spring, and 5.0 mg/L for the fall/winter period. The average ammonia concentration in the plant's final effluent was 1.60 mg/L and translates into loading of 9.49 kg/day in 2011, 1.96 mg/L (16.75 kg/day) in 2012 and 2.19 mg/L (12.70 kg/day) in 2013 (Ontario Clean Water Agency, 2012, 2013, 2014).

The MOE Certificate of Approval objective for TSS concentrations in the effluent is 20.0 mg/L. The Certificate of Approval limit is 25.0 mg/L. Average TSS concentrations in the plant's final effluent was less than 2.0 mg/L in 2011 and translates into TSS loading of 14.14 kg/day, less than 3.5 mg/L or 29.2 kg/day in 2012, and less than 2.78 mg/L or 19.07 kg/day in 2013 (Ontario Clean Water Agency, 2012, 2013, 2014).

Annual phosphorus loads from the Coboconk WWTP were calculated as a sum of daily loads, which, in turn, have been calculated as the daily average phosphorus concentration found in the final effluent from the lagoons multiplied by the daily volume of effluent. The initial numbers of the daily flow and average phosphorus concentrations have been provided by the City of Kawartha Lakes Public Works Department.

7.7 Phosphorus Load and Balances

The three-year average total phosphorus load is 8,303 kg into Balsam Lake and 16,368 kg into Cameron Lake ***(Tables 7.17 and 7.18).*** The highest phosphorus loadings into both lakes were in 2013-2014, about 10,234 kg into Balsam Lake and 20,666 kg into Cameron Lake. The lowest loadings were observed in 2011-2012, when only 6,781 kg and 11,828 kg entered the lakes as a result of very low flow during the spring 2012. The phosphorus load into the lakes is distributed quite unevenly between the four major sources:

1) **The river flow** TP loading into Balsam Lake was 5,131 kg or 75.7% of the total phosphorus loading into the lake in 2011-2012, 6,379 kg or 79.9% in 2012-2013 and 8,491 kg or 83.0% kg in 2013-2014 ***(Table 7.17)***. The average three-year river flow phosphorus loading was 6,667 kg. The largest individual source of phosphorus was the **Gull River**, which loaded 4,276 kg, 5,591 kg and 7,558 kg into Balsam Lake in 2011-2012, 2012-2013 and 2013-2014 correspondingly. The river flow TP loading into Cameron Lake was 6,868 kg or 58.1% of the total phosphorus loading into the lake in 2011-2012, 11,411 kg or 68.7% in 2012-2013 and 14,225 kg or 68.8% kg in 2013-2014 ***(Table 7.18)***. The average three-year river flow phosphorus loading was 10,835 kg. The largest individual source of phosphorus was the **Burnt River**, which loaded 6,070 kg, 10,896 kg and 13,568 kg into the lake in 2011-2012, 2012-2013 and 2013-2014 correspondingly. The flow from Balsam Lake, which is not included in the river flow numbers above, is the second largest source of phosphorus for Cameron Lake ***(Table 7.18)***.

2) **Atmospheric deposition** (wet and dry) of total phosphorus on the lakes' water surface was 765 kg in 2011-2012, 579 kg in 2012-2013 and 854 kg in 2013-2014. The average atmospheric load over the three year period was 560 kg into Balsam Lake and 173 kg into Cameron Lake totalling 733 kg for both lakes.

3) **Shoreline urban stormwater** phosphorus loading into Balsam Lake was estimated at approximately 212 kg in 2011-2012, 219 kg in 2012-2013, and 236 in 2013-2014.The average load over the three-year period was 222 kg. Shoreline urban stormwater phosphorus loading into Cameron Lake was estimated at approximately 145 kg in 2011-2012, 150 kg in 2012-2013 and 161 in 2013-2014.The average load over the three-year period was 152 kg. The total average annual urban phosphorus load into both lakes was 374 kg over the three-year period.

4) **Septic systems**. Phosphorus loading from private septic systems around the lakes was estimated at 1,214 kg annually. When calculated for each lake separately, phosphorus loading into Balsam Lake is 851 kg and into Cameron Lake is 363 kg. Total amount includes 773 kg from year-round houses, 257 kg from summer cottages, 65 kg from trailer parks and campgrounds, 11.2 kg from houses with holding tanks (some grey water) and 108.1 kg from failed systems.

Calculated average and annual phosphorus loadings into Balsam Lake, as well as average and annual phosphorus exports from the lake via the Rosedale River and Balsam-Mitchell canal, are presented in ***Table 7.17***. A breakdown of the average phosphorus load from each major source during the 2011-2014 monitoring period is presented at ***Figure 7.17.***

Table 7.17. Balsam Lake Phosphorus Budget for 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Sources of Phosphorus	2011-2012		2012-2013		2013-2014		Average	
	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %
River flow as:								
Gull River	4,276	63.1	5,591	70.8	7,558	73.9	5,808	70.0
Corben Creek	222	3.3	266	3.4	261	2.6	250	3.0
Local streams and overland flow	633	9.3	522	6.6	672	6.6	609	7.3
Atmospheric deposition	585	8.6	442	5.6	653	6.4	560	6.7
Shoreline urban runoff	212	3.1	219	2.8	236	2.3	222	2.7
Septic systems	851	12.6	851	10.8	851	8.3	851	10.2
Coboconk WWTP	2.0	0.03	3.4	0.04	4.0	0.04	3.1	0.04
Total Load	**6,781**	**100**	**7,985**	**100**	**10,234**	**100**	**8,303**	**100**
TP Export	**4,990**	**73.6**	**5,277**	**66.8**	**6,736**	**65.8**	**5,668**	**68.3**
TP net loading*	**1,791**	**26.4**	**2,618**	**33.2**	**3,498**	**34.2**	**2,635**	**31.7**

**Net loading – amount of phosphorus that is annually accumulated in the lake and is a difference between total annual load into the lake from all sources and annual loss of phosphorus from the lake with the flow via the lake outlet in Rosedale and canal from Balsam Lake into Mitchell Lake.*

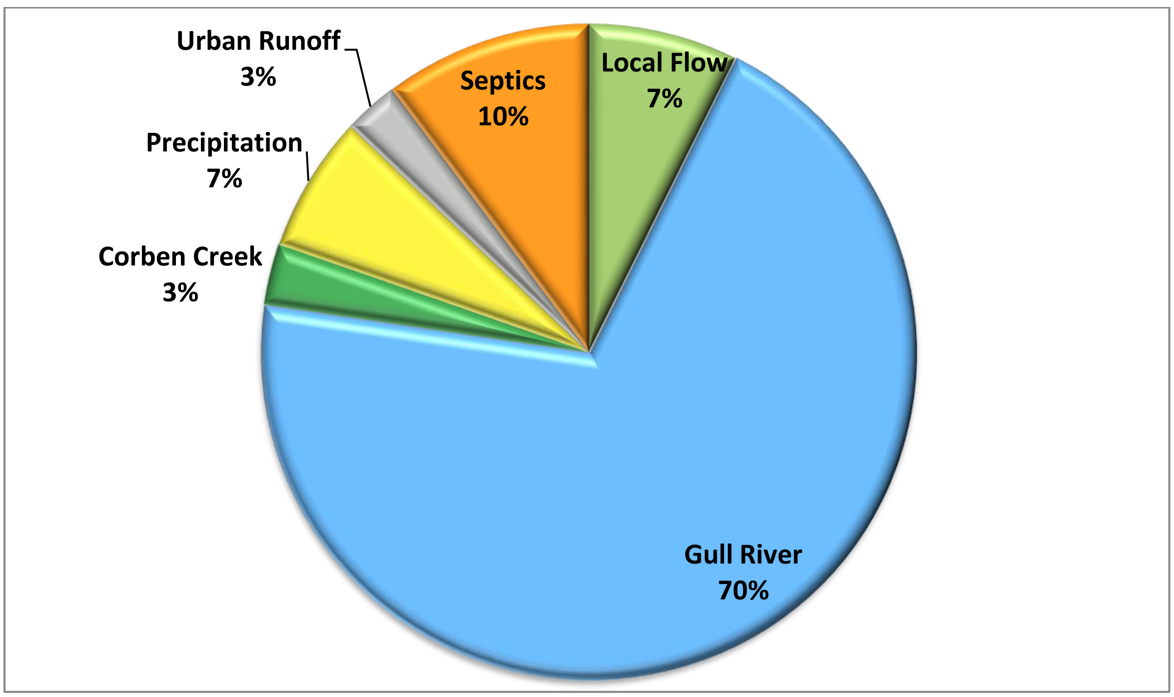

Figure 7.17. Average Phosphorus Load into Balsam Lake from Different Sources During 2011-2014 Monitoring Period

The Gull River is the largest source of phosphorus for Balsam Lake and the second largest for the Balsam Cameron lakes system. It transports 70% of the total phosphorus load into Balsam Lake ***(Figure 7.17)***. Between years, the phosphorus load from the Gull River watershed varied from 63 to almost 74%. The phosphorus amount that enters the lake with the Gull River flow is generated outside the study area ***(Figure 7.1)***. (This is also the case with the Burnt River watershed.)

The Gull River watershed occupies 1,347 km^2 and the Burnt River watershed occupies 1,489 km^2. Combined, they are ten times larger than the Balsam and Cameron lakes watershed itself. At the same time, the Balsam and Cameron lakes watershed accounts for 5.4% of the water entering the lakes, but contributes 14.4% of the total phosphorus load.

609 kg or 7.3% of the total phosphorus load enters the lake with the Staples River flow and local surface runoff from the Balsam Lake subwatershed ***(Table 7.17).*** Shoreline urban runoff accounts for 2.7% of the phosphorus entering Balsam Lake. This is human-generated phosphorus as well as phosphorus from shoreline septic systems which contributes 10.2% of the total load. Close to 7% of phosphorus enters the lake with different types of precipitation, such as rain, snow, hail, dew, etc. Finally, the Coboconk Wastewater Treatment Plant annually generates only 2-3 kg of phosphorus which is less than 0.04% of the total phosphorus load.

Average phosphorus export from Balsam Lake over the 2011-2014 monitoring period is estimated at 5,668 kg per year. As a result, average annual net phosphorus loading into the lake is 2,635 kg or 32% of the total loading.

Calculated average and annual phosphorus loadings into Cameron Lake, as well as average and annual phosphorus exports from the lake via its outlet in Fenelon Falls, are presented in ***Table 7.18***. A breakdown of the average phosphorus load between the major phosphorus sources during the 2011-2014 monitoring period is presented in ***Figure 7.18.***

Table 7.18. Cameron Lake Phosphorus Budget for 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Sources of Phosphorus	2011-2012		2012-2013		2013-2014		Average	
	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %
River flow as:								
Burnt River	6,070	51.3	10,896	65.6	13,568	65.7	10,178	62.2
Balsam Lake	4,271	36.1	4,550	27.4	5,714	27.6	4,845	29.6
Local streams and overland flow	798	6.7	514	3.1	658	3.2	657	4.0
Atmospheric deposition	181	1.5	137	0.8	202	1.0	173	1.1
Shoreline urban runoff	145	1.2	150	0.9	161	0.8	152	0.9
Septic systems	363	3.1	363	2.2	363	1.8	363	2.2
Total Load	**11,828**	**100**	**16,610**	**100**	**20,666**	**100**	**16,368**	**100**
TP Export	**10,033**	**84.8**	**14,731**	**88.7**	**17,885**	**86.5**	**14,216**	**86.9**
TP net loading*	**1,795**	**15.2**	**1,879**	**11.3**	**2,781**	**13.5**	**2,151**	**13.1**

**Net loading – amount of phosphorus that is annually accumulated in the lake and is a difference between total annual load into the lake from all sources and annual loss of phosphorus from the lake with the flow via the lake outlet in Fenelon Falls.*

It can be seen that the Burnt River flow, which transports more than 62% of the total phosphorus load, is the largest source of phosphorus not only for Cameron Lake, but for the entire two-lake system ***(Figure 7.18)***. During three years, the phosphorus load from the Burnt River watershed varied from 51 to almost 66%. On average, it carries more than 62% of the total phosphorus load. The Balsam Lake flow is the second most significant source of phosphorus to Cameron Lake. It brings between 4,271 and 5,714 kg of phosphorus every year, or approximately 30% of total load. Similar to the Gull River phosphorus load that enters the Balsam Lake, the phosphorus amount that enters Cameron Lake with the Burnt River and Balsam Lake flow is generated outside the Cameron Lake watershed ***(Figure 7.1)***.

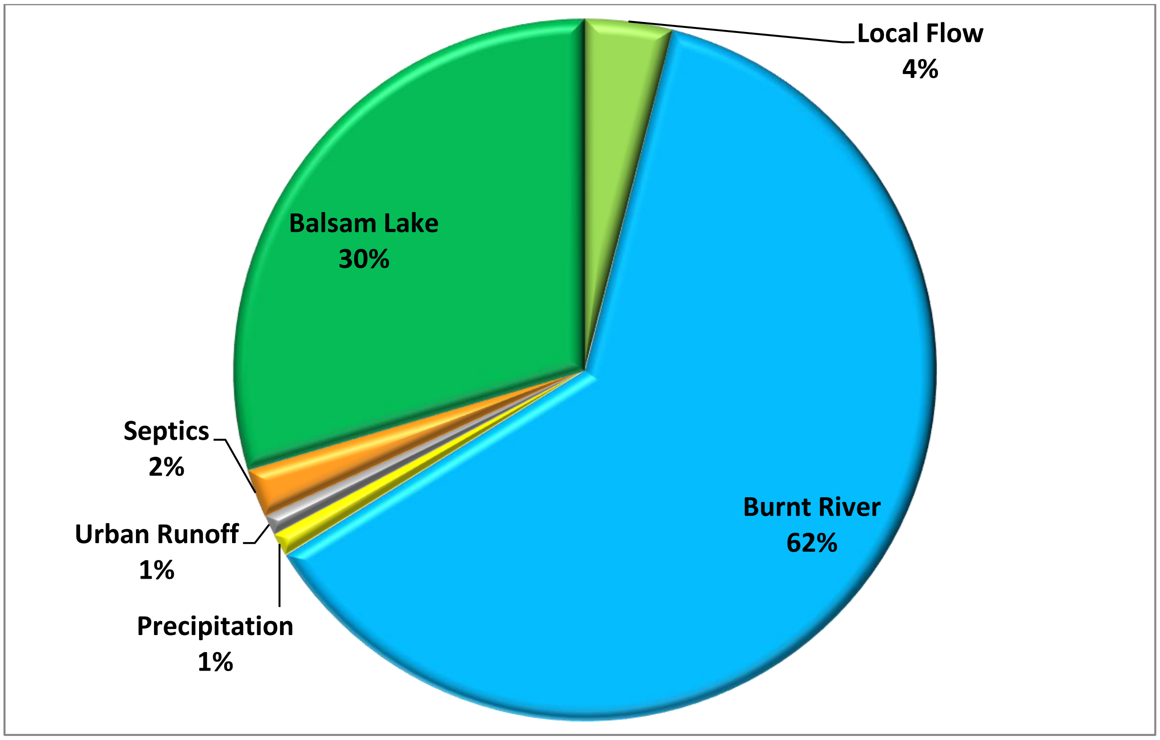

Figure 7.18. Average Phosphorus Load into Cameron Lake from Different Sources During 2011-2014 Monitoring Period

657 kg or 4.0% of the total phosphorus load enters the lake with local surface runoff and local stream flow. The Martin Creek South subwatershed is the largest source of phosphorus among local watersheds. On average, it generates 268 kg of phosphorus ***(Table 7.19).*** One percent of phosphorus enters Cameron Lake with the shoreline urban runoff and two percent comes from shoreline septic systems. Precipitation brings on average 173 kg of phosphorus or 1.1% of its total load.

Average phosphorus export from Cameron Lake into Sturgeon Lake over the 2011-2014 monitoring period is estimated at 14,216 kg per year. As a result, average annual net phosphorus loading into the lake is 2,151 kg.

Average phosphorus loading with the river flow and surface runoff into both lakes is 17,502 kg annually, or more than 88% of the total load. Distribution of the total river flow phosphorus load between different tributaries and subwatersheds is shown in ***Table 7.19***. The most significant sources, as noted, are the Burnt and Gull rivers. The least amount of phosphorus enters the lakes from the immediate Cameron Lake subwatershed (the smallest subwatershed) which generates, on average, 138 kg annually.

It is important to remember that the Burnt and Gull rivers are the largest sources of phosphorus not because they have high phosphorus concentrations in the water, but because a very large volume of water from their vast watersheds outside the planning area enters Balsam and Cameron lakes. When one looks at the Balsam Lake and Cameron Lake water budgets, it can be seen that approximately 89% of the total lake water inflow originates from the Burnt and Gull river watersheds ***(Tables 6.6 and 6.7)***.

Table 7.19. Phosphorus Load into Balsam and Cameron Lakes with River Flow in 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Watercourse / Subwatershed	2011-2012		2012-2013		2013-2014		Average	
	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %	TP, kg	TP, %
Balsam Lake								
Gull River	4,276	35.6	5,591	31.4	7,558	33.3	5,808	33.2
Corben Creek	222	1.9	266	1.5	261	1.1	250	1.4
Staples River	172	1.4	183	1.0	212	0.9	189	1.1
Balsam L. Watershed	461	3.8	339	1.9	460	2.0	420	2.4
Subtotal	**5,131**	**42.8**	**6,379**	**35.9**	**8,491**	**37.4**	**6,667**	**38.1**
Cameron Lake								
Burnt River	6,070	50.6	10,896	61.2	13,568	59.7	10,178	58.2
Martin Creek South	310	2.6	214	1.2	279	1.2	268	1.5
Pearns Creek	348	2.9	168	0.9	237	1.0	251	1.4
Cameron L. Watershed	140	1.2	133	0.7	141	0.6	138	0.8
Subtotal	**6,868**	**57.2**	**11,411**	**64.1**	**14,225**	**62.6**	**10,835**	**61.9**
TOTAL	**11,999**	**100**	**17,790**	**100**	**22,716**	**100**	**17,502**	**100**

The local subwatersheds in the study area include Martin Creek South, Pearns Creek, Staples River as well as the Cameron Lake and Balsam Lake subwatersheds. Among local subwatersheds, the Balsam Lake subwatershed (which is the biggest one) generates the largest amount of phosphorus, 420 kg annually. (An additional 222 kg of phosphorus enters the lake from urban areas within the subwatershed). It is followed by the Martin Creek South subwatershed (268 kg) and the Pearns Creek subwatershed (251 kg).

In the course of further analysis, phosphorus loading from the local subwatersheds was split between several categories of TP sources in order to show how much phosphorus is entering the lakes from natural sources/processes and how much is the product of human activities, primarily agricultural and urban runoff as well as the loading from shoreline septic systems around the lakes. In order to determine phosphorus loadings from natural sources and from agricultural fields, loading coefficients from the CANWET model were used. The MOE Phosphorus Loading Tool was also utilized for calculations (Hutchinson Environmental Sciences, 2012).

Estimated TP loads from three major land use categories, namely agricultural runoff, urban runoff and natural sources, as well as from shoreline septic systems, are presented in ***Table 7.20*** for the Balsam Lake subwatershed and in ***Table 7.21*** for the Cameron Lake subwatershed.

Table 7.20. Phosphorus Load into Balsam Lake from Local Source Categories

Source / Category of Sources	TP Load, kg	% of Local TP Load	% of Total Load
Local Natural Sources	506	30	6.1
Local Urban Runoff	222	13	2.7
Local Agricultural Runoff	103	6	1.2
Shoreline Septics	851	51	10.2
Total from Local Sources	1,682	100	20.3

Table 7.21. Phosphorus Load into Cameron Lake from Local Source Categories

Source / Category of Sources	TP Load, kg	% of Local TP Load	% of Total Load
Local Natural Sources	304	26	1.9
Local Urban Runoff	152	13	0.9
Local Agricultural Runoff	353	30	2.2
Shoreline Septics	363	31	2.2
Total from Local Sources	1,172	100	7.2

The Balsam and Cameron Lakes Management Plan requires specific benchmarks and targets in order to develop implementation actions focused on improving the lakes' environmental health. Among such benchmarks, phosphorus loading targets for the local subwatersheds have a high importance. As mentioned, all local subwatersheds occasionally had phosphorus concentrations that did not meet the Provincial Water Quality Objective. If monthly TP concentrations in the water of the local tributaries always meet the PWQO (0.03 mg/L), then phosphorus loads from local subwatersheds will decrease. Based on this assumption, the following targeted loadings and needed reductions from each local subwatershed were developed ***(Table 7.22).***

Table 7.22. Current and Desired Phosphorus Loads from Local Subwatersheds

Watercourse/ Subwatershed	2011-2014 Average Annual TP Loading, kg	TP Loading Within the PWQO, kg	Overall TP Reduction Required, kg
Martin Creek South	267.7	246.8	20.9
Pearns Creek	251.1	225.5	25.6
Staples River	189.0	183.6	5.4
Balsam Lake Subwatershed	642.2	515.7	126.5
Cameron Lake Subwatershed	290.0	207.0	83.0
Total	**1640**	**1379**	**261**

7.8 Nitrogen Load and Balances

The three-year average total nitrogen load is 299,365 kg into Balsam Lake, and 527,960 kg into Cameron Lake. The highest nitrogen loading into both lakes was in 2013-2014 with 393,405 kg into Balsam Lake, and 710,192 kg into Cameron Lake. The lowest loading was observed in 2011-2012, which was as low as 204,113 kg in Balsam Lake, and 340,443 kg in Cameron Lake, primarily as a result of very low spring flow. The total nitrogen load into Balsam Lake and Cameron Lake can be distributed between four major sources:

1) **The river flow** TN loading into Balsam Lake was 161,076 kg in 2011-2012, 252,925 kg in 2012-2013 and 337,452 kg in 2013-2014. The average load over the three-year period was 250,485 kg ***(Table 7.23).*** The largest source of nitrogen is the **Gull River**, which transported 133,912 kg, 221,697 kg and 301,364 kg in 2011-2012, 2012-2013 and 2013-2014 respectively. Nitrogen load with **local stream flow** was 21,462 kg, 22,363 kg and 26,563 kg in the 2011-2012, 2012-2013 and 2013-2014 hydrologic years correspondingly. The average nitrogen load from local tributaries over the three-year period was 23,463 kg. The river flow TN loading into Cameron Lake was 205,913 kg in 2011-2012, 355,610 kg in 2012-2013 and 393,566 kg in 2013-2014 ***(Table 7.24).*** The average three-year river flow nitrogen loading was 318,363 kg. The **Burnt River**, with loading numbers of 185,269, 335,121 and 371,970 kg of nitrogen in 2011-2012, 2012-2013

and 2013-2014 correspondingly, is the largest source of nitrogen not only for Cameron Lake, but for the entire Balsam and Cameron lakes system. The flow from Balsam Lake, which is not included in the river flow numbers above, is the second largest source of nitrogen for Cameron Lake ***(Table 7.24, Figure 7.20).***

2) **Atmospheric deposition** (wet and dry) of total nitrogen on the lakes' water surface was 42,534 kg in 2011-2012, 48,244 kg in 2012-2013 and 58,811 kg in 2013-2014. The average atmospheric load over the three-year period was 49,863 kg, including 38,104 kg into Balsam Lake and 11,759 kg into Cameron Lake ***(Tables 7.23 and 7.24).***

3) **Shoreline urban stormwater** nitrogen loading into Balsam Lake was estimated at approximately 2,122 kg in 2011-2012, 2,192 kg in 2012-2013 and 2,366 in 2013-2014.The average load over the three-year period was 2,227 kg ***(Table 7.23).*** Direct shoreline urban stormwater nitrogen loading into Cameron Lake was estimated at approximately 1,446 kg in 2011-2012, 1,494 kg in 2012-2013 and 1,606 in 2013-2014.The average load over the three-year period was 1,515 kg ***(Table 7.24).*** The total average annual urban nitrogen load into both lakes was 3,739 kg during the three-year period.

4) **Septic systems.** Nitrogen load from private septic systems around the lakes was estimated at 11,470 kg annually. Nitrogen loading into Balsam Lake is 8,308 kg, and into Cameron Lake is 3,162 kg

Another very small source of nitrogen for Balsam Lake is the Coboconk Wastewater Treatment Plant which generated 110 kg in 2011-2012, 292 kg in 2012-2013 and 323 kg in 2013-2014. The average nitrogen load over the three-year period was less than 242 kg.

Calculated average and annual nitrogen loadings into Balsam Lake, as well as average and annual nitrogen exports from the lake via the Rosedale River and Balsam-Mitchell canal, are presented in ***Table 7.23***. A breakdown of the average nitrogen load between its major sources during the 2011-2014 monitoring period is presented in ***Figure 7.19.***

Table 7.23. Balsam Lake Nitrogen Budget for 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Sources of Nitrogen	2011-2012		2012-2013		2013-2014		Average	
	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %
River flow as:								
Gull River	133,912	65.6	221,697	73.8	301,364	76.6	218,991	73.2
Corben Creek	5,702	2.8	8,865	2.9	9,525	2.4	8,301	2.7
Local streams and overland flow	21,462	10.5	22,363	7.4	26,563	6.8	23,463	7.8
Atmospheric deposition	32,497	15.9	36,859	12.3	44,956	11.4	38,104	12.7
Shoreline urban runoff	2,122	1.0	2,192	0.7	2,366	0.6	2,227	0.7
Septic systems	8,308	4.1	8,308	2.8	8,308	2.1	8,308	2.8
Coboconk WWTP	110	0.1	292	0.1	323	0.1	242	0.1
Total Load	**204,113**	**100**	**300,576**	**100**	**393,405**	**100**	**299,365**	**100**
TN Export	**144,879**	**71**	**186,017**	**62**	**337,996**	**86**	**222,964**	**74**
TN net loading*	**59,234**	**29**	**114,559**	**38**	**55,409**	**14**	**76,401**	**26**

**Net loading – amount of nitrogen that is annually accumulated in the lake and is a difference between total annual load into the lake from all sources and annual loss of nitrogen from the lake with the flow via the lake outlet in Rosedale and canal from Balsam Lake into Mitchell Lake.*

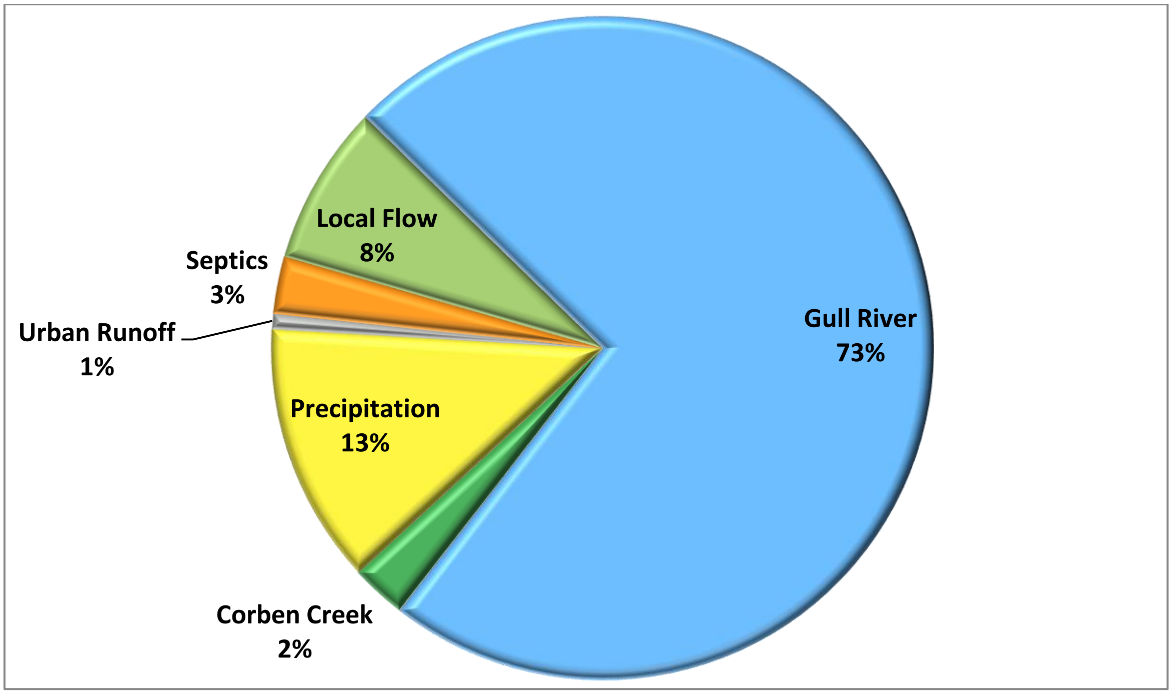

Figure 7.19. Average Nitrogen Load into Balsam Lake from Different Sources During 2011-2014 Monitoring Period

As mentioned, the Gull River is the largest source of nitrogen for Balsam Lake. On average, it contributes around 73% of the nitrogen load into the lake ***(Figure 7.19)***. Precipitation is the second largest source of nitrogen for the lake and contributes almost 13% of the total nitrogen load thanks to the lake's large surface area. Almost 8% of nitrogen enters the lake with local flow (Staples River and Balsam Lake subwatersheds).

Average nitrogen export from Balsam Lake over the 2011-2014 monitoring period is estimated at 222,964 kg per year. As a result, the average annual net nitrogen load into the lake is 76,401 kg or 26% of the total loading.

Table 7.24. Cameron Lake Nitrogen Budget for 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Sources of Nitrogen	2011-2012		2012-2013		2013-2014		Average	
	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %
River flow as:								
Burnt River	185,269	54.4	335,121	62.8	371,712	52.3	297,367	56.3
Balsam Lake	119,885	35.2	161,596	30.3	298,261	42.0	193,247	36.6
Local streams and overland flow	20,644	6.1	20,489	3.8	21,596	3.0	20,910	4.0
Atmospheric deposition	10,037	2.9	11,385	2.1	13,855	2.0	11,759	2.2
Shoreline urban runoff	1,446	0.4	1,494	0.3	1,606	0.2	1,515	0.3
Septic systems	3,162	0.9	3,162	0.6	3,162	0.4	3,162	0.6
Total Load	**340,443**	**100**	**533,246**	**100**	**710,192**	**100**	**527,960**	**100**
TN Export	**322,911**	**95**	**485,483**	**91**	**648,538**	**91**	**485,644**	**92**
TN net loading*	**17,532**	**5**	**47,763**	**9**	**61,654**	**9**	**42,316**	**8**

**Net loading – amount of nitrogen that is annually accumulated in the lake and is a difference between total annual load into the lake from all sources and annual loss of nitrogen from the lake with the flow via the lake outlet in Fenelon Falls.*

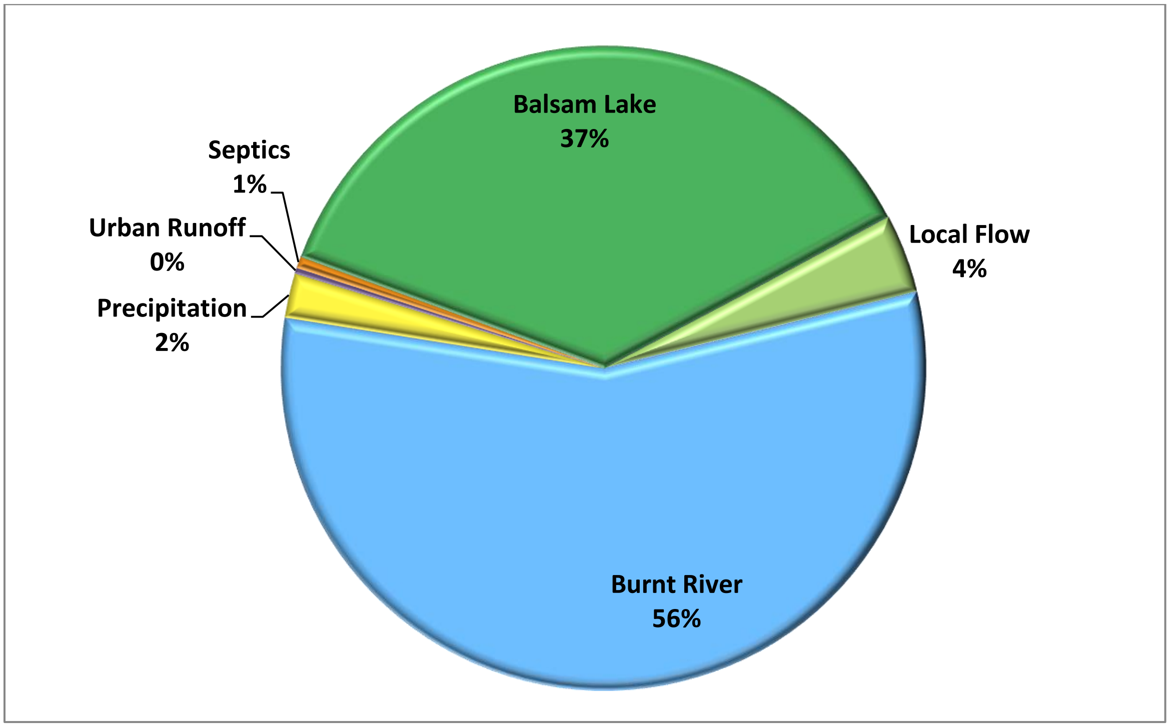

Figure 7.20. Average Nitrogen Load into Cameron Lake from Different Sources During 2011-2014 Monitoring Period

Calculated average and annual nitrogen loadings into Cameron Lake, as well as average and annual nitrogen exports from the lake outlet in Fenelon Falls, are presented in ***Table 7.24***. A breakdown of the average nitrogen load between its major sources during the 2011-2014 monitoring period is presented at ***Figure 7.20.***

The Burnt River transports from 52-63% of the annual nitrogen load into Cameron Lake with an average number being at 56% ***(Figure 7.20)***. Those fluctuations are mainly regulated by the volume of flow as nitrogen concentrations did not vary much during three years. The Balsam Lake flow is the second largest source of nitrogen to Cameron Lake, 37% of the total nitrogen load. 4.0% of the total nitrogen load enters the lake with local flow ***(Figure 7.20).*** The Pearns Creek subwatershed, Martin Creek South and Cameron Lake subwatersheds represent the local flow category and, combined, are responsible for approximately 4% of nitrogen load.

Average annual nitrogen export from Cameron Lake into Sturgeon Lake over the 2011-2014 monitoring period is estimated at 485,644 kg. It results in an average annual net nitrogen load into Cameron Lake of 42,316 kg or 8% of the total loading ***(Table 7.24).***

Average annual nitrogen loading with the river flow and surface runoff into both lakes is 568,847 kg. Balsam Lake receives 250,485 kg., and Cameron Lake gets 318,363 kg. A breakdown of the river flow nitrogen load between the tributaries and subwatersheds is shown in ***Table 7.25***. The Gull River contributes 87% of the nitrogen load within the river flow category for Balsam Lake, while the Burnt River provides more than 93% for Cameron Lake. As with phosphorus, the Cameron Lake subwatershed generates the least amount of nitrogen, from 3,437 kg to 4,440 kg annually. This subwatershed is the smallest one (25.4 km^2) within the study area.

Table 7.25. Nitrogen Load into Balsam and Cameron Lakes with River Flow in 2011-2012, 2012-2013 and 2013-2014 Hydrologic Years

Watercourse / Subwatershed	2011-2012		2012-2013		2013-2014		Average	
	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %	TN, kg	TN, %
Balsam Lake								
Gull River	133,912	36.5	221,697	36.4	301,364	41.2	218,991	38.5
Corben Creek	5,702	1.6	8,865	1.5	9,525	1.3	8,031	1.4
Staples River	5,225	1.4	6,621	1.1	8,715	1.2	6,854	1.2
Balsam L. Watershed	16,237	4.4	15,742	2.6	17,848	2.4	16,609	2.9
Subtotal	161,076	43.9	252,925	41.6	337,452	46.2	250,485	44.0
Cameron Lake								
Burnt River	185,269	50.5	335,121	55.1	371,970	50.9	297,453	52.3
Martin Creek South	9,061	2.5	8,626	1.4	10,059	1.4	9,249	1.6
Pearns Creek	7,999	2.2	7,423	1.2	8,100	1.1	7,841	1.4
Cameron L. Watershed	3,584	1.0	4,440	0.7	3,437	0.5	3,820	0.7
Subtotal	205,913	56.1	355,610	58.4	393,566	53.8	318,363	56.0
TOTAL	**366,989**	**100**	**608,535**	**100**	**731,018**	**100**	**568,847**	**100**

8.0 Aquatic Ecosystems

8.1 Summary of Observations and Issues

OBSERVATIONS

- ***Balsam Lake, Cameron Lake and their tributaries support diverse, cool / warm water fish communities****.* Approximately 36 fish species have been documented within the core Balsam Lake and Cameron Lake management planning area. Most of these species are common throughout all of the Kawartha Lakes. The fish community structure in both lakes has changed over time through intentional stocking, range extensions, unintentional introductions and non-native species invasions. Between 1999 and 2011, the most large-bodied fish species found in Balsam Lake, in terms of relative biomass, were smallmouth bass, black crappie, walleye, bluegill, common carp, muskellunge, largemouth bass, rock bass and white sucker. Lake herring, a coldwater fish species, has been documented in the deeper basins of both lakes, however, the amount of coldwater habitat to support this species is limited to small volumes in the deeper basins. No known species listed as Special Concern, Threatened or Endangered have been documented.
- ***Lake tributaries provide important ecological pathways to-and-from the lakes****. T*here are approximately 20 tributaries that drain directly into Balsam Lake and approximately 9 that drain directly into Cameron Lake. Many of these, including the Gull River, Staples River, Pearns Creek, Marin Creek South and Hannivan's Creek have been documented as providing spawning habitat for important migratory lake-dwelling fish species such as walleye, muskellunge and/or white sucker. The dams located at Rosedale, Coboconk and Fenelon Falls act as physical barriers that limit migratory routes and other ecological pathways. However, the lock and canal systems facilitate the movement of aquatic life between lakes.
- ***Nearshore areas are relatively limited within both lakes, and provide important aquatic habitat****.* Shallow nearshore areas (<3 meters in depth) are extremely important areas for biological productivity. They are utilized by many fish, including important top predator species such as muskellunge and walleye, for spawning, nursery, and feeding. Balsam and Cameron lakes have a relatively narrow width of nearshore area (compared to most other Kawartha Lakes), the majority of which are located adjacent to shorelines and in the bays at the outlets of major tributaries. The low natural productivity of both lakes makes these nearshore areas especially important in supporting the aquatic ecosystem.
- ***Walleye populations are stable.*** Many Kawartha Lakes have recently experienced dramatic declines in walleye populations, largely attributed to changes to their aquatic ecosystem that have favoured other fish species (e.g., bass). Balsam and Cameron lakes have not experienced such a drastic ecosystem shift during the same time period. As such, Balsam Lake walleye populations have remained relatively stable. Lake-specific walleye regulations introduced in 2001, and decreased walleye harvest over the years, have likely also contributed to walleye stability.
- ***The lakes support a significant recreational fishery with the most targeted species being walleye, smallmouth bass, largemouth bass and muskellunge.*** Other important fishery species include: yellow perch, black crappie and sunfish. The Kawartha Lakes, which include Balsam and Cameron lakes, support one of the largest inland lake recreational fisheries in Ontario. Angler activity has been relatively consistent over the last decade. It's estimated to be 50,000 angler hours per year (11 angler hours per hectare). This is below the average for the Kawartha Lakes, yet is still considered significant in terms of recreational use.

KEY ISSUES

- ***Establishment of non-native, invasive aquatic species that alter the aquatic ecosystem.*** Balsam Lake and Cameron Lake have been exposed to a variety of non-native aquatic species, including fish (e.g., common carp, bluegill, black crappie), invertebrates (e.g., zebra mussels, rusty crayfish), and aquatic plants (e.g., common reed, Eurasian water milfoil). In addition to these existing non-native species, there are others that are at immediate risk of becoming established (e.g., round goby). Proliferations of non-native species are considered invasive when they have negative ecological and economic impacts. The interconnected nature of the Kawartha Lakes, along with high recreational usage, facilitates the spread of invasive species. Northern pike have recently become established in Balsam Lake, and their relative biomass is increasing which may lead to future negative impacts for native muskellunge populations.
- ***Loss and fragmentation of aquatic habitat along the shoreline, and small-to-medium sized tributaries.*** A significant portion of the shorelines on both lakes have been altered through development. Many areas have been hardened with concrete, armourstone and other non-natural materials which can have impacts for the nearshore area and can reduce aquatic habitat potential. Aquatic habitat loss and fragmentation is evident along most small to medium-sized tributaries (particularly in their headwaters), due to land being converted to agricultural production. Existing natural riparian cover along these stream corridors does not meet minimum recommended guidelines to support high ecological integrity. Stream benthic macroinvertebrate communities confirm a certain degree of stream habitat degradation as almost half of all sites sampled show biological impairment.
- ***Climate change has the potential to continue to alter aquatic ecosystem conditions.*** The impacts of climate change will emanate from well beyond the watershed, but they can affect physical and biotic attributes and ecological functions within the watershed. Climate change trends can be considered a large factor influencing the productive capacity of fisheries. Water temperature increases associated with climate change can influence factors such as year-class strength, recruitment, growth and survival of fishes. It is generally predicted that on a provincial scale increases in water temperatures will favour the production of warm-water fishes, while reducing production of cool/coldwater fishes. Coldwater fishes in particular, are sensitive to increasing water temperatures that can lead to reduced populations of lake herring, which are already limited in Balsam and Cameron lakes.

KEY INFORMATION GAPS

- ***Limited understanding of how stressors such as climate change, cumulative development and invasive species will impact the aquatic ecosystem.*** Aquatic habitat and aquatic communities within both lakes have been altered throughout the years in response to various pressures. It is important to have a comprehensive understanding of how these stressors interact within both lakes and their watersheds, for example, by determining lake capacity thresholds. Moreover, no known standards exist for determining what constitutes a "healthy aquatic ecosystem" that is specific to the Kawartha Lakes. This is particularly important for characterizing aquatic ecosystem condition in areas where no long-term data set exists.
- ***Limited understanding of Cameron Lake's aquatic habitat and aquatic communities.*** Cameron Lake has not been as intensively monitored as has Balsam Lake, therefore important elements of the aquatic ecosystem (e.g., fish community changes) are not as thoroughly understood. Since Cameron Lake is a neighbouring lake, it is reasonable to assume that its aquatic ecosystem has properties similar to Balsam Lake. However, studies on the Kawartha Lakes have demonstrated that each lake can have several unique characteristics that are significant for its aquatic ecosystem.

- ***Limited understanding of small-bodied fish communities.*** Sampling practice has largely been focused on tracking large-bodied fish species that are important in supporting the recreational fishery, therefore little is known regarding the status of small-bodied fish communities. These fishes are important components of the aquatic ecosystem in both lakes and their tributaries. Obtaining a more thorough understanding of their diversity and population trends will be beneficial towards a comprehensive characterization of the aquatic ecosystem.

8.2 Introduction

This chapter provides an overview of important components of the aquatic ecosystems of Balsam Lake and Cameron Lake by characterizing lake-based and tributary-based elements.

An aquatic ecosystem is life within water bodies and their relationship to, and connection with, living and non-living components. Maintaining healthy aquatic ecosystems is integral in maintaining healthy lakes.

Communities and individuals who rely on the lakes benefit from healthy aquatic ecosystems through the goods and services they provide such as: quality recreational opportunities, clean water, biodiversity and other lake-based functions. Local municipalities rely on healthy aquatic ecosystems to support their lake-based economies (the foundation of which is tourism), and to provide high quality lifestyle opportunities for residents, cottagers and visitors.

The key aquatic ecosystem components that are critical in supporting the above-mentioned benefits are characterized below. A particular emphasis is placed on aquatic life (communities of species) and aquatic habitats (features and functions that maintain life) that exist/interact within the lakes and their tributaries.

8.3 Lake Ecosystems

8.3.1 Aquatic Habitat

The abundance, composition and productivity of aquatic communities are dependent on the quality and availability of habitats in a lake. Changes in habitat can affect aquatic communities by, for example, creating favourable conditions for one species that in turn shifts aquatic community composition or available prey resources. Physical habitat includes all spatial and temporal extents of lake morphology, hydrology, substrate type and physical cover, nutrient, optical and thermal features of an aquatic ecosystem. These habitat components differ among zones of a lake; most obviously between the littoral - nearshore zone (depths ~ 1 – 3 m) and the pelagic/profundal - offshore zone (depths > 3 m). This section will characterize the lake-based aquatic habitat of Balsam Lake and Cameron Lake specific to aquatic communities, and describe recent changes observed in the abiotic and biological habitat components detailing potential consequences for the resident aquatic communities. Due to data limitations for Cameron Lake, the discussions focus mainly on Balsam Lake. Notwithstanding, many of the key aquatic habitat functions within Balsam Lake are also applicable to Cameron Lake.

Defining the Aquatic Habitat in Balsam Lake

Balsam Lake has a surface area of 47.7 km^2 and it is one of the deeper lakes in the series of connected water bodies. It has a maximum depth of approximately 15 m (restricted to a deep hole near the west-centre of the lake), and a mean depth of 5 m. Cameron Lake has a surface area of 14.7 km^2, and (excluding Stony Lake) is the deepest Kawartha Lake. It has a maximum depth of 18 m (east-centre of the lake), and a mean depth of 9 m. In terms of total aquatic habitat available, by volume, Balsam Lake contains 237 million m^3 of water, and Cameron Lake contains 100 million m^3.

The littoral habitat in Balsam Lake and Cameron Lake is limited in both geographic area and water volume. Littoral zones are typically the most productive areas in lakes as there is fast turnover of essential nutrients due to erosional run-off and stream discharge. Most lake-based fish spawn in the nearshore area, and the prey of game fish are mainly restricted to the littoral zone (Keast and Harker, 1977). The amount, quality and access to this productive area are essential factors for biological productivity. In Balsam Lake, bottom topography reveals that the littoral habitat (< 3 m) is confined primarily to areas immediately adjacent to the shoreline, and the south ends of West Bay and South Bay. This distinctive lake morphology results in 52% of the available water volume contained at depths of < 3 m, and 48% of water contained at depths > 3 m. This is in contrast to the lakes in the southern Kawartha Lakes region (i.e., Rice Lake and Lake Scugog) that are more uniformly shallow holding ~ 90% of the available water in the littoral region. Therefore, the most productive area of Balsam Lake (and Cameron Lake) is relatively limited compared to most of the other lakes within the Kawartha Lakes region.

The suitability of aquatic habitat is also influenced by nutrient availability. Nutrient loadings, in particular phosphorus, are commonly the first element to limit biological productivity. They are influenced by local hydrology and drainage, as well as land use. Balsam Lake and Cameron Lake are situated at the top of the Kawartha Lakes systems and, as such, receive most of their water from the Gull River and Burnt River which are nutrient-poor sources draining relatively undeveloped lands off the Canadian Shield. This, in turn, limits the natural productivity of both lakes. Nutrient loadings are inherently linked to water clarity, which also plays an important role in determining habitat quality. Water clarity can be a limiting factor to aquatic organisms (e.g., walleye) that rely on visual cues for predation and/or predator detection. It is also important for the production and distribution (spatially and at depth) of aquatic plants by limiting the amount of light available for photosynthesis. Balsam Lake and Cameron Lake are two of clearest lakes within the Kawartha Lakes, having average Secchi depths (from 2011-2014) of 4.13m and 3.38m respectively. Secchi depth alone is not sufficient to estimate light at a given depth, but does provide a measure of light attenuation based on total suspended solids in the water column.

Vegetative cover and bottom substrate are other important physical characteristics of aquatic habitat that have implications for the productivity of aquatic communities. Generally, macrophytes are expected to increase nearshore productivity (Jude and Pappas, 1992). In addition, macrophytes increase the structural complexity of the littoral habitats which has been shown to increase fish species richness and influences predator–prey interactions (Crowder and Cooper, 1982; Eadie and Keast, 1984). Little information exists in terms of macrophyte composition and distribution in Balsam Lake and Cameron Lake, however, they are likely confined to the littoral zones of the lake in areas that are protected from constant wind and wave energy.

Thermal regime is another important habitat component with strong links to aquatic communities. Water temperature is a crucial habitat component for all fish communities, with each species having preferred thermal habitat conditions for reproduction, survival and growth. Surface thermal conditions across Balsam Lake and Cameron Lake were assessed from 2011-2014 on a monthly basis from May to October. Surface water temperatures (i.e., 2m and less) were similar between the two lakes, averaging 20.6°C (maximum = 28.4; minimum = 14.0) on Balsam Lake, and averaging 20.7°C (maximum = 28.5; minimum = 14.7) on Cameron Lake. Thermal regime not only affects the suitability of aquatic habitat, but also accessibility to habitat due to the vertical thermal structure. During most of the year, both lakes are well-mixed. From June through August, however, the vertical thermal structure in both lakes temporarily stratifies in the deepest basins. This permits relatively colder water to exist at depth within these areas of the lakes. For example, in July 2013 water temperatures within the deep east-central basin of Cameron Lake ranged from 27.9°C at the surface to 15.6°C at the bottom near the substrate. However, one would not expect any sizable amount of cold water habitat because lake morphology limits the amount of volume available within the deep, cold areas of the basins.

Another physical limnological attribute that may enhance or limit access to aquatic habitat are adequate dissolved oxygen concentrations to support aquatic respiration. Summer dissolved oxygen concentrations appear relatively stable in the surface waters and are somewhat uniform with depth. However, as discussed in ***Chapter 7*** (***Figures 7.13 and 7.14***), there are occasional oxygen reductions in the bottom waters of the deep basins of both lakes during periods of temporary stratification.

Recent Changes in Kawartha Lakes Aquatic Habitat and Consequences for Aquatic Communities

Over the last 50 years, major land use changes within the Kawartha Lakes have included land clearing for agriculture, increasing urbanization along the shoreline and hardening of the shoreline/lake interface. Changes in shoreline development and land use patterns can have wide-spread implications for aquatic habitat. In addition, changes in nutrient inputs from watershed sources have also played a role in affecting aquatic habitat.

Over recent decades, modest increases in water clarity have occurred in Balsam Lake as a result of reduced nutrient loadings starting in the late 1980s. Phosphorus levels in both lakes have, for the most part, been reduced to below the Provincial Water Quality Objectives limit (< 20 µg/L). These relatively low nutrient levels limit the potential for primary production. The observed decline in nutrient inputs, along with the arrival of zebra mussels (*Dreissena polymorpha*) in the mid-1990s, have led to a modest, yet statistically significant increased clarity in the lake water (Robillard and Fox, 2006). For example, in Balsam Lake, Secchi depth measurements between 1972 and 1976 averaged 3.9 m, whereas from 2011-2014 they averaged 4.13 m. These observed changes in Balsam Lake are quite modest compared to dramatic increases in Secchi depth observed in other Kawartha Lakes (e.g., Sturgeon Lake and Rice Lake). Increases in water clarity typically translate into an increase in the maximum depth of macrophyte colonization.

Climate change is also a continuing stressor affecting thermal and hydrologic lake conditions. Neighbouring Sturgeon Lake has shown a slight increase of ~1°C in sustained summer (June, July and August) water temperatures. Such changes in water temperature over time are becoming increasingly recognized as factors that influence year-class strength, recruitment, growth and survival of fishes. For example, in eastern Lake Ontario, it has been predicted that an increase in water temperature of 1°C above the mean would result in an almost 2.5-fold increase in the relative recruitment of smallmouth bass, whereas coolwater species would experience a 2.4-fold decline in relative recruitment (Casselman et al., 2002). Changes in thermal regime may also affect the availability of deep, cold waters within the deep basins of Balsam and Cameron lakes. Currently, lake herring (a coldwater fish) is considered rare in the Kawartha Lakes, however, recent surveys have captured occasional lake herring that are likely from populations resident to cold northern headwaters. The presence of lake herring indicates marginal summer profundal habitat for coldwater species. Changes in thermal attributes (absolute values and vertical structure) may compromise accessibility and/or suitability of deep-water habitat for these uncommon species - for example by deepening the thermocline thus reducing the available volume of cold, hypolimnetic aquatic habitat.

8.3.2 Fish Communities

General Species Composition

The fish community in Balsam Lake has been monitored since the 1970s by the Ontario Ministry of Natural Resources and Forestry (OMNRF), Kawartha Lakes Fisheries Assessment Unit (KLFAU). Monitoring has been focused on three key predatory fish species (walleye, muskellunge and smallmouth bass) that maintain stability in the fish community and support a recreational fishery. Over the years, a variety of netting survey methods have been implemented on Balsam Lake including trap net, gill net, seining, trawling, and electrofishing. Most recent surveys have used standard provincial netting protocols including Nearshore Community Index Netting, End-of-Spring Trap Netting, Fall Walleye Index Netting and others. Each survey method has unique characteristics that affect the sample catch because of gear, season, or location. Cameron Lake is not part of routine KLFAU monitoring program therefore the discussions within this section are focused on Balsam Lake.

Balsam Lake's fish community composition reflects its cool/warmwater thermal regime and oligotrophic nutrient status. Of the approximately 36 fish species that have been formally documented within the BCLMP planning area, 29 species have been found within Balsam Lake, and 19 species within Cameron Lake (***Table 8.1***). Historically, the large-bodied fish species were most often represented by muskellunge, smallmouth bass, pumpkinseed and yellow perch populations. However, the large-bodied fish community structure has become increasingly altered over time due to intentional stocking, range extensions of species native to the Great Lakes basin, unintentional introductions and non-native species invasions.

The interconnected nature of the Kawartha Lakes facilitates the spread of non-native species. Common carp were accidentally introduced into the Great Lakes system approximately 100 years ago and have been present in Balsam Lake since at least the 1970s. Walleye were intentionally introduced to the Kawartha Lakes region in the 1930s to provide recreational angling opportunities. Largemouth bass and rock bass are native to the Trent River system and the construction of locks and canals between waterways have allowed these species to expand their ranges into Balsam Lake and Cameron Lake. More recently, bluegill and black crappie have become established in the lakes; both species are native to eastern and central North America preferring the warm shallow waters of large and small lakes that have abundant aquatic vegetation. They have expanded their ranges through the Trent-Severn Waterway after initially becoming established in Rice Lake. Bluegill was first detected in Balsam Lake in 1993, whereas black crappie appeared in 1999 (Kawartha Lakes Fisheries Assessment Unit, OMNRF, Lindsay, unpublished data). Northern pike have expanded along the Trent-Severn Waterway from Lake Simcoe into the Kawartha Lakes and have now become established in Balsam Lake. Round goby has not yet been detected in Balsam Lake or Cameron Lake, but has been observed in the Otonabee River, near Peterborough. The round goby is considered an invasive species at immediate risk of becoming established. It poses a threat to native fish community structure by negatively impacting species diversity through competition with, and predation on, native fish species in areas where they have become established (Kornis et al., 2012).

In Balsam Lake, the recent fish community (in terms of relative biomass of species caught between 1998 and 2011) consists of smallmouth bass, black crappie, walleye, bluegill, common carp, rock bass, largemouth bass, white sucker, muskellunge, and pumpkinseed (***Figure 8.1***). Other large-bodied species that contribute to the biomass of the lake include: brown bullhead, northern pike, redhorse, yellow perch, burbot and golden shiner. The fish community also includes small-bodied forage fish species such as minnows, darters, shiners and trout-perch. Little is known about the status of these small-bodied species within the Balsam Lake and Cameron Lake basins because routine monitoring (using large netting) does not efficiently catch them. Historic records from other Kawartha Lakes and their tributaries indicate the potential for a diverse community. Overall, typical species of the Balsam Lake fish community are members of the cool/warmwater guild. Lake herring, a coldwater species, is an exception and has been captured in low numbers at depths within the deep central-lake basins of both lakes.

Table 8.1. Comparison of Fish Species Present or Recorded Historically in Balsam and Cameron Lakes and Their Tributaries Within the BCLMP Planning Area

Fish Species* - Common Name	Tributaries within the BCLMP planning boundary	Balsam Lake	Cameron Lake
Black Crappie[1]		X	X
Blacknose Dace	X		X
Blacknose Shiner	X		
Bluegill[1]	X	X	
Bluntnose Minnow	X	X	X
Brassy Minnow	X		
Brook Stickleback	X	X	
Brown Bullhead		X	X
Burbot		X	
Central Mudminnow	X	X	X
Cisco (Lake Herring)		X	X
Common Carp[1]		X	X
Common Shiner	X		
Creek Chub	X	X	
Emerald Shiner		X	
Fathead Minnow	X	X	
Finescale Dace	X		
Golden Shiner		X	X
Iowa Darter	X	X	X
Largemouth Bass[1]	X	X	X
Least Darter		X	
Logperch		X	
Mottled Sculpin	X		
Muskellunge	X	X	X
Northern Pike	X	X	
Northern Redbelly Dace	X		
Pearl Dace	X	X	
Redhorse		X	
Pumpkinseed	X	X	X
Rock Bass	X	X	X
Smallmouth Bass		X	X
Spottail Shiner		X	X
Trout-perch		X	X
Walleye[1]		X	X
White Sucker	X	X	X
Yellow Perch	X	X	X

** Source of species list include: KLFAU data, historical OMNRF lake and stream surveys, Royal Ontario Museum records; OMNRF Aquatic Resource Area data, and Kawartha Conservation 2013 data.[1] denotes species that are non-native to the Kawartha Lakes region.*

According to the 2011 survey, Balsam Lake had the lowest **catch-per-unit-effort (CUE)** at 29 fish per net (***Figure 8.2***), and **lowest biomass-per-unit-effort (BUE)** at 4.055 kg per net, relatively to five other Kawartha Lakes (Buckhorn, Chemong, Pigeon, Rice and Scugog). This is due to the relatively low productivity of its aquatic ecosystem (i.e., oligotrophic status) compared to other downstream Kawartha Lakes, as well as the relatively small extent of littoral areas and relatively fewer macrophytes. In terms of the proportion of BUE by species within the Kawartha Lakes during recent surveys (***Figure 8.3***), the fish communities within the Kawartha Lakes are relatively similar with some notable exceptions. One key feature of Balsam Lake is its relative evenness in terms of fish species. In the other Kawartha Lakes, bluegill makes up the largest proportion of the overall BUE. This is not the case in Balsam Lake, where black crappie and smallmouth bass make up the bulk of the BUE. Rock bass and muskellunge have proportionally higher BUE in Balsam Lake than in the other lakes as well.

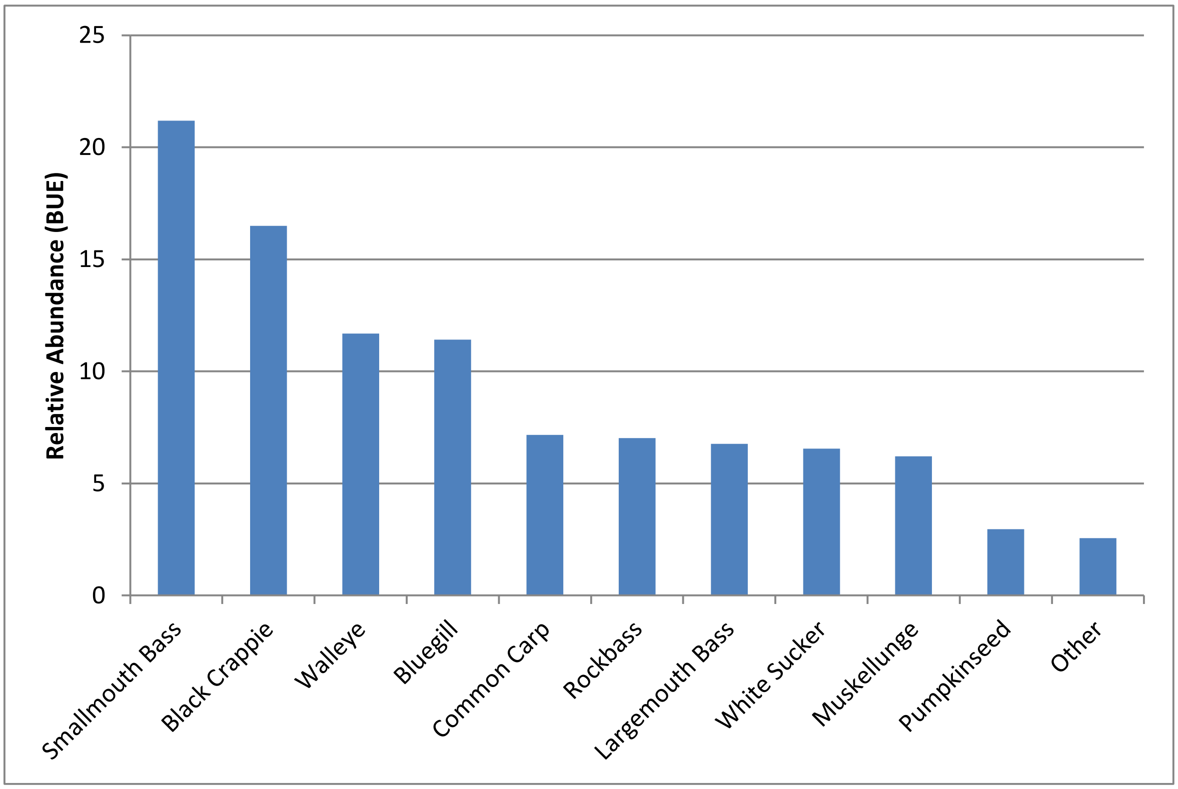

Figure 8.1. The Relative Percentage of Fish Communities in Balsam Lake, 1998-2011

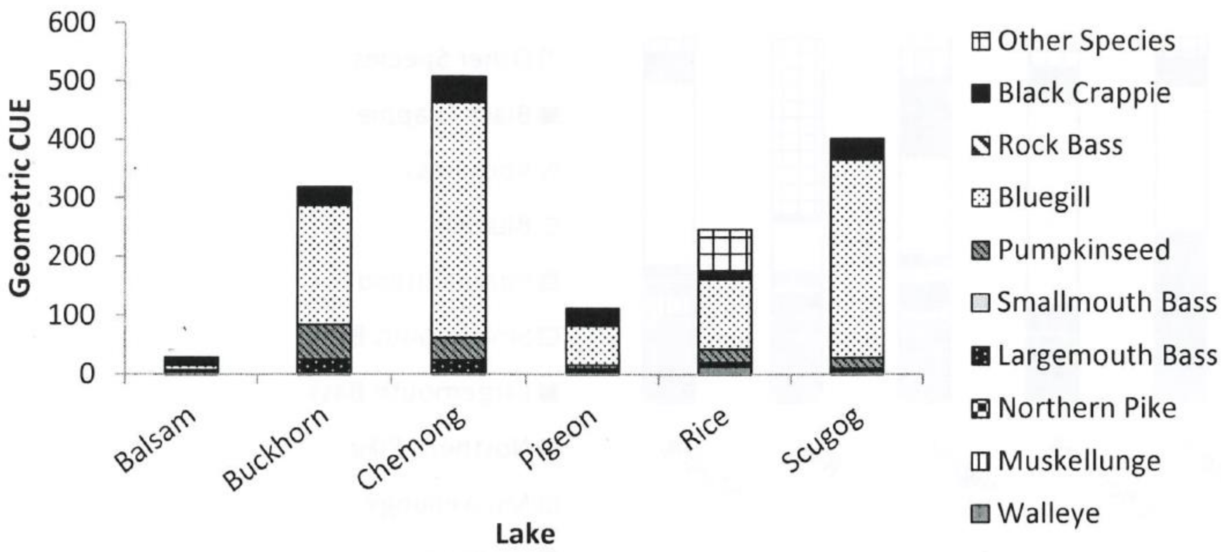

Figure 8.2. Geometric Catch-per-unit-effort (CUE) of Major Species for Six of the Kawartha Lakes from the Most Recent (2011 for Balsam Lake) Nearshore Community Index Netting Surveys

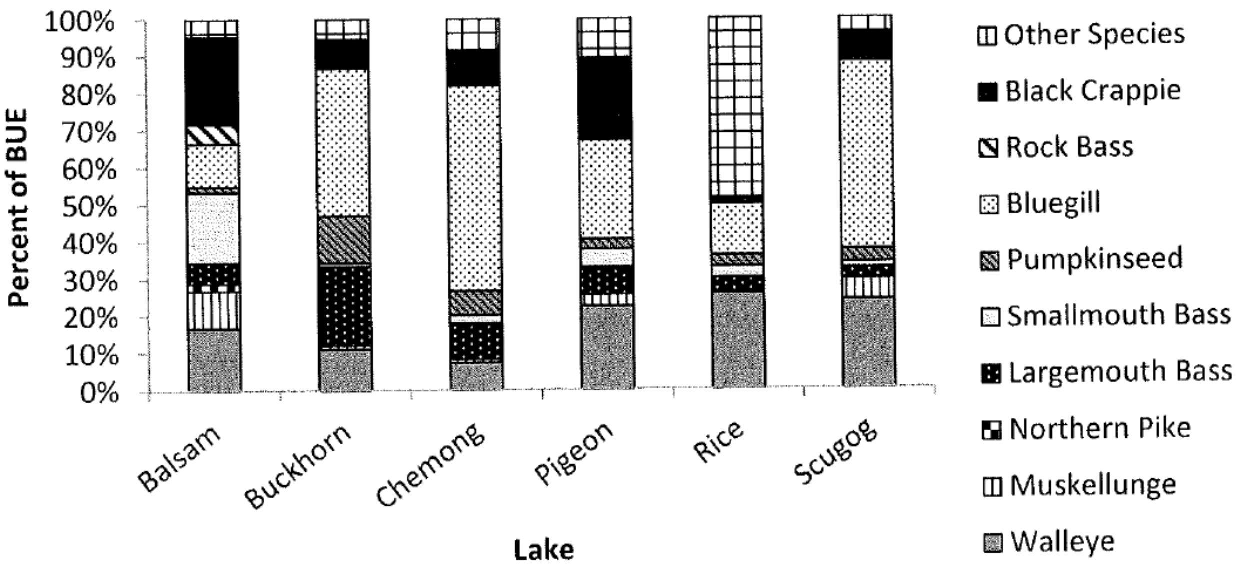

Figure 8.3. Proportion of Biomass-per-unit-effort (BUE) of Major Species for Six of the Kawartha Lakes from the Most Recent (2011 for Balsam Lake) Nearshore Community Index Netting Surveys

Changes in Balsam Lake fish communities

As documented by Robillard and Fox (2006), over the period from 1980 to 2003, the Kawartha Lakes have experienced a regional-scale decline in the relative abundance of walleye and an increase in the relative abundance of largemouth bass and smallmouth bass. These changes were associated with reductions in phosphorus concentration and increases in water clarity and summer temperature. Balsam Lake was not immune to these regional-scale changes. However, compared to other Kawartha Lakes, Balsam Lake has historically been low in phosphorus, relatively clear, and supported relatively few walleye. Therefore, these changes have been more subtle than experienced in other historically productive Kawartha Lakes such as Lake Scugog and Rice Lake.

Figure 8.4 shows the catch rates of individual fish species from more recent surveys spanning 1998-2011 on Balsam Lake. The short time series and variable catch from year to year makes it difficult to determine statistically significant trends in relative abundance. Declines are apparent for some species (rock bass, pumpkinseed, largemouth bass) and increases for others (black crappie). The only statistically significant change has been the decline in pumpkinseed. Within the survey period, overall CUE of all species caught in Balsam Lake peaked in 2002. This peak was largely due to increased catches of bluegill which increased from an average of 22% of the total catch to 47%. Since then the proportion of bluegill caught has decreased back to approximately 26%. From 1998 to 2002, black crappie made up approximately 4.5% of the overall CUE. In 2006, the black crappie population peaked and has since made up an average of 38% of the overall CUE. In terms of biomass, black crappie have contributed a large proportion of the total BUE since 2006 - approximately 53%. This remained fairly consistent from 2007 to 2010 and decreased to 35% of the total BUE in 2011. As the CUE and BUE of black crappie has increased, the proportion of other warmwater species has decreased. For example, the BUE for largemouth bass, pumpkinseed and rock bass slightly decreased from 1998 to 2011. Northern pike were initially detected in Balsam Lake 2001 and have established a population that is currently at moderate abundance.

Balsam Lake walleye populations have remained stable during the 1998-2011 monitoring period. Natural reproduction has produced a fairly stable abundance of year classes and the survival rate of larger fish has increased. This is likely due in large part to lake stability in terms of aquatic habitat conditions and fish communities, but is also likely connected to the implementation of walleye harvest regulations in 2001. The objective of the regulations was to reduce the number of fish harvested between 37- 55 cm, while still allowing fishing opportunities and harvest of walleye < 37, and > 55 cm.

Muskellunge populations have also remained stable during the 1998-2011 monitoring period, despite the fact that northern pike populations have increased during this time. There is a significant concern that, due to their similar habitat requirements and aggressive juvenile life stage, none-native northern pike populations will continue to proliferate to the detriment of native muskellunge populations. The latest data from KLFAU (2014 – not included in this report) indicate that northern pike relative biomass within Balsam Lake is presently more than 4 times greater than its average between 1999-2011. Furthermore, recent monitoring by Muskies Canada in traditional muskellunge spawning and nursery areas of Balsam Lake indicate that there is clear overlap between these species spawning in the same areas (Muskies Canada, unpublished).

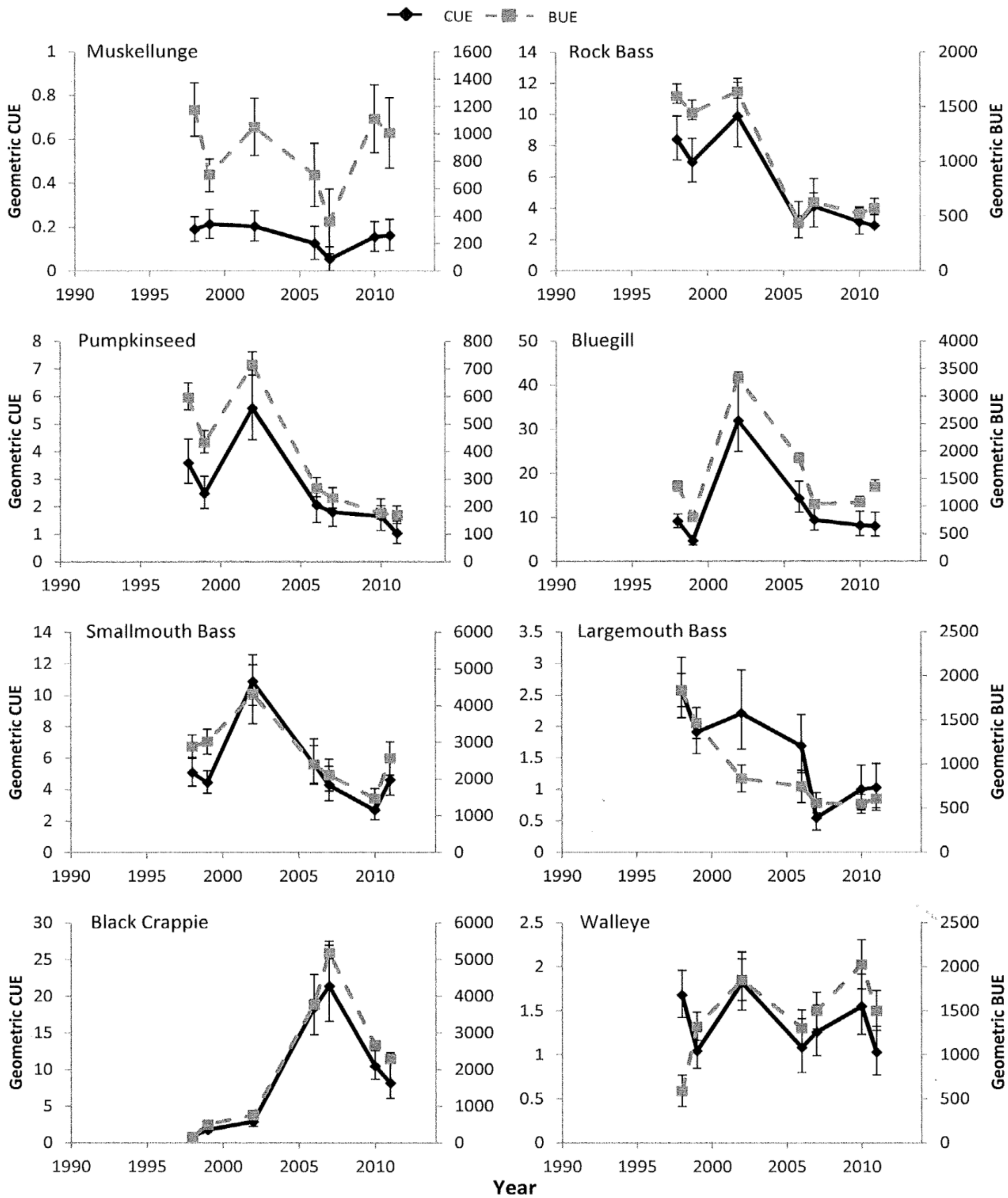

Figure 8.4. Trends in the Geometric Catch-per-unit Effort (CUE) and Biomass-per-unit Effort (BUE) of Species Caught During Nearshore Community Index Netting on Balsam Lake from 1998 to 2011. Solid Line – the Least Squares Regression

Status of the Balsam Lake Recreational Fishery

Balsam Lake is located within the Kawartha Lakes area which supports a significant recreational fishery. In the open water season, the most sought-after species have traditionally been walleye and muskellunge. The recreational fishery is assessed by the MNRF through angler (creel) surveys on individual lakes to estimate the magnitude of the fishery (hours spent fishing), and the harvest by species. It is a competitively fished lake with multiple tournaments per year (Kerr, 2009).

Boating angler effort has been assessed on Balsam Lake since 1978 by obtaining estimates of total angler effort within an index season, being between the opening of walleye season extending through Labour Day (***Table 8.2***).

Table 8.2. Estimated Angler-hours for the Survey Index Season on Balsam Lake in 1978-2010 (hours, thousands)

Year	Season Dates (mm/dd)	Total	Walleye	Musky	Bass sp.	Panfish Sp.	Bluegill	Y. Perch	Bl. Crappie
1978	05.13 - 09.08	125.2	52.8						
1982	05.08 - 09.06	130.6	80.7	2.9	9.9	3.7	0.0	2.5	0.0
1986	05.10 - 09.01	99.4	68.3	2.1	20.3	8.1	0.0	6.8	0.0
1990	05.12 - 09.03	89.0	60.6	2.9	17.4	2.0	0.0	1.8	0.0
1994	05.14 - 09.05	52.9	33.4	1.7	13.5	4.3	0.6	2.9	0.0
1999	05.08 - 09.06	72.2	33.1	1.7	20.8	4.4	0.0	3.5	0.1
2001	05.12 - 09.03	69.4	35.7	2.2	17.7	6.2	<0.1	4.8	0.0
2002	05.11 - 09.02	57.4	13.4	2.8	20.9	4.1	0.0	3.5	0.0
2003	05.10 - 09.01	31.7	11.2	1.6	4.5	2.6	0.1	2.0	<0.1
2006	05.13 - 09.04	66.0	17.2	3.6	20.4	4.2	0.5	2.7	0.1
2010	05.08 - 09.04	55.9	18.1	4.5	15.3	1.5	0.0	0.9	0.3
2014	05.10 - 09.01	50.6	11.7	5.5	8.0	0.5	0.0	0.4	<0.1

During this sample period, estimates of total angler effort were highest from 1978 to 1990, with a peak of 130,000 angler hours in 1982, but have been less than 80,000 angler hours since 1994. In 2014, 51,000 angler hours were spent on Balsam Lake - a reduction of more than 60% from the peak period. The decline in angler activity over the years is not unique to Balsam Lake. It has been experienced in all Kawartha Lakes as well as most of Ontario's other lakes. Current total angler effort in Balsam Lake is approximately 11 angler hours per hectare, whereas total effort on Cameron Lake is approximately 20 angler hours per hectare. These are below the average effort expended across all Kawartha Lakes (30 angler hours per hectare).

The Balsam Lake boat fishery has traditionally targeted walleye more than any other species. Other high targeted species include smallmouth bass, largemouth bass and muskellunge. Recent changes in the population structure of these species have shifted angling efforts away from walleye towards bass species. Recent estimates from a 2010 survey of walleye harvested are 0.24 kg/ha, which is relatively low. A winter ice fishing season was recently opened in 2010 that permits angling for panfish species.

8.4 Tributary-Based Ecosystems

8.4.1 Aquatic Habitat

Figure 8.5 shows the best-available mapping of the watercourse network within the core BCLMP planning area (does not include the Gull River, Burnt River and Corben Creek). When combined, the watercourse network totals almost 300 km in length, all of which can be considered as probable aquatic habitat that directly supports or contributes to aquatic life. The majority of the stream network (approximately 72% or 215 km of total length) flows through natural lands, primarily through swampland (41%) and upland forested areas (15%).

Approximately 24% or 72 km flows through agricultural areas that are evenly split between croplands and pasturelands. The remainder of the network (4%) flows through developed areas, mainly through areas of rural development and under roads.

Figure 8.6 shows the watercourse network, and ***Table 8.3*** lists their respective lengths by stream order. Stream ordering, as introduced by Strahler (1957), is a method of classifying the branching complexity and size of the stream network. First-order streams are watercourses with no tributaries; second-order streams begin when two first-order streams meet; and so on proceeding in a downstream manner. As outlined in the River Continuum Concept (Vannote et al., 1980), stream ordering is a useful approach to help classify watercourse reaches that exhibit similar biological properties. Stream orders within the BCLMP planning area range from one to four. The majority of watercourses (over 75% by length), are small first- and second-order streams. These “headwaters” are typically small, ill-defined and inconspicuous ephemeral or intermittent stream corridors that usually dry up during extended dry periods (e.g., during summer and winter). Headwaters are typically far-removed from the lake, but serve an important function by providing seasonal aquatic habitat when flow does occur, as well as conveying food, nutrients, and water flow that are used by aquatic life residing downstream in the larger and more identifiable watercourses. These larger streams sections, of third- and fourth-orders, comprise 25% of the total length of the stream network. These sections typically flow continuously, thus providing aquatic habitat year-round.

Table 8.3. Length of Streams Within Each Subwatershed by Strahler Order

Subwatersheds	1st Order	2nd Order	3rd Order	4th Order	Total Length
Balsam Lake subwatershed	57.9	20.6	2.5	6.3	87.4
Cameron Lake subwatershed	7.9	4.2	1.9	-	14.1
Martin Creek South	18.7	12.1	12.4	-	43.1
Pearns Creek	33.4	11.5	4.1	13.2	62.2
Staples River	34.7	11.5	4.8	15.2	66.3
Total Length	152.7 (56%)	59.9 (22%)	25.7 (9%)	34.7 (13%)	273.0

Within the BCLMP planning area, there are approximately 20 tributaries that drain directly into Balsam Lake and approximately 9 that drain directly into Cameron Lake. All of these provide important aquatic habitat pathways to-and-from the lakes. The aquatic habitat within these tributaries helps maintain functioning aquatic communities within the lakes by providing spawning habitat for lake-based migratory fishes, providing a corridor for the movement of aquatic organisms, water flow, food and energy transport which all contribute to the aquatic biodiversity of the lake basins, among other functions. The outlet sections of these tributaries are transitional areas between the lotic flowing water “stream-like” environments and the lacustrine still-water “lake-like” environments. These transitional areas are biodiversity hot-spots.

Many fish species in Balsam and Cameron lakes migrate up lake tributaries in late winter/early spring to reproduce (e.g., walleye, muskellunge and white sucker). Many tributary-dwelling fish species migrate to the lake and to refuge pools to avoid stream freeze-up during winter months. Therefore, unimpeded access both along tributaries, as well as to-and-from the lake is critical to maintain healthy fish populations in the lakes. Typically, the larger stream sections connected to the lake are most important in terms of providing habitat for lake-dwelling communities. In terms of watercourses flowing directly into Balsam Lake, Staples River and an unnamed Balsam Lake tributary are the largest, entering the lake as 4th-order streams into West Bay and South Bay respectively. The next largest to enter the lake, as a 3rd-order stream, is an unnamed tributary that enters near Blanchards Road and Balsam Lake Drive. The rest include seven 2nd-order streams, and seven 1st order streams. In terms of watercourses flowing directly into Cameron Lake, Pearns Creek is the largest, entering the lake as a 4th-order stream into McFarland Bay. The next largest, as 3rd-order streams, are Martin Creek South and an unnamed tributary flowing through Fenelon Falls. The rest include a 2nd-order stream and three 1st-order streams.

Figure 8.7 shows the approximate locations of spawning habitats for two important top predator fish, muskellunge and walleye (Gartner Lee and French Planning, 2002). Muskellunge in particular have been observed migrating up several tributaries to access spawning habitat. Populations in Balsam Lake have been found using habitat up Staples River (500 m upstream of Fish Hawk Rd.), Hannivan's Creek (1 km upstream of County Road 48) and an unnamed tributary flowing into South Bay (upstream to Elm Tree Rd.). Within Cameron Lake, muskellunge have been found to migrate up Pearns Creek (up to Country Ln.), and Martin Creek South (almost to Country Ln.). Maintaining migratory access to these areas is critical to maintaining healthy populations of these fish species. Access to aquatic habitat can be fragmented by man-made obstructions including dams, weirs, and perched or blocked culverts, as well as by natural obstructions such as steep river channels and fast flowing waters. Not only do such features impede migration, but they can also isolate populations and limit their access to suitable resident habitat.

Figure 8.6 shows the location of known barriers within, or immediately adjacent to, the BCLMP study area. There is a dam at Coboconk, a dam and lock just east of Rosedale, a dam and lock at Fenelon Falls, and a guard gate (usually open only from late spring to early fall, but in rare cases also opened in spring to pass extreme flows westward) along the Trent Canal. Historically, prior to the installation of these structures, aquatic communities and habitats within Balsam Lake and Cameron Lake were, in general, isolated from each other as well as from adjacent Mitchell Lake and Sturgeon Lake. This was due to high gradient river systems that were likely too steep to facilitate upstream passage from one side to the other. The building of the Trent-Severn Waterway created artificial connections between lake systems. Although migratory fish remain isolated due to these structures, the lakes are now, for all intents and purposes, connected to Lake Simcoe to the west, and to Lake Ontario to the east. This connection has facilitated the gradual movement and colonization of some fish species (e.g., bluegill, black crappie, northern pike) and other aquatic species that are non-native to the Kawartha Lakes system into Balsam Lake and Cameron Lake.

The transitional zones between aquatic and terrestrial environmental are called the riparian area. Natural riparian areas encompass a range of vegetation types (i.e., forest, wetland, meadow), and provide similar benefits along tributaries as do natural shorelines around lakes. These include: stabilizing stream banks, reducing erosion, moderating water temperatures, filtering contaminants, providing cover and spawning habitat for fishes, and supplying nutrients and food for the watercourse (Gregory et al., 1991). To characterize riparian areas within BCLMP planning area, the extent and type of land cover along the watercourse was interpreted from aerial photography taken in 2008. Natural cover (e.g., forest, wetlands, etc.) within the riparian areas was classified according to Ecological Land Classification methodology (Lee et al., 1998), whereas non-natural land cover (e.g., agricultural lands, urban areas, aggregate pits, etc.) was classified according to methods developed to complement this protocol [developed by Credit Valley Conservation (1998)].

Various studies have investigated the minimum riparian buffer width necessary to maintain the ecological integrity of watercourses, often ranging from 5 metres to 300 metres depending on the functions they provide (OMAFRA, 2003) ***(Figure 8.8).*** A larger width may be required in areas adjacent to pristine or highly valued wetlands or streams, in close proximity to high impact land use activities, or with steep bank slopes, highly erodible soils, or sparse vegetation (Fischer and Fischenich, 2000). In general, a 30 m width of natural vegetation on both sides of the watercourse is of sufficient size to provide beneficial functions such as aquatic habitat, bank stability, and sediment removal. Studies in southern Ontario have demonstrated that that stream degradation occurs (e.g., loss of sensitive species) when riparian vegetation amounted to less than seventy-five percent of the total stream length (Environment Canada, 2013). Thus, as a general guideline, it is recommended that to help maintain the ecological integrity of the aquatic ecosystem, at least 75 % of the total length of watercourses should have natural riparian areas, preferably as wide as 30m, on either side of the top of bank-full stage.

Table 8.4 lists the percentages of 30 metre riparian areas consisting of natural, agricultural or developed lands along all tributaries within the study area, by stream order. At 72 % existing natural riparian areas, the watercourses within the BCLMP are just shy of minimum recommended guidelines. An increase in natural vegetation of 50 hectares is needed to achieve the guideline. Natural riparian areas by stream order range from 64-93%, and are more extensive along larger (higher-order) stream sections and are reduced along smaller streams to accommodate agricultural land use. Developed riparian areas account for 3-6% and tend to exist along tributaries that are nearer to the lake. Guidelines are not met along the headwater first- or second-order streams, requiring an increase of 100 hectares and 24 hectares of natural vegetation respectively.

Table 8.4. Riparian Land Use (30 m on Both Sides) by Strahler Order for all Subwatersheds Combined

Stream Order	Riparian Area Size	Natural	Agriculture	Developed	Natural riparian needed to achieve 75% of length
1st order	925 ha	64%	32%	4%	100 ha (11%)
2nd order	360 ha	68%	28%	4%	24 ha (7%)
3rd order	156 ha	89%	5%	6%	-
4th order	289 ha	93%	4%	3%	-
All Combined	1730 ha	72%	24%	4%	50 ha (3%)

Table 8.5 lists the percentages of 30 m riparian areas by subwatershed. Natural riparian area coverage ranges from 64-84%, agricultural areas ranges from 12-33%, and developed lands ranges from 2-13%. Four of the five subwatersheds within the planning area do not meet minimum ecological requirements. They include: the Cameron Lake subwatershed, Staples River, Pearns Creek and Martin Creek South subwatersheds. Martin Creek South would require the least amount of additional natural cover (8 ha) to achieve the 75% guideline, whereas the Staples River would require the most (43 ha).

Water temperature plays an important role in the overall health of aquatic ecosystems, affecting rates of productivity, timing of reproduction and movement of aquatic organisms (Caissie, 2006). Fish and other aquatic organisms often have specific temperature preferences which can ultimately determine their distribution within watercourses. This thermal habitat is influenced by a number of factors including: air temperature, precipitation, relative humidity, flow, geology, topography, land use, channel morphology and riparian vegetation (Poole and Berman, 2001). Thermal habitat is often categorized into three broad types: warmwater, coolwater and coldwater. Warmwater designations imply that the watercourse is known to contain, or is likely to support, warmwater fishes (e.g., bluntnose minnow, fathead minnow, largemouth bass, etc.). Coolwater and coldwater designation implies that these watercourses are known to contain, or are likely capable of supporting, coldwater fishes (e.g., brook trout, mottled sculpin, etc.). Coldwater streams are particularly sensitive to land use impacts. This is due to the relatively narrow habitat requirements of coldwater fishes (e.g., the need for stable groundwater discharge areas, clean cold water, high levels of dissolved oxygen, etc.).

Table 8.5. Riparian Land Use (30m on Both Sides) in Subwatersheds of the Balsam and Cameron Lakes Watershed

Subwatershed	Riparian Area Size	Natural	Agriculture	Development	Natural riparian needed to achieve 75% of length
Balsam Lake sbwtshd.	590 ha	84%	12%	4%	-
Cameron Lake sbwtshd.	84 ha	64%	23%	13%	9 (11%)
Martin Creek South	254 ha	72%	24%	4%	8 (3%)
Pearns Creek	408 ha	65%	33%	2%	41 (10%)
Staples River	395 ha	64%	33%	3%	43 (11%)
All Combined	1730 ha	72%	24%	4%	50 (3%)

In summer of 2013, the thermal regime of the watercourses was assessed at all third-order and fourth-order stream-road crossings to identify any potentially sensitive areas. In total, 33 sites were sampled by taking spot-measurements of water temperature following the module outlined in the Ontario Stream Assessment Protocol (Stanfield, 2010) with slight modifications to the time of collection as per Chu et al. (2009). The data from these surveys were used to assign a thermal regime status of coldwater, coolwater, or warmwater to each sample site, based on the relationships between air temperatures and water temperatures observed in streams across southern Ontario and the types of resident fishes (Stoneman and Jones, 1996). Prior to these surveys, the thermal regime classification of all tributaries within the BCLMP study area were designated as warmwater, as interpreted from fish community sampling in the mid-1970s. As shown in ***Figure 8.9***, just over half of the 2013 sample sites have a coolwater thermal regime, whereas the rest have a warmwater thermal regime. No coldwater sites were identified. This sampling substantiates, to a certain degree, the warmwater classification of all tributaries. However, multiple coolwater sites suggest that certain sections of these watercourses, particularly along Pearns Creek and the unnamed tributary flowing into South Bay of Balsam Lake, may be capable of supporting more sensitive habitat and aquatic communities than previously thought. This is further supported by the presence of mottled sculpin, a coldwater fish that was captured in Pearns Creek during recent fish sampling.

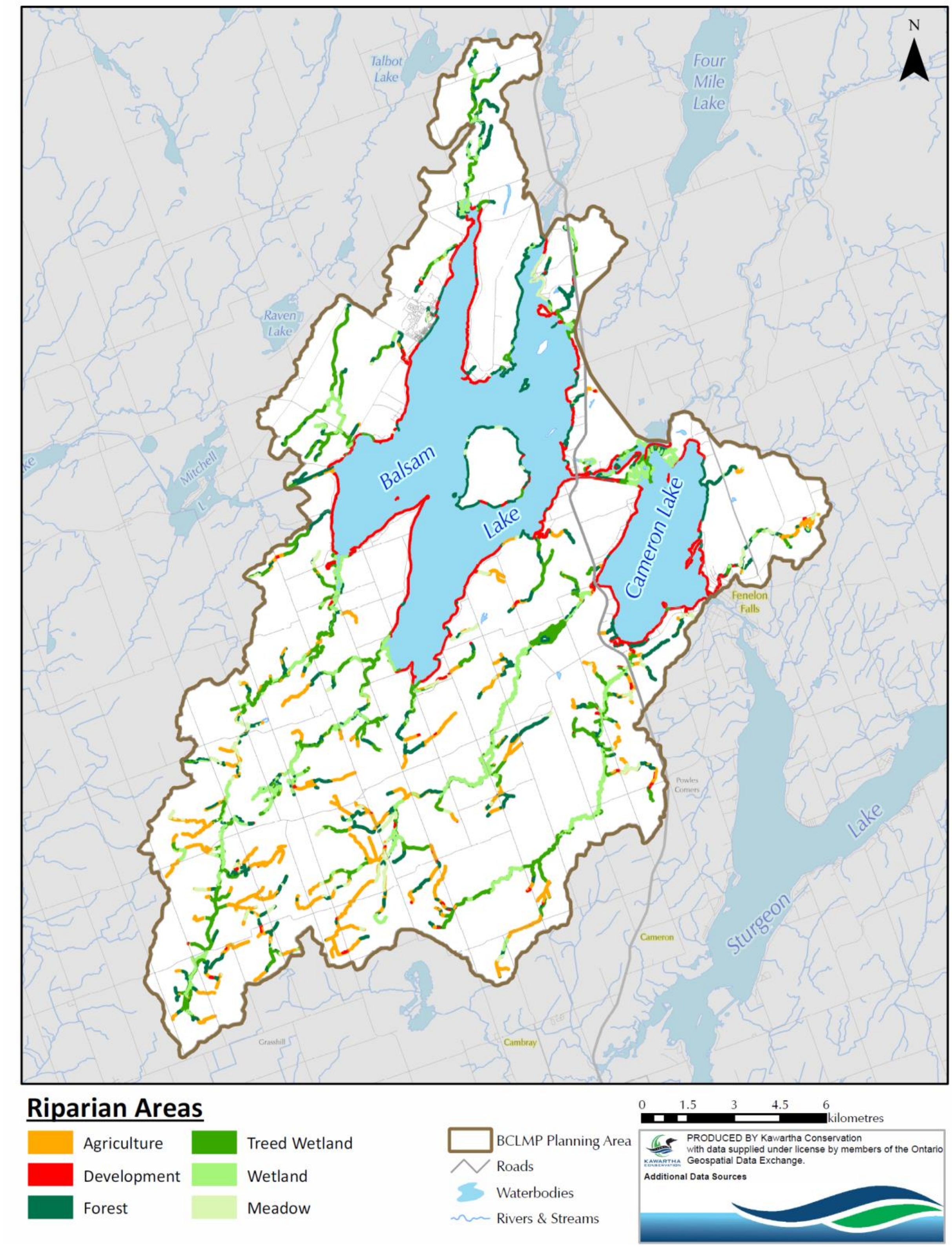

Figure 8.5. Land Use Along Stream Corridors and Lake Shorelines in the Balsam and Cameron Lakes Watershed

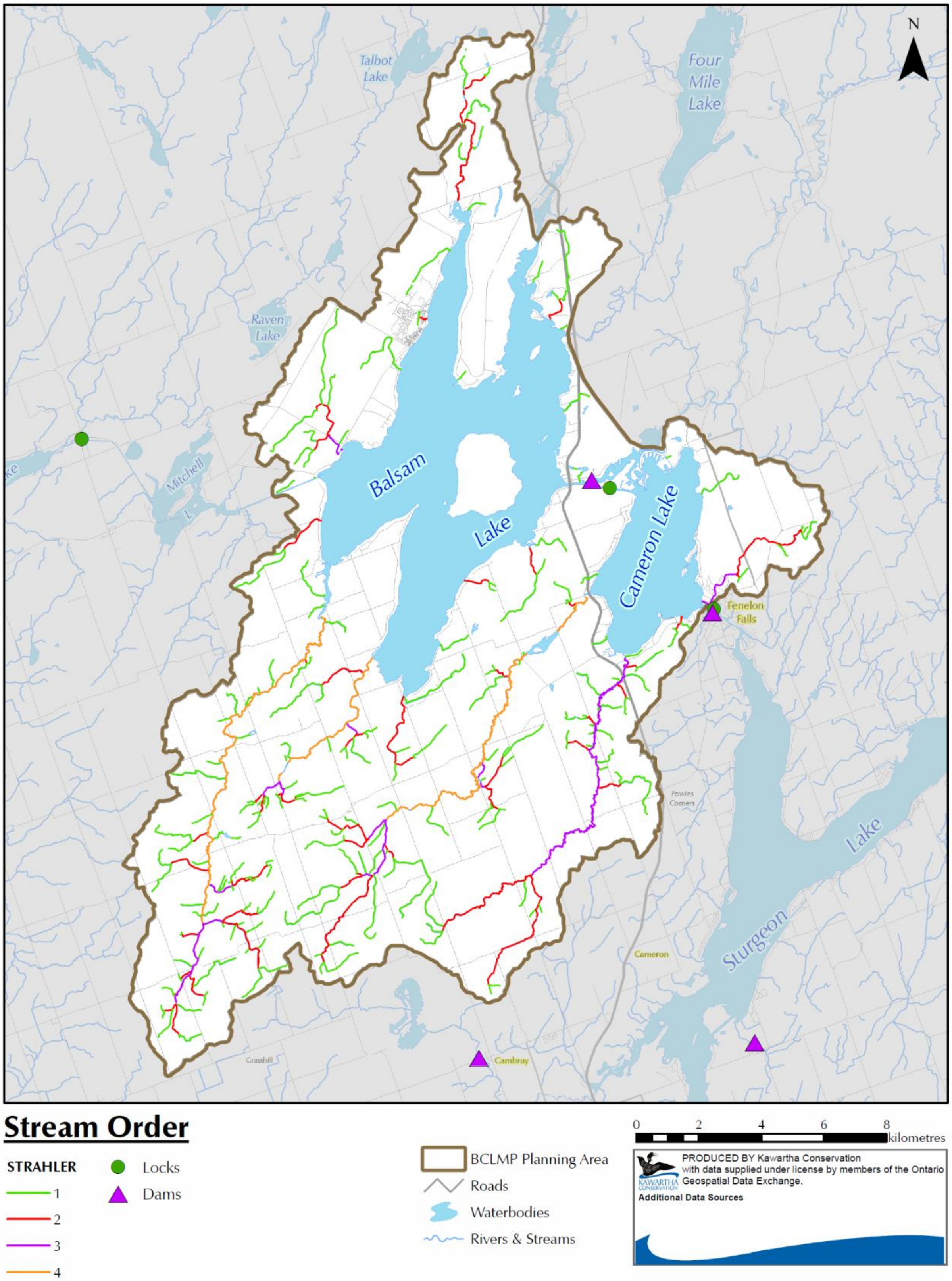

Figure 8.6. Watercourse Network by Strahler Order

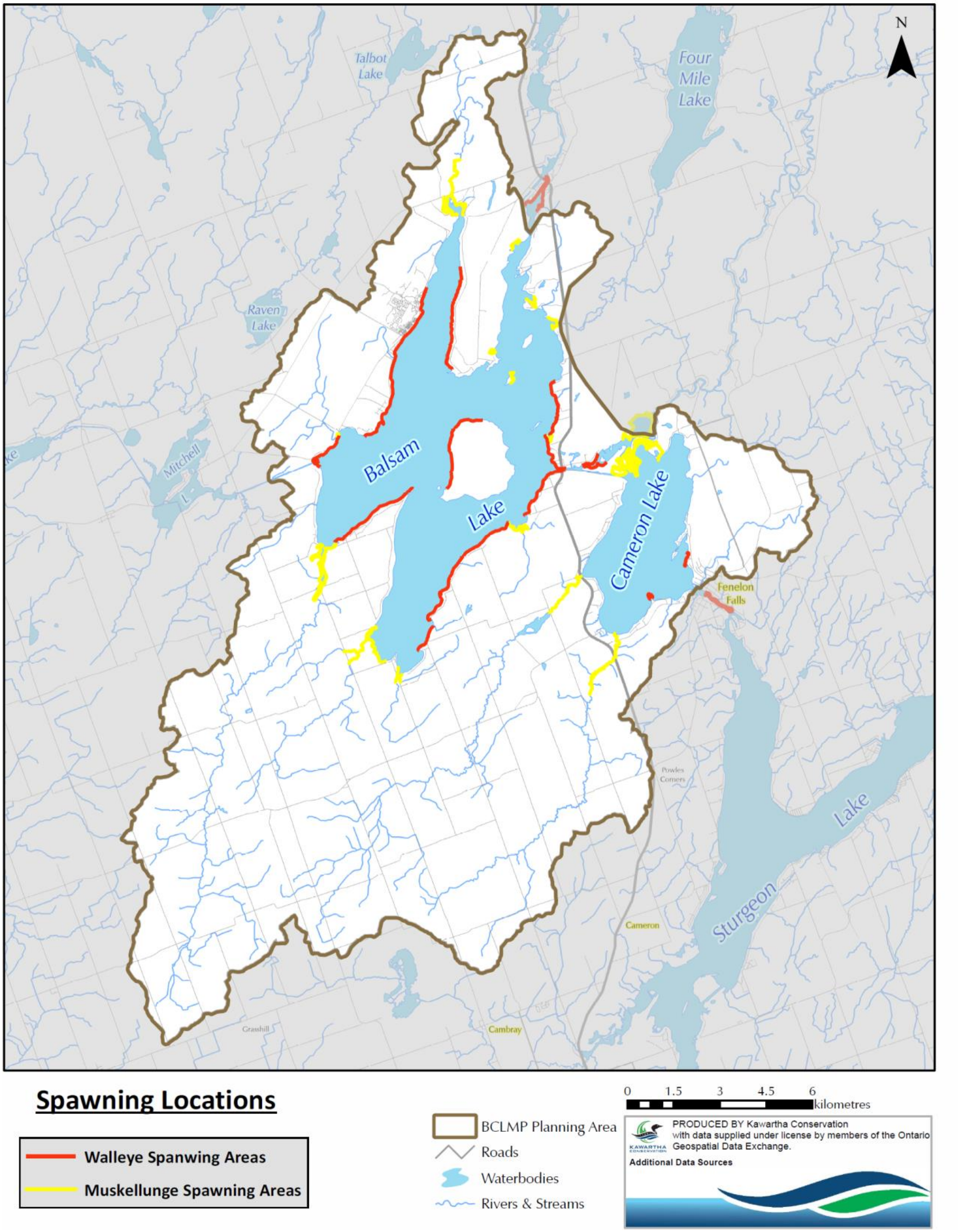

Figure 8.7. Walleye and Muskellunge Spawning Areas

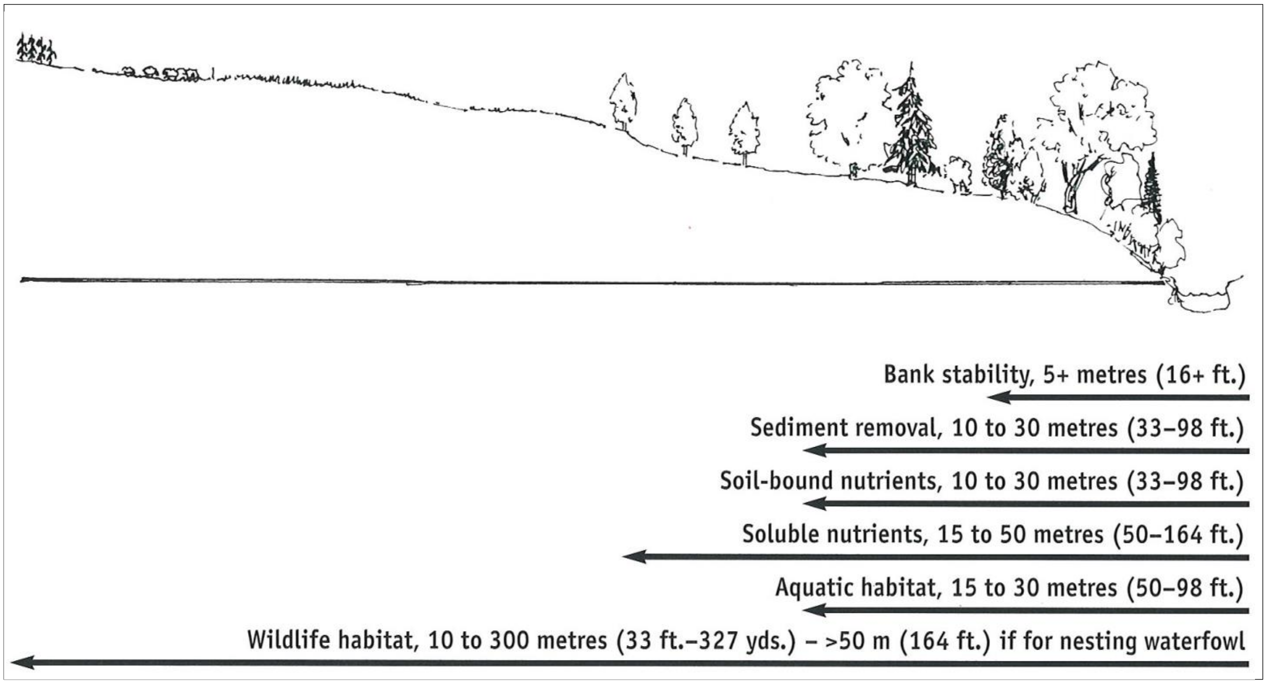

Figure 8.8. Summary of Important Functions of Natural Riparian Areas by Width

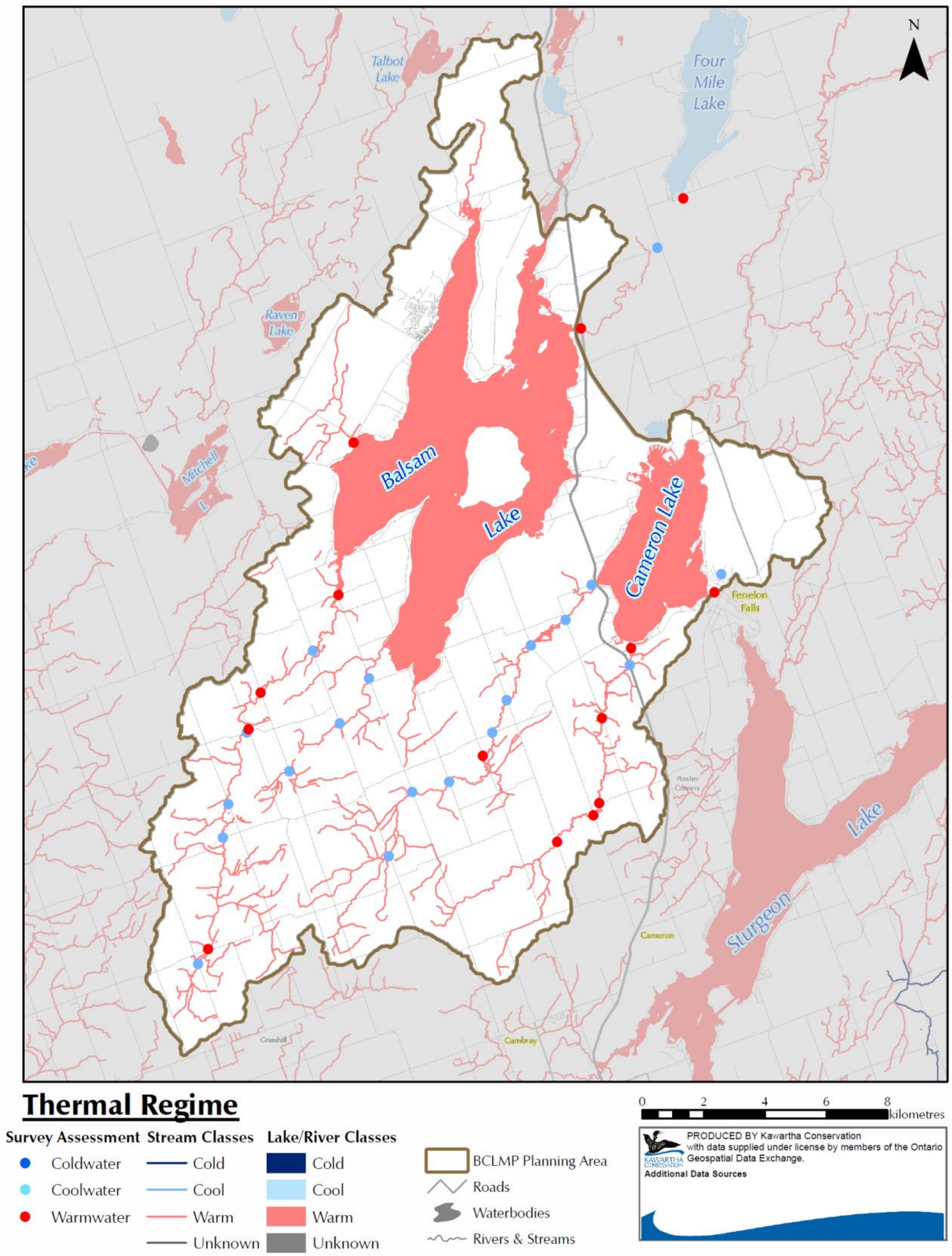

Figure 8.9. Thermal Regime Designations

8.4.2 Fish Communities

Within the tributaries of the BCLMP planning area, approximately 23 unique fish species have been documented ***(Table 8.6).*** By subwatershed, 16 species have been found in Martin Creek South, 14 in Staples River, 10 in Pearns Creek, and 9 in the Balsam Lake subwatershed. There is no known sampling in the Cameron Lake subwatershed so there are no formal fish records. Fish species records by subwatershed are found in ***Appendix 5.*** Data was summarized from OMNR Stream Surveys in 1976-77, Kawartha Conservation BCLMP sampling in 2013, and data exported from the OMNR Aquatic Resources Areas in 2006. ***Figure 8.10*** shows the locations of sample sites. All of the documented fish species are considered common to the area. The majority are considered warmwater fish, except for one coldwater species: mottled sculpin. There are no fish species that are considered to be at risk, meaning classified as Special Concern, Threatened or Endangered.

Table 8.6. Documented Fish Species in the Balsam and Cameron Lakes Tributaries

Brook Stickleback	Creek Chub
Bass Sp.	Central Mudminnow
Northern Pearl Dace	Iowa Darter
White Sucker	Pumpkinseed
Northern Redbelly Dace	Fathead Minnow
Finescale Dace	Blacknose Dace
Brassy Minnow	*Rock Bass
Common Shiner	*Largemouth Bass
Yellow Perch	Muskellunge
*Northern Pike	Bluntnose Minnow
Mottled Sculpin	Bullhead Sp.
*Bluegill	

*indicates species that are non-native.

Of all documented species within the BCLMP planning area, 4 species (17% of total richness) are not considered native to this area: northern pike, bluegill, rock bass and largemouth bass. All are native to the Lake Ontario drainage basin, but due to the physical isolation of the Kawartha Lakes from Lake Ontario (i.e., pre Trent-Severn Waterway) these species traditionally had no access to Balsam Lake and Cameron Lake. According to OMNR (2008), largemouth bass were deliberately introduced into the Kawartha Lakes in the mid-19th century; rock bass and then bluegill expanded their range from the construction of locks and canals and, more recently, northern pike have expanded their range from neighboring waterways via the canal system. Largemouth bass, rock bass, and bluegill are now considered "naturalized" in the Kawartha Lakes, because they have been here for long time periods and have integrated with the aquatic communities of the lakes. Northern pike, on the other hand, can be considered an invasive species due to its ability to outcompete and displace native muskellunge populations.

To determine if fish communities within tributaries have changed over time, historical OMNR mid-1970s sample sites were re-sampled in 2013 by Kawartha Conservation. Unfortunately, for the historical sites it is unknown what type of gear was used to sample the site, as well as how much effort (e.g., how large an area sampled over how much time) was put in to catch fish. It is known, however, at which road/stream intersection the sampling occurred. In 2013, sampling was conducted using two techniques. In "wadeable" flowing stream sections, a single-pass electrofishing method, as outlined in the Ontario Stream Assessment Protocol (Stanfield, 2010), was used to determine fish species composition. In wadeable sluggish stream sections, triple-pass seine netting was employed from the shore to catch fish. ***Table 8.7*** provides a summary of this historical vs. present comparison. There were 10 sites that were sampled in 2013, as well as in 1976-77, on the following tributaries: the Staples River (4 sites), Martin Creek South (3), Pearns Creek (2) and one site in the Balsam Lake subwatershed. All fish species documented at comparison sites are found in ***Appendix 6.***

Table 8.7. Comparison of Fish Species Richness and Similarity Between Same Sites Sampled in 2013 and in 1970s

		Richness (# species)		**Similarity (%)**
Subwatershed	**Site ID**	**2013**	**1976-77**	**2013 vs. 1976/77**
Staples River	SR1976_01	1	2	0
	SR1976_02	6	2	14
	SR1976_03	5	7	20
	SR1976_04	5	3	33
	ALL	**9**	**10**	**36**
Pearns Creek	PC1976_01	4	3	17
	PC1976_02	5	3	60
	ALL	**6**	**7**	**63**
Martin Creek South	MCS1976_01	5	2	0
	MCS1976_02	3	4	40
	MCS1976_03	8	6	67
	ALL	**15**	**7**	**38**
Balsam Lake Subwatershed	BEX1977_01	4	5	13
BCLMP Planning Area		**19**	**14**	**57%**
Unique Species to each sampling period		Rock Bass	Bass Sp.	
		Largemouth Bass	Iowa Darter	
		Yellow Perch	Blacknose Dace	
		Northern Pike	Common Shiner	
		Mottled Sculpin		
		Bluegill		
		Muskellunge		
		Bluntnose Minnow		
		Bullhead Sp.		

When examining all fish species caught from both time periods, two measures were used: species richness (an index of taxa diversity), and % similarity (how many species were common to both sampling events). These measures provide insight into whether any major shifts in community composition have occurred. Since there were relatively few sites in each subwatershed, for comparison purposes results from each site and each subwatershed were pooled together. In terms of species richness, 14 and 19 species were recorded during the 1976-77 and 2013 sampling events respectively. There was 57 % similarly between the species of fishes found between sampling events. This suggests that fish communities, based on our sampled sites, remain relatively dissimilar. The unique species found in 1976-77 surveys include: blacknose dace, common shiner and an undetermined bass species. The unique species found in 2013 include: rock bass, largemouth bass, yellow perch, northern pike, mottled sculpin, bluegill, muskellunge, bluntnose minnow and an undetermined bullhead species. All of the unique fish species in both sampling events are relatively common in Kawartha Lake tributaries and could have been present but were just not captured within the subwatersheds. The notable exceptions are northern pike, bluegill, and rockbass, all of which are new to the lake watershed since the mid-70s.

8.4.3 Benthic Macroinvertebrates

Benthic Macroinvertebrates (benthos) have been widely utilized in biological assessments to characterize water quality and aquatic ecosystem health. Sampling for benthos is advantageous because they are abundant in most streams, serve as primary food source for fish, respond to ecosystem stress and are relatively inexpensive to collect (Barbour et al., 1999).

In spring of 2013, Kawartha Conservation conducted a bioassessment (using benthic Macroinvertebrates) to gain insight into the status of the current condition of the aquatic ecosystem within the subwatersheds of Balsam Lake and Cameron Lake. Well-defined, wadeable steams within subwatersheds that directly drain into Balsam Lake and Cameron Lake were targeted for assessment. Based on previous benthos surveys in neighbouring Sturgeon Lake basin, we know small 1st order streams are typically dry or ill-defined, so they were excluded. The remaining streams (i.e., 2nd to 4th order), which comprise 44% of total stream length, were targeted for sampling. Fifty sites were randomly chosen on the targeted streams using GRTS selection methodology outlined in USEPA (2011). One-third (16 sites) were randomly chosen and actually sampled. Most sites not sampled were due to there being no distinct "wadeable channel". In many cases, it was difficult to connect with landowners to obtain permission. In terms of geographic distribution, at least 1 site is located in each subwatershed, and 75% of samples were located in Staples River and Martin Creek South.

The bioassessment is based on sampling 16 random sites, following the transect kick-and-sweep methodology outlined in the 'Streams' module of the Ontario Benthos Biomonitoring Network (OBBN) protocol (Jones et al., 2005). All benthos collected were preserved in alcohol and identified under a microscope to family-level taxonomic resolution wherever possible. ***Table 8.8*** provides a summary of the major habitat characteristics at all bioassessment sites. All sites were sampled in May with water temperatures ranging from 9 to 19^{o}C. Stream sizes sampled were small-to-large, having wetted widths ranging from 0.5 to 15 m and maximum depths ranging from 100 to 950 mm. The majority of substrates were dominated by fine particles (e.g., silt and sand) which occur far more frequently than coarse substrates (e.g., gravel and cobble). Most watercourses are relatively slow-flowing, having water velocities ranging from 0 to 50 mm hydraulic head.

All raw benthos taxa data are found in ***Appendix 7.*** Approximately 52 unique taxa were found within the planning area. In terms of major OBBN groupings when all sites are combined, midges, stoneflies, mussels, scuds, snails, mayflies and beetles collectively comprise over 85% of all taxa, the remaining being mostly large zooplankton, aquatic earthworms, sow bugs and blackflies ***(Figure 8.11).*** In terms of benthos families, the top five taxa within the planning area are Chironomidae (22%), Perlodidae (16%), Sphaeriidae (12%), Gammaridae (10%) and Siphlonuridae (5%), which collectively comprise approximately 65% of all taxa. In terms of common benthos found at most sites, Chironomidae and Sphaeriidae were found at 100% of sites;, Oligochaetae at 94%; Gammaridae at 81%; Planorbidae at 75%; Perlodidae, Asellidae, Physidae and Dytiscidae at 63%; and, Tabanidae, unknown Ephemeroptera, and Lymnaidae at 50% of sites.

Table 8.8. Site and Habitat Characteristics at Bioassessment Sites

Site ID	Subwatershed	Date	Water Temp (°C)	Substrate (dom+subdom)	Depth (mm)	Hydraulic Head (mm)	Width (m)
BCL234-10	Martin Creek South	May 13, 2013	12	Silt and sand	180-235	0-5	0.7-1.0
BCL234-12	Martin Creek South	May 10, 2013	17	Silt and sand	350-850	0	10-15
BCL234-26	Martin Creek South	May 21, 2013	18	Silt and sand	180-240	0	5.0-8.0
BCL234-28	Martin Creek South	May 10, 2013	17	Sand and silt	720-950	0	10-15
BCL234-29	Martin Creek South	May 21, 2013	17	Sand and gravel	140-270	0-5	1.2-1.6
BCL234-08	Pearns Creek	May 14, 2013	18	Gravel and sand	140-260	0-10	1.2-1.6
BCL234-11	Staples River	May 27, 2013	14	Silt and sand	435-565	0	2.2-2.8
BCL234-16	Staples River	May 23, 2013	18	Sand and gravel	240-260	5	1.1-1.6
BCL234-20	Staples River	May 23, 2013	19	Sand and silt	610-840	5-25	3.0-5.8
BCL234-24	Staples River	May 15, 2013	13	Silt and sand	165-250	0	0.7-1.3
BCL234-32	Staples River	May 14, 2013	9	Silt and sand	100-150	0	0.8-0.9
BCL234-36	Staples River	May 14, 2013	10	Gravel and clay	490-580	5-10	1.6-3.3
BCL234-40	Staples River	May 23, 2013	19	Gravel and cobble	180-270	30-50	1.0-1.5
BCL234-21	Balsam Lake Tribs.	May 10, 2013	11	Sand and gravel	180-435	0	2.5-3.4
BCL234-44	Cameron Lake Tribs.	May 29, 2013	18	Gravel and sand	165-285	5-15	0.9-1.4
BCL234-47	Balsam Lake Tribs.	May 21, 2013	14	Sand and silt	230-370	0-10	0.5-1.0

To characterize aquatic ecosystem health within the subwatersheds, benthos data are summarized for each site using the Hilsenhoff Family Biotic Index (Hilsenhoff, 1988). In this approach, taxa identified down to the family-level are assigned a value between 0 (least tolerant) to 10 (most tolerant) based on their tolerances to nutrient enrichment according to values in Conservation Ontario (2011). An index value is calculated by summarizing the number of benthos in a given taxa, multiplied by their tolerance value, and divided by the number of total organisms in the sample. This approach is similar to the methodology used by conservation authorities for Watershed Reporting (Conservation Ontario, 2011). It should be noted that this biotic index performs most accurate when applied to streams with fast flowing water (i.e., riffles) and coarse substrates (i.e., gravel, cobble). Since many of the sites exhibited slow velocities and fine substrates, biotic index determinations should be interpreted with some caution as these systems may naturally (i.e., under minimal stress) contain tolerant benthos. Currently, no know scientifically-defensible biocriteria standards exist for all types of streams in the Kawartha Lakes.

As shown in ***Table 8.9***, compared to the Hilsenhoff Family Biotic Index, sites were classified as Excellent (19%), Very Good (6%), Good (25%), Fair (6%), Fairly Poor (28%), Poor (6%), and Very Poor (0%). In terms of Watershed Reporting grade-values, sites were classified as grade: A (25%), B (25%), C (6%), D (38%), and F (6%). Just over half the sites (56%) were determined to be in a state that was Fair (C-grade) or better, whereas 44% scored worse than Fair. The sites that rated fair or better had much higher representation of mayflies, stoneflies and caddisflies within the sample. Mayflies, stoneflies, and caddisflies are considered sensitive taxa, and abundances of benthos within these orders are known to decrease in response to increasing perturbation (Barbour et al. 1999). These taxa represent 28% of all taxa counts within the Balsam Lake and Cameron Lake tributaries, and were found at 94% of the sites. Over 70% of these taxa were stoneflies, which are particularly sensitive to impairment. Perlodidae had the widest distribution among stonefly taxa, being found at 63% of all sites.

It has also been documented that impaired streams have a reduced number of taxa in their aquatic ecosystem (reduced biodiversity), while frequently creating an environment that is favorable to only a few taxa that tend to be pollution-tolerant forms. According to 2013 data, there were approximately 52 unique taxa found when pooling all sites, and taxa richness at each site ranged from 6 to 25 (average of 15.9). The Simpson's Diversity Index (Simpson, 1949) considers both taxonomic richness as well as evenness on a scale of 0 (low diversity) to 1 (high diversity). Among the BCLMP sample sites, index values ranged from 0.12 to 0.89 (average of 0.65). From 2013 benthos data, the target streams exhibit a medium-to-high level of diversity.

Table 8.9. Family Biotic Index and Watershed Report Card Results

Family Biotic Index	Watershed Report Card Grade	BCLMP Sites #, %
0.00-3.75 (Excellent)	A	3,19%
3.76-4.25 (Very Good)	A	1, 6%
4.26-5.00 (Good)	B	4, 25%
5.01-5.75 (Fair)	C	1, 6%
5.76-6.50 (Fairly Poor)	D	6, 38%
6.51-7.25 (Poor)	F	1, 6%
7.26-10.00 (Very Poor)	F	0, 0%

When comparing benthos communities found in a similar 2012 bioassessment of tributaries of Sturgeon Lake, the tributaries of Balsam and Cameron lakes appear to be in better aquatic ecological condition ***(Table 8.10).*** Within Sturgeon Lake basin, only 28% of the sites scored fair or better whereas 72% of the sites scored worse than fair. Similarly, the average sensitive benthos communities at each site within Balsam and Cameron tributaries were more than double the average sensitive EPT% taxa at BCLMP sites. [EPT refers to Mayflies (Ephemeroptera), Stoneflies (Plecoptera) and Caddisflies (Trichoptera).] In contrast, taxa richness and Simpsons Diversity Index values were higher in Sturgeon Lake tributaries than in Balsam Lake tributaries. This may be influenced by the fact that a number of taxa that were "unknown" (i.e., unidentifiable) were recorded as a unique taxa. Sturgeon Lake sampling had more "unknown" taxa than Balsam Lake. At this time, it is unclear whether they are in fact unique taxa at the given sample site, or if they are the same taxa as already recorded.

Table 8.10. Comparison of Bioassessment Results Between Tributaries of the Balsam and Cameron Lakes and Sturgeon Lake Watersheds

		Balsam and Cameron Lakes Tributaries (2013)	**Sturgeon Lake Tributaries (2012)**
Number of Random Sites		16	18
Family Biotic Index	*Range:*	2.44-7.03	4.52-6.91
	Average:	5.17 (Fair)	6.06 (Fairly Poor)
Watershed Report Card Grade	*Range:*	A-F	B-F
	Average:	C Grade	D Grade
Taxa Richness (per site)	*Range:*	6-25	10-25
	Average:	16	17
Simpsons Diversity Index	*Range:*	0.12-0.89	0.63-0.87
	Average:	0.65	0.76
Sensitive Taxa - %EPT	*Range:*	0-81%	0-51%
	Average:	28%	11%

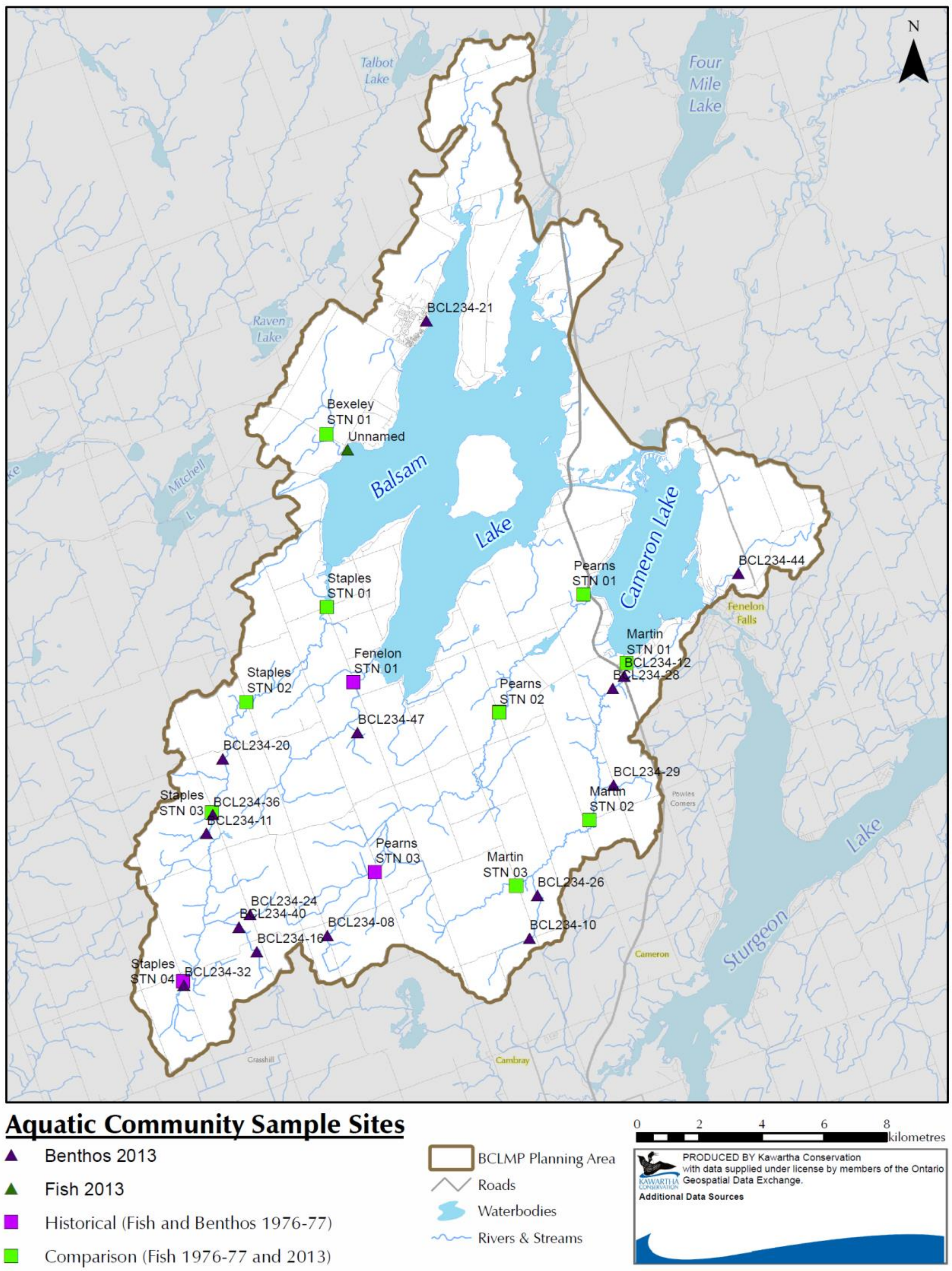

Figure 8.10. Aquatic Community Sample Sites

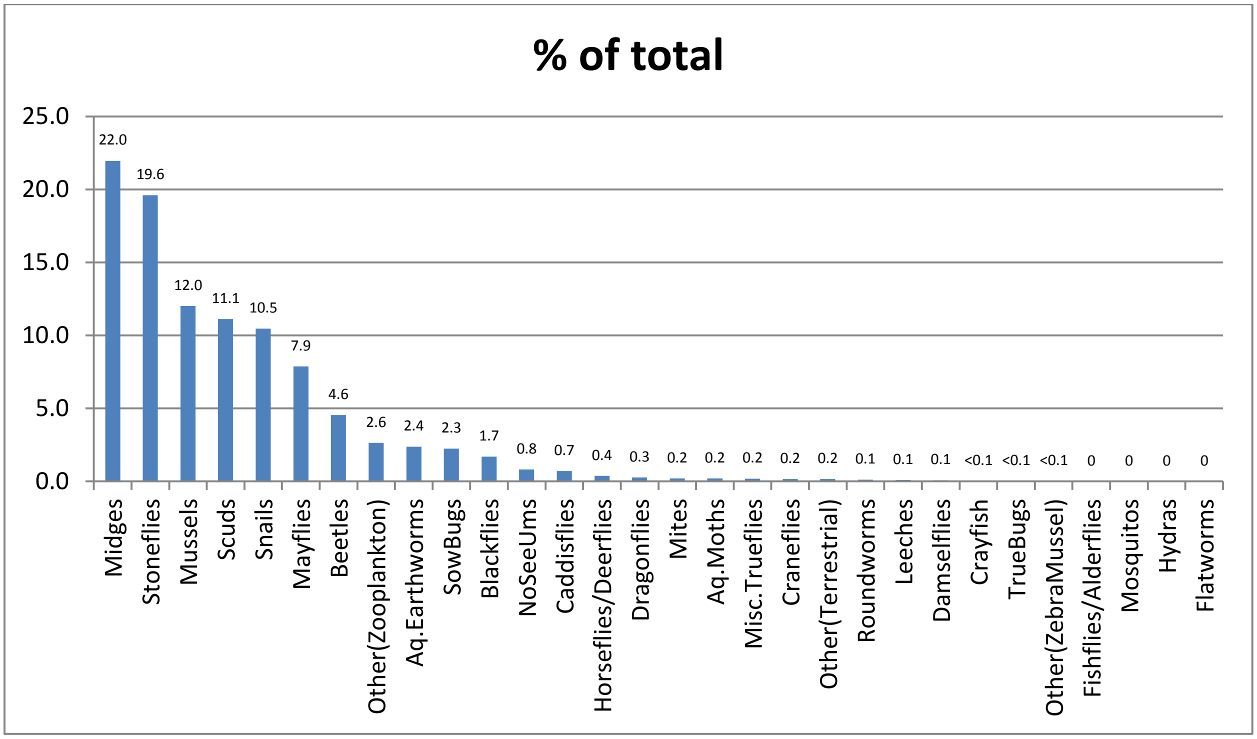

Figure 8.11. Major Benthos Taxa Found in the Tributaries

9.0 Terrestrial Ecology

This section reports on the terrestrial natural heritage system within the Balsam and Cameron lakes watershed through an analysis of existing natural cover, vegetation communities, wildlife habitat, biodiversity, and significant natural heritage features.

9.1 Summary of Observations and Issues

OBSERVATIONS

- Natural Heritage conditions are better in the northern part of the Balsam and Cameron lakes watershed where there is less urban development and less intensive and non-intensive agriculture;
- 5.1% of the Balsam Lake watershed and 14.6% of the Cameron Lake watershed include Areas of Natural and Scientific Interest (ANSI); and
- The Balsam and Cameron lakes watershed has an abundance of wetlands, the majority being swamp-type wetlands.

ISSUES

- A number of natural heritage features exist in the Balsam and Cameron lakes watershed that may be considered locally significant, however, they are not afforded any legislative protection;
- Forest cover is below 30% in the Pearns Creek subwatershed and the Staples River subwatershed, and is at 33% for the entire Cameron Lake watershed and 35% for the entire Balsam Lake watershed;
- Interior forest and deep interior forest are below guidelines for the entire Balsam and Cameron lakes watershed;
- The existing natural heritage features are fragmented and lacking in connections, particularly in the southern more-developed areas in the watershed; and
- With increasing farmland values and cash crop returns, there is a trend to clear more land for agriculture. This often means clearing brush from former agricultural lands of lower land classes that were abandoned, reducing natural buffers alongside watercourses, destruction of linkages between habitats or even converting grown forest areas into agriculture.

9.2 Natural Cover

An area of natural cover refers to land that has not been significantly influenced by anthropogenic activity. Areas of natural cover provide many benefits and perform a variety of functions that are essential to overall watershed health, including:

- filtering nutrients, sediments and pollutants from surface water runoff;
- improving air quality through filtration and oxygen generation;
- improving the natural aesthetic of communities thus contributing to the well-being of local citizens;
- maintaining aquatic and terrestrial wildlife habitat;
- performing flood attenuation;
- providing opportunities for recreation and for people to connect with the natural world through activities such as hiking, nature viewing, biking, fishing and hunting;
- providing wildlife habitat and preserving biodiversity;
- reducing shoreline erosion by slowing and reducing surface water runoff;

- sequestering carbon to reduce atmospheric carbon dioxide levels, thus contributing to the mitigation of the effects of climate change; and,
- moderating summer temperature extremes through transpiration.

Alteration of natural cover within the watershed, particularly within headwaters, wetlands, large forest tracts and riparian buffer areas, may affect any or all of the above functions.

The entire Cameron Lake watershed contains 40 km^2 of natural cover, representing 36% of the total terrestrial area. This includes only areas classified as forest, wetland, and open water. There is a further 7% cover found in meadow and cultural forest. The entire Balsam Lake watershed contains 71 km^2 of natural cover, representing 44% of the total terrestrial area. There is a further 12% cover found in areas of meadow and cultural forest. ***Figures 9.1 and 9.2*** demonstrate the natural cover types existing within the watersheds. Meadows and cultural plantations are separated out from natural cover because they do not represent natural cover areas, but rather areas that are under recent human influence. ***Table 9.1*** illustrates the percentage of each land use type within the watershed.

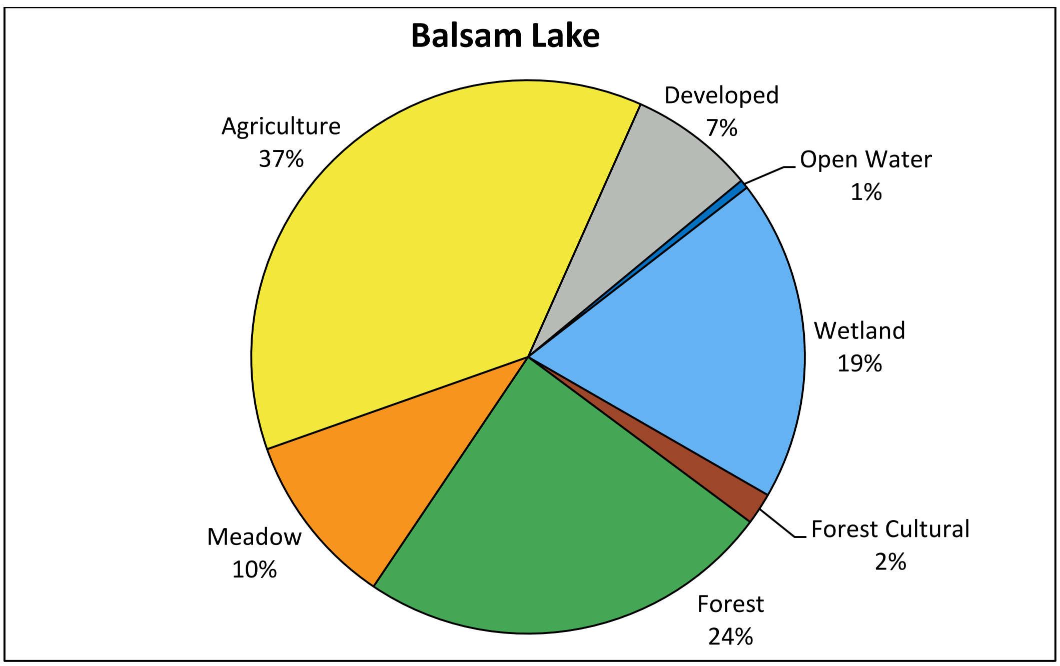

Figure 9.1. Balsam Lake Watershed Land Cover Based on Ecological Land Classification

For management purposes, ecologists have created a hierarchy for the naming of ecosystems to reduce the complexity of managing the ecological resources on our planet. The area that the Balsam and Cameron lakes watershed falls in has been separated into management units known as eco-districts. Eco-districts, 71 of which are found in Ontario, are distinguished by their characteristic pattern of landscape features, with similar climate, soils and elevation. Eco-district 6E-8 represents the southern portion of the Balsam and Cameron lakes watershed, while eco-district 6E-9 makes up the north. Ecodistrict 6E-8 is the drumlinized till plain that extends across the Kawartha Lakes and eastward and consists of deciduous, mixed and coniferous forests, with extensive areas of swamp and to a lesser extent, marsh. Eco-district 6E-9 follows the southern edge of the Canadian Shield and includes the limestone plains of the Carden Alvar. An extensive area of almost 70% natural cover exists in this eco-district, consisting of mostly mixed and deciduous forests, as well as almost 20% wetlands. The

Great Lake Conservation Blueprint would require that 30% of eco-district 6E-8 and 23% of eco-district 6E-9 be set aside in order meet conservation targets.

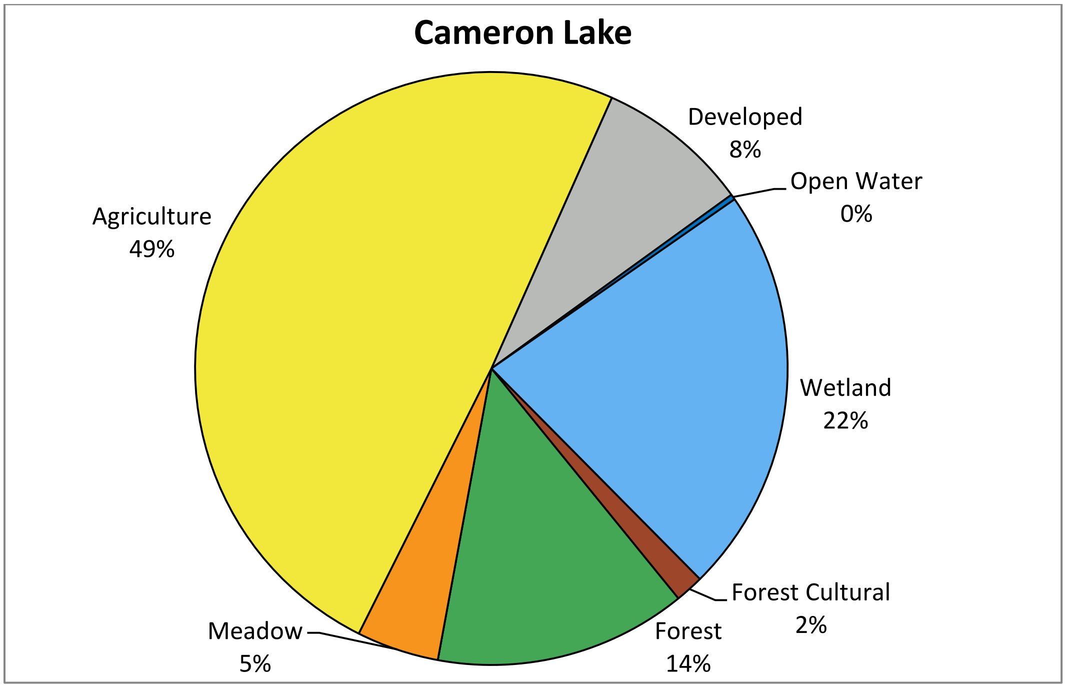

Figure 9.2. Cameron Lake Watershed Land Cover Based on Ecological Land Classification

Table 9.1. Area and Percentage of Cover Types in the Balsam and Cameron Lake Watersheds

Land Use	**Watershed Area (km^2)**		**Watershed Area (%)**	
	Balsam	Cameron	Balsam	Cameron
Watershed (terrestrial portion)	162.76	111.10	100	100
Forest	39.47	15.30	24.25	13.77
Forested Wetland	24.37	19.19	14.97	17.27
Non-Forested Wetland	6.23	5.52	3.83	4.97
Meadow	16.54	4.99	10.16	4.49
Total Cover (including plantations, meadows and thickets)	89.62	46.73	55.07	42.06

Forests

Forests covered more than 90% of Southern Ontario prior to European settlement (Larson et al., 1999) and currently account for 41% of the terrestrial portion of the Balsam Lake watershed [a combination of upland forests (26%) and forested/treed wetlands (15%)]. The Cameron Lake watershed is 32% forested, with 15% upland forest and 17% forested/treed wetlands. When determining the total natural cover for the watershed, forested wetlands cannot be double counted as part of both forests and wetlands, therefore forests, forested wetlands and wetlands are counted separately to determine the total natural cover area. The forests that are found in the Balsam and Cameron lakes watershed are most likely either cleared areas that were abandoned and regenerated over time, or the remnants of forests that were cleared during European settlement. Today most of the forests and woodlands found in this area are relatively young and quite different from older forests that survived the clearing of the landscape and are now quite rare in Ontario. Today's forests are found in areas that are unsuitable for agriculture or development, such as swamps and river valleys that are prone to flooding, and are therefore often quite fragmented. This is reflected in the Cameron Lake watershed by the fact that the dominant natural area type is coniferous swamp and that coniferous, mixed and deciduous swamps account for 17% of the Cameron Lake landscape and over half of the forested areas in the watershed. The Balsam Lake watershed differs in that a greater area has been left untouched by intensive agriculture due to the lack of suitable soil. Therefore the dominant natural area type in the Balsam Lake watershed is upland forest with coniferous, mixed and deciduous forests making up 24% of the watershed area.

Both Balsam Lake (41%) and Cameron Lake (32%) watersheds, are currently above the target of 30% forest cover for Areas of Concern Watersheds within the great lakes basin (Environment Canada, 2004), and only the Cameron Lake watershed is below the Conservation Ontario target (Conservation Ontario, 2011) of 35% forest cover for watersheds in Ontario. There are subwatersheds within each watershed that fall below the targets (***Figure 9.3).***

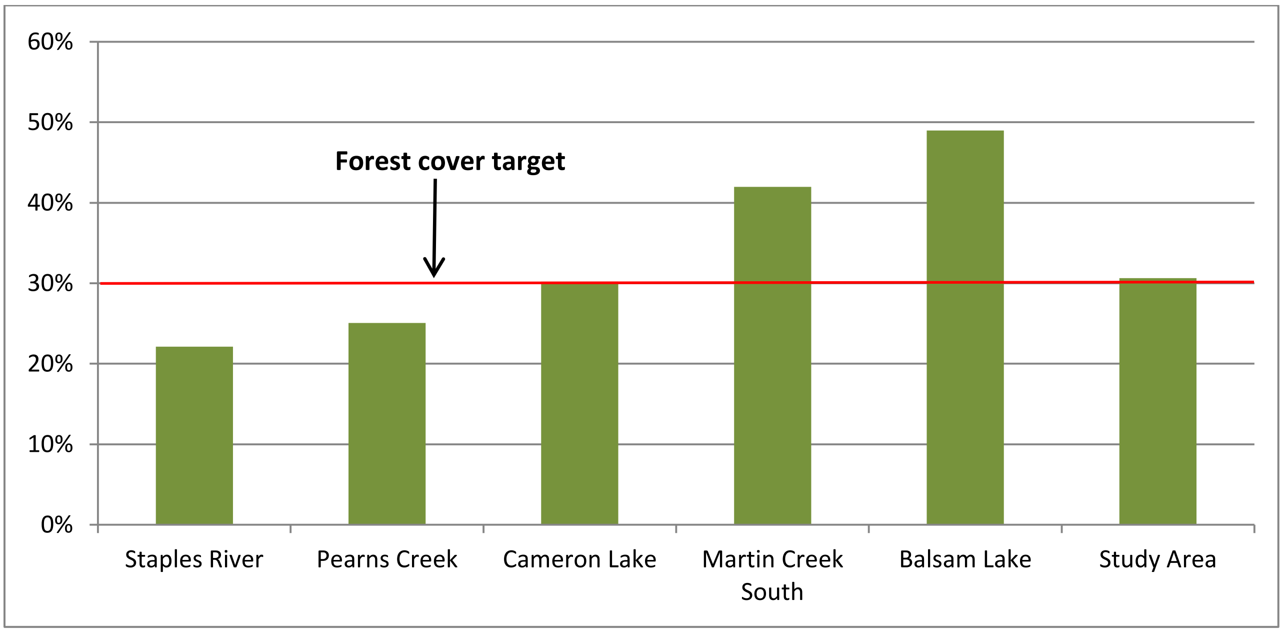

Figure 9.3. Forest Cover in the Balsam and Cameron Lakes Watershed

Comparing the amount of forest cover with target levels suggests that some restoration efforts to increase forest cover would be beneficial for overall watershed health. The areas of the watershed available for forest restoration include all those areas not already under natural cover. This includes lands currently being used for agriculture, inactive landfill, manicured open space, urban areas, aggregate extraction areas and rural development ***(Chapter 3: Land Use)***. This determination was made based on an assessment of the amounts of each vegetation community type and land use type existing in the watershed.

Areas that are inappropriate for forest restoration include roads, active landfill sites and active aggregate extraction areas. If forest restoration was completed in urban areas and rural development areas, it would be possible only in small patches and would not increase the percentage of forest cover enough to meet target levels. Additionally, restoration efforts will have the highest benefit if they are focused on areas where habitat connectivity can be simultaneously improved.

9.3 Ecological Land Classification

Ecological Land Classification (ELC) is a method used to further classify natural cover types into vegetation community types within the Balsam and Cameron lakes watershed. Vegetation communities in the watershed were classified and mapped in 2011-2013 using the ELC System for Southern Ontario (Lee et al., 1998). All areas of the watershed were classified through interpretation of 2008 aerial photography. In the Cameron Lake watershed, 13 unique types of cultural areas, and 13 unique types of natural areas, based on the community series level of detail, were identified. In the Balsam Lake watershed, 14 cultural and 13 natural areas were identified. Cultural areas refer to communities that have resulted from, or are maintained by, human-based influences. Cultural areas are often disturbed. Where plant species are present, many are of non-native origin, and many are invasive. Natural areas refer to natural cover that has not been subject to recent severe human-based disturbance. It therefore offers higher quality habitat and is a valuable watershed resource. Vegetation community types are described in ***Attachment 8***, and mapped in ***Figure 9.4***.

The ELC assessment shows that the Cameron Lake watershed contains 64% cultural community types and 36% natural community types, while Balsam Lake contains 56% cultural communities and 44% natural communities. Coniferous swamps in Cameron Lake watershed at 11%, and coniferous forests in Balsam Lake watershed at 11%, comprise the greatest area of the natural cover community types. Mixed forests and mixed swamps are the next two most-dominant community types. Eight different wetland types have been identified within both the Cameron Lake watershed and the Balsam Lake watershed, and account for 22% in Cameron and 19% in Balsam. The watersheds contain mostly coniferous swamp, mixed swamp and thicket swamp. The rest is made up of equal amounts of deciduous swamp, meadow marsh and shallow marsh, with only minimal areas of aquatic wetland communities within the watershed, and very few bog and fen communities. The areas classified as marsh types do not include the areas in/on Balsam and Cameron lakes, as the ELC classification was only applied to terrestrial communities.

9.4 Terrestrial Biodiversity

The diversity of terrestrial flora and fauna species that are supported by the available habitat within the watershed can provide an insight into the overall ecological health and condition of the watershed. The existence of significant species, such as designated species at risk or species populations known to be in decline, can assist with prioritization of conservation work within the watershed.

The Great Lakes Blueprint for Biodiversity has identified 29 species at risk as conservation targets within ecodistricts 6E-8 and 6E-9 (Henson et al., 2005).

It is important to consider the species identified at an ecodistrict level as well as a watershed level since terrestrial species are not bounded by watersheds, and therefore they may be dependent on specific features found either inside or outside of the Balsam and Cameron lakes watershed. Furthermore, when developing a terrestrial natural heritage system, it makes sense to follow an established blueprint for biodiversity rather than creating one at the Balsam and Cameron lakes watershed-level.

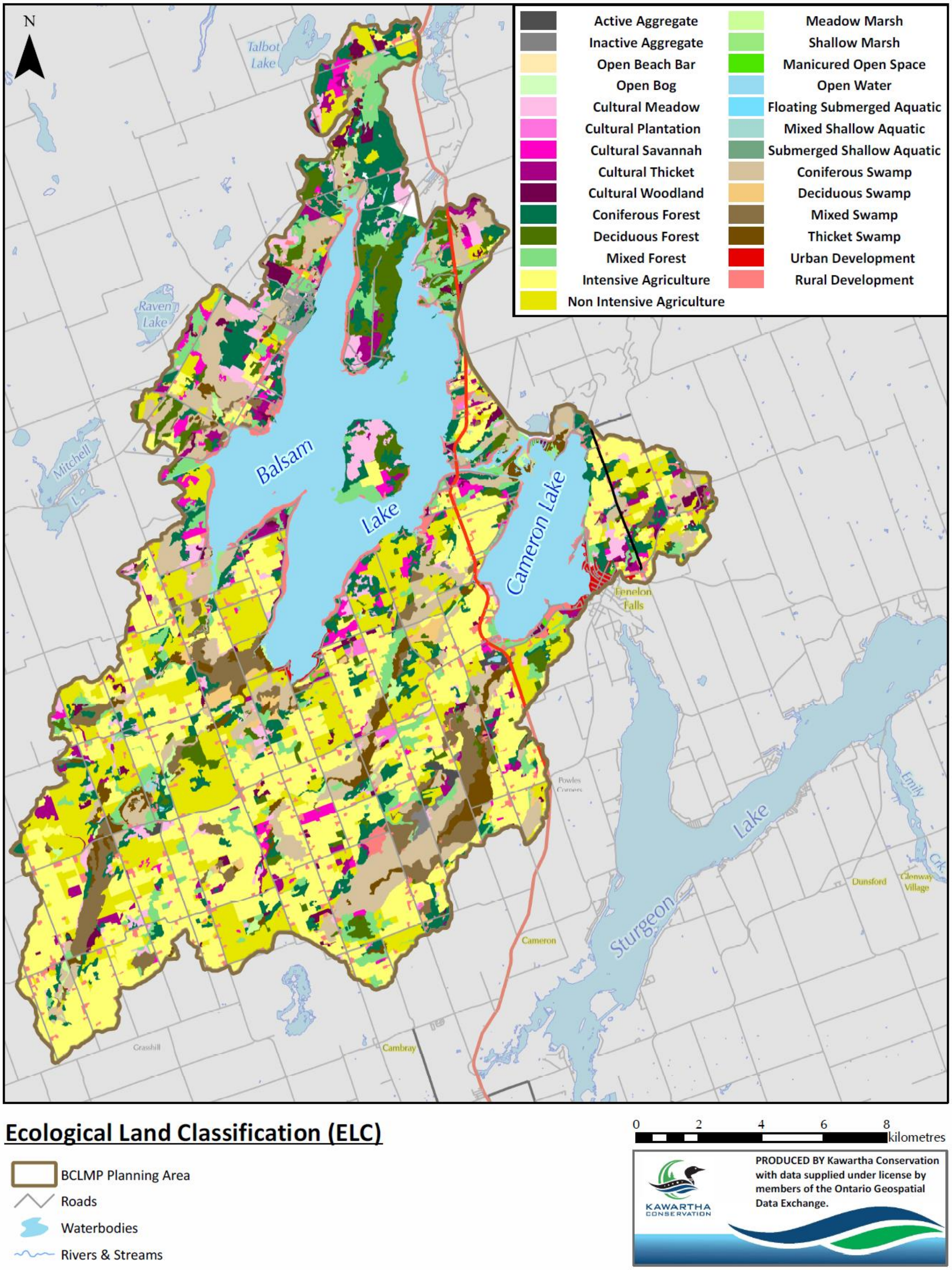

Figure 9.4. Ecological Land Classification of the Balsam and Cameron Lakes Watershed

Woodlands and Bio-Diversity

Forests were the dominant terrestrial vegetation community throughout Ontario prior to European settlement. In today's southern and central Ontario landscape, our remaining forest cover is mostly small, fragmented woodlands separated by agricultural land, urban/residential areas and expansive transportation networks.

These 'island' woodlands provide habitat for species that benefit from both the forest and the adjacent land uses – e.g. deer, wild turkeys, raccoons, squirrels. Larger woodlands, or woodlands connected by corridors of natural vegetation are, however, healthier and provide the varied habitat required by many native woodland species.

Large woodlands contain an increasingly rare, high-quality wildlife habitat referred to as the "forest interior". As a rule, forest interior habitat is that portion of woodlands greater than 100 meters from any edge – a field, road or hydro corridor. To put this into perspective, a square 4 hectare (10 acre) woodlot measures 200 meters by 200 meters and will contain only 1 hectare of forest interior habitat. Some bird species require up to 2 ha of home range, and will not tolerate other nesting pairs of the same species within their range. In fact, some species require an area of interior habitat sufficiently large for social interaction of several nesting pairs. ***Table 9.2*** lists the general response of species to varying sizes of forest patches.

Like many natural heritage features, guidelines for the minimum amount of forest interior have been developed. Environment Canada recommends that the proportion of the watershed that is interior forest cover, 100 meters or further from the forest edge, should be greater than 10%. The proportion of the watershed that is forest cover 200 meters or further from the forest edge should be greater than 5%. The Balsam Lake watershed has 3.3 % interior (>100m) and 0.4 % deep interior (>200m) and the Cameron Lake watershed has 0.5 % interior (>100m) and 0 % deep interior (>200m). The Balsam and Cameron lake watersheds are therefore both below the targets for interior forest cover. ***Figure 9.5*** shows the distribution of interior forest areas within the watershed.

Table 9.2. Anticipated Response by Forest Birds to the Size of the Largest Forest Patch

Size of Largest Forest Patch (hectares)	Response by Forest Associated Birds
200	Will support 80 percent of edge-intolerant species including most area-sensitive species.
100	Will support approximately 60 percent of edge-intolerant species including most area-sensitive species.
50 – 75	Will support some edge-intolerant species, but several will be absent and edge-tolerant species will dominate.
20 – 50	May support a few area-sensitive species but few that are intolerant of edge habitat.
<20	Dominated by edge-tolerant species only.

* Environment Canada (2004)

9.5 Species and Habitats at Risk

Endangered, rare and threatened species and their habitat

Significant numbers of endangered, rare and threatened species, and their habitats, exist within several areas of the watershed. A full list of species and their habitats is available on the MNRF Natural Heritage Information Centre web site.

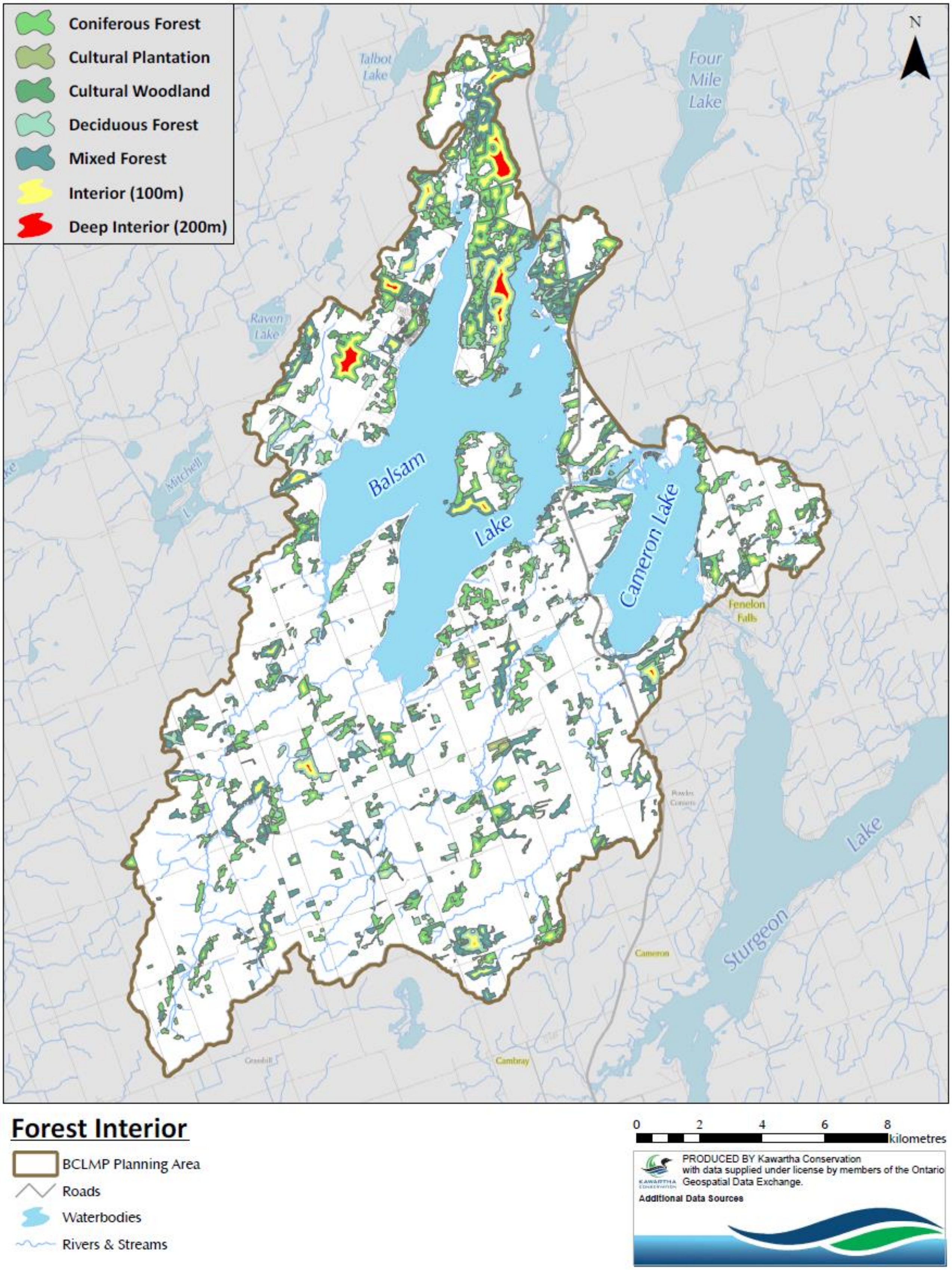

Figure 9.5. Areas of Interior Forest in the Balsam and Cameron Lakes Watershed

9.6 Significant Natural Heritage Features

Identifying significant natural heritage features provides an understanding of the unique conservation values associated with the watershed. This understanding allows natural heritage management efforts within the watershed to be focused on areas where they are most needed and can be most effective. Significant natural heritage features applicable to the terrestrial ecology of the watershed are discussed in the following sections.

Areas of Natural and Scientific Interest

Areas of Natural and Scientific Interest (ANSI) are areas that have been identified by the Ontario Ministry of Natural Resources and Forestry as having provincially or regionally significant representative ecological or geological features. Life Science ANSIs are designated based on ecological significance, and Earth Science ANSIs are designated based on geological significance. There are five ANSI sites within the Balsam Lake watershed and 3 in the Cameron Lake watershed. They encompass 8.37 km^2 or 5.1% of the Balsam Lake watershed terrestrial area, and 16.2 km^2 or 14.6% of the Cameron Lake watershed terrestrial area ***(Figure 9.6). Table 9.3*** describes each candidate ANSI site.

There are a number of locally significant areas of natural and scientific interest located in the Balsam and Cameron lakes watershed that have not been classified or identified by the province or Kawartha Conservation as regionally or provincially significant. These locally significant areas are an opportunity for further study, characterization and, potentially, inclusion into a natural heritage system.

Table 9.3. ANSI Sites in the Balsam and Cameron Lakes Watershed

Site Name	Type	Area (ha)
Cobourg Hill No. 1 Railway Cut	ANSI – Earth Science	0.52
Cobourg Hill No. 1 Middle Road Cut	ANSI – Earth Science	0.76
Indian Point	ANSI- Life Science	805
Burnt River Mouth Wetlands	ANSI- Life Science	167
Goose Lake Esker/Kame Complex	ANSI- Earth Science	0.022
Zion Road Cut	ANSI – Earth Science	0.026
Cameron Rock Drumlin	ANSI, Earth Science	0.31

Significant Wildlife Habitat

The identification of significant wildlife habitat (SWH) areas for the watershed was guided by the Significant Wildlife Habitat Technical Guide (OMNR, 2000) and mapping provided by the MNR.

SWH is defined as: an area where plants, animals and other organisms live or have the potential to live and find adequate amounts of food, water, shelter and space to sustain their population, including an area where a species concentrates at a vulnerable point in its annual or life cycle and an area that is important to a migratory or non-migratory species (OMNR, 2000).

This discussion of SWH excludes types of habitat addressed in other sections of this report. SWH described in this section includes seasonal concentration areas, rare vegetation communities and animal movement corridors.

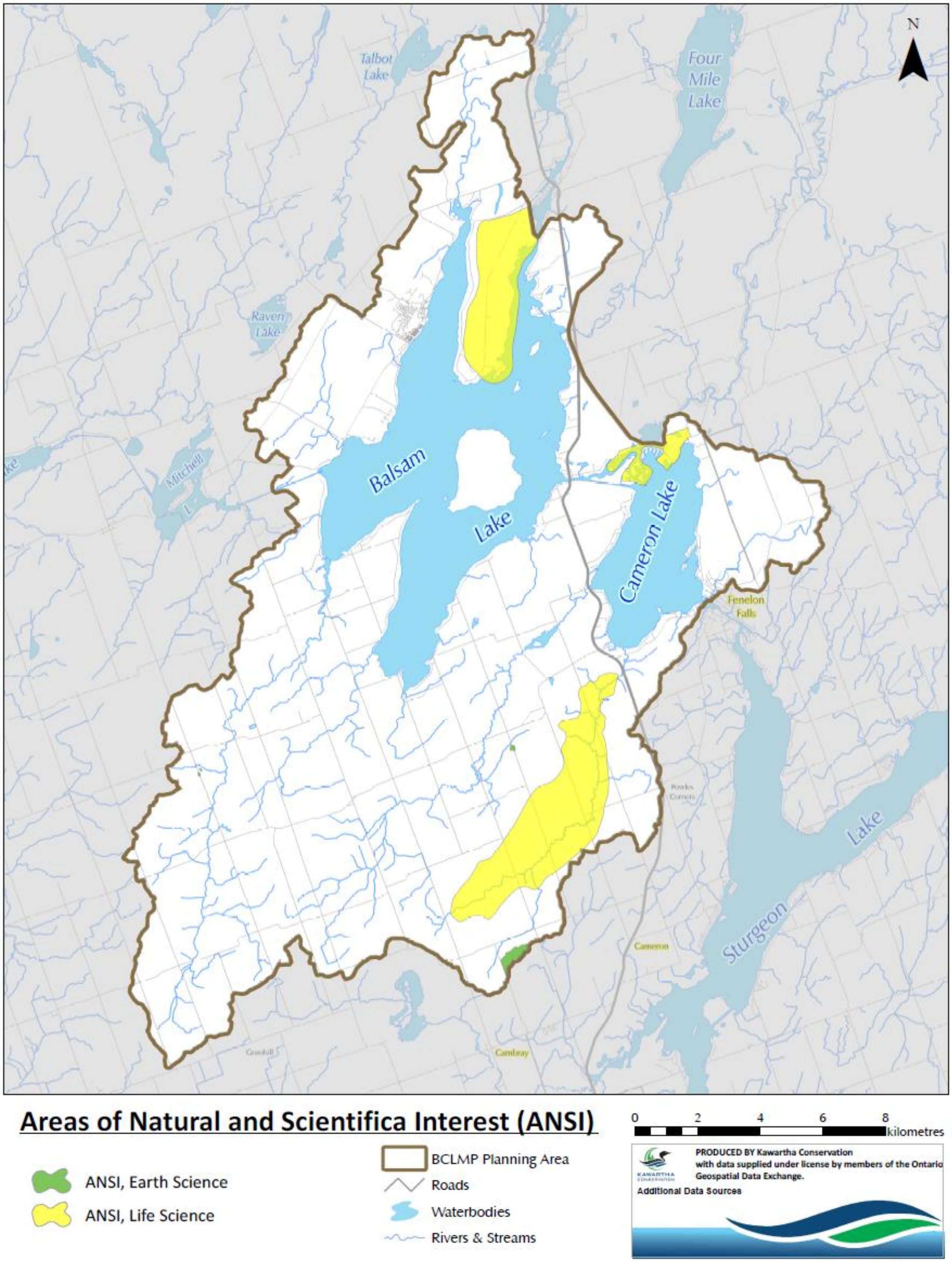

Figure 9.6. Areas of Natural Scientific Interest in the Balsam and Cameron Lakes Watershed

Seasonal Concentration Areas

Seasonal concentration areas are areas where a particular wildlife species congregate or that a species relies on during a certain time of year (such as deer wintering yards, migratory bird stop-overs or reptile hibernation areas). Known seasonal concentration areas for wildlife within this watershed include deer wintering yards.

Animal Movement Corridors

Animal Movement Corridors are typically long, narrow areas used by wildlife to move from one habitat to another. Such corridors facilitate seasonal migration, allow animals to move throughout a larger home range, and improve genetic diversity in species populations. To effectively serve their purpose, animal movement corridors must meet the needs of the species using the corridor. This includes consideration of corridor width, length, percent natural vegetation cover and species composition.

The areas of the Balsam and Cameron lakes watershed that are natural heritage features, such as wetlands and forests, are composed of both **Core** (large, unbroken areas that support a greater number of species and diversity) and **Linkages** in the form of corridors. These areas of natural cover are clustered primarily along the shoreline of Balsam and Cameron lakes and within the natural areas along the surrounding tributaries. As the natural areas within the Balsam and Cameron lakes watershed tend to be quite fragmented, improving corridors and linkages should be a planning priority.

Significant Woodlands

Woodlands are considered significant because of the features and functions that they provide. Significant woodlands may include areas that have supported a treed community for more than 100 years, contain significant species, contain or support other significant natural heritage features (such as significant wildlife habitat), provide supporting habitat for another Key Natural Heritage Feature (KNHF), or act as an ecological linkage between KNHFs. Significant woodlands within the watershed are illustrated in ***Figure 9.7.***

Wetlands

Wetlands are key natural heritage and hydrologically sensitive features that occur on the landscape as single contiguous entities, or as complexes made up of a grouping of several small wetlands. All wetlands have high ecological value and are significant to the management of the watershed. The classification of provincially significant wetlands assists with prioritizing wetlands for conservation and protection under the Ontario Provincial Policy Statement. ***Figure 9.8*** illustrates the location of wetlands within the watershed. ***Figure 9.4*** also illustrates wetland classification by indicating the vegetation community series.

Environment Canada guideline on wildlife habitat recommends that approximately 10% of each watershed and 6% of each subwatershed in the Great Lakes basin should be wetland (Environment Canada, 2004). This guideline is based on evidence that occurrences of high flows and floods decrease significantly as the amount of wetland in a watershed increases. This inversely proportional relationship holds true until the amount of wetland reaches 10% of the watershed, at which point the decrease in flood occurrences begin to level off.

The Balsam Lake watershed contains approximately 31 km^2 of wetland representing 19% of the terrestrial area, and the Cameron Lake watershed contains 25 km^2 of wetland representing 22% of the terrestrial area. Both exceed the 10% minimum recommended percentage of wetland cover. Of those wetlands, approximately 47 km^2 (84%) have been designated as provincially significant. All evaluated wetlands, including provincially significant wetlands (PSWs), are illustrated in ***Figure 9.8.***

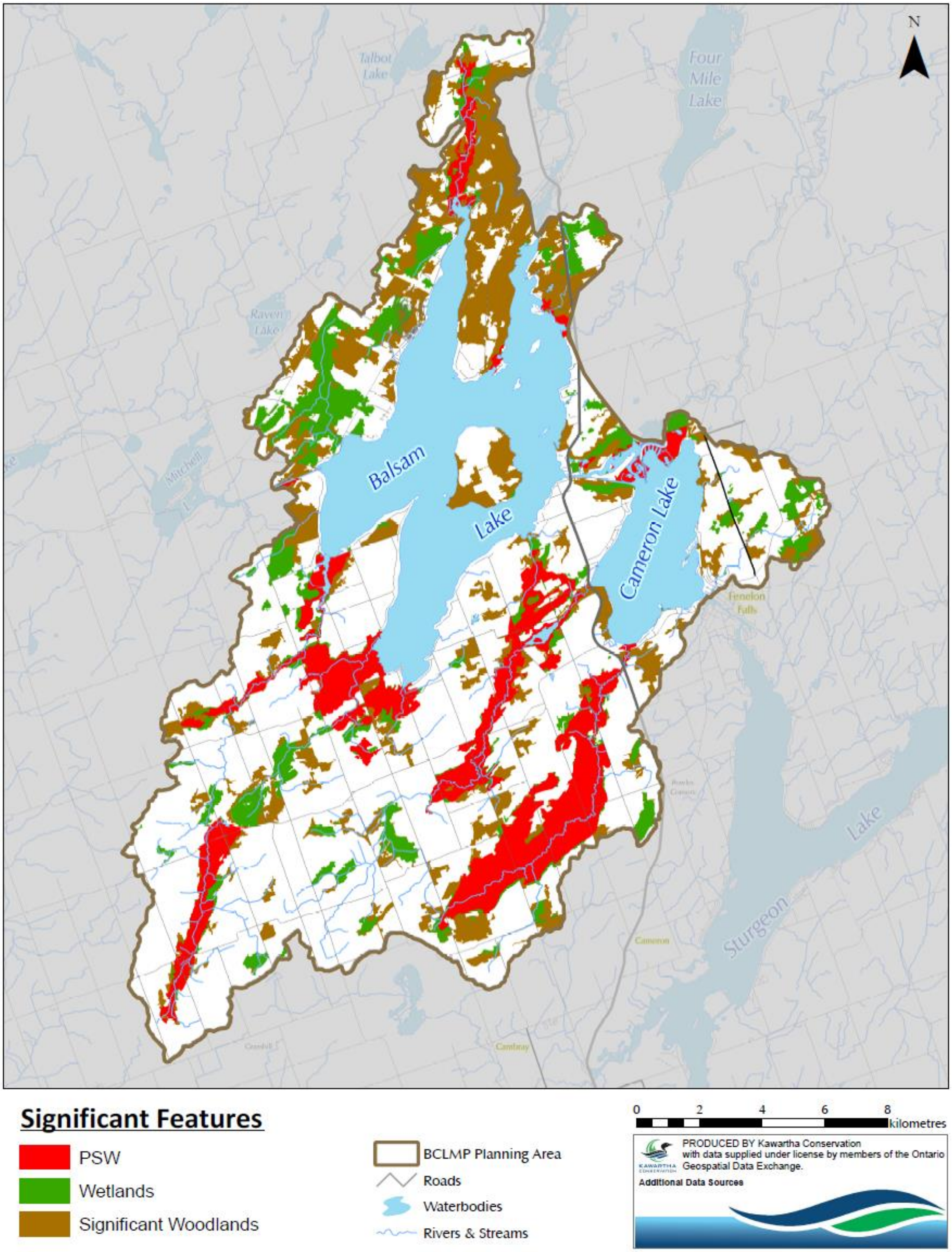

Figure 9.7. Significant Natural Features in the Balsam and Cameron Lakes Watershed

Wetlands have also been classified through air photo interpretation to a community series level using the ELC System for southern Ontario, first approximation (Lee et al, 1998). The wetland types identified are further described in ***Appendix 8.***

Forested wetlands, including headwater wetlands, are full of life and home to a complex food web that includes various microbes, bacteria, invertebrates and larger life forms. These include mammals, birds, reptiles, amphibians, fish, insects and other invertebrates that use wetlands as habitat for all or part of their life cycles, (including breeding and nesting , migratory stopovers, resting and shelter, and food). In addition, wetlands perform these valuable functions within a watershed:

- Wetlands play a significant role as water filters, having the capacity to remove harmful impurities, bacteria and excess nutrients. In fact, wetlands are such effective filters that constructed wetlands have been used for decades to treat urban stormwater runoff in Europe (We're now seeing this in Ontario). A study conducted on 57 wetlands from around the world concluded that 80% of wetlands studied reduced nitrogen loadings, and 84% of wetlands studied reduced phosphorus loadings with water flowing through them (Fisher and Acreman, 2004).
- Wetland plants are effective for stabilizing shoreline areas, trapping sediments and lessening the effects of erosion.
- Wetlands store water, reduce flood events and help replenish groundwater. After storms or spring snow melt, water is gradually released into streams and rivers - a critical function that helps maintain stream flow during periods of drought.

Ecological Goods and Services

Natural areas such as wetlands and forests are a critical part of any terrestrial ecosystem. However, the value of natural areas goes far beyond the role they play in local ecosystems. Recently, it has become more common to identify the benefits that are produced by ecological functions, and to translate those benefits into the monetary value of the ecological goods and services that they produce. Examples of ecological goods and services are: clean air, fresh water, maintaining biodiversity, renewal of soil and vegetation, carbon storage, pollination and natural biological controls.

The type of natural area may influence its ecological goods and services value, but its location on the landscape is also a major factor. For example, wetlands found in non-urban, non-coastal areas are valued at $15,170/ha, however, an urban wetland is valued at $161,420/ha (Troy & Bagstad, 2009).The values placed on various land cover types were estimated by looking at the benefits that people obtain directly or indirectly from ecological systems. Some examples are food production, climate stabilization and flood control, aesthetic views and recreational opportunities, to name a few. A joint study by Ducks Unlimited and the University of Guelph determined that the riparian wetlands in the Black River subwatershed (Lake Simcoe CA) provide phosphorous removal that equates to $292,661 in water treatment services (Pattison et al., 2011).

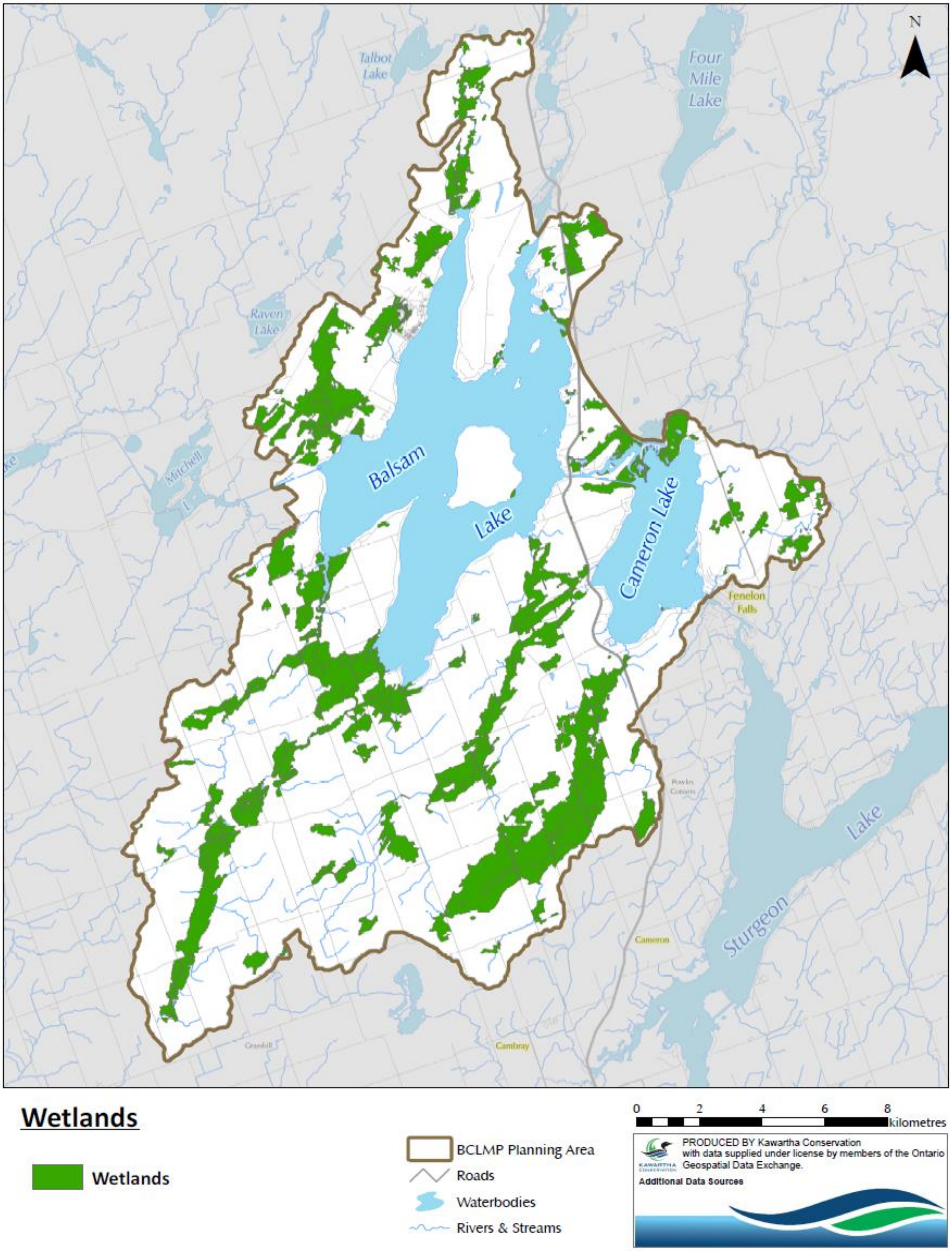

Figure 9.8. Evaluated Wetlands in the Balsam and Cameron Lakes Watershed

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Glossary

Agricultural Area:	A portion of the watershed where the predominant land use is agriculture or agriculture-related
Agricultural activities:	Refers to any actions related to farm operations. This includes(but is not limited to): growing crops, raising livestock, spreading manure, irrigation and clearing fields
Anthropogenic:	Effects, processes or materials that are derived from, or as a result of, human activities
Aquatic system:	An ecosystem located within a water body (Also see: Ecosystem)
Aquatic vegetation:	Refers to plants and algae that grow within an aquatic environment
Aquifer:	Layer of permeable rocks or loose materials (gravel, sand) that is saturated with water and through which groundwater moves and can be extracted using water well
Baseflow:	The portion of stream flow that is entirely attributed to groundwater inputs
Benthics:	Organisms that live in the benthic zone at the bottom of a water body
Best management practice (BMP):	A term used to describe the preferred method of management that has proven to reliably lead to a desired result. Usually associated with stormwater management or agricultural practices
Bioaccumulation:	The build-up of substances such as pesticides or heavy metals within an organism. This occurs when the organism obtains a substance at a greater rate than it can dissipate it.
Biodiversity:	The variability among living organisms and the ecological complexes of which they are part. A healthy ecosystem is traditionally one with a high level of biodiversity.
Biosolids:	A term used in wastewater management referring to treated sludge from commercial and domestic sewage and wastewater treatment.
Biota:	The total collection of organisms of a geographic region.
Coldwater fish:	Fish species such as brook trout that prefer colder water temperatures (usually below 15˚C).
Conductivity:	In regards to water, conductivity measures the ability of a water sample to conduct electricity. This is dependent on the concentration of dissolved salts and other ionizing chemicals.
Dissolved oxygen (DO):	An amount of oxygen that is being dissolved in the water column.
Drumlin:	A geographic feature created through glaciation in the form of a “tear drop” shaped hill. Usually occurs in clusters or “fields”.
Dry deposition:	Materials such as dust that fall out of the atmosphere onto the earth’s surface.
Ecological functions:	The natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes.
Ecosystem:	A recognizable ecological unit such as a group of plant and animal species living together in a particular area.

End-of-pipe practices:	Stormwater management controls or facilities located at a storm sewer outlet. (Also see: stormwater management controls, stormwater management facilities)
Erosion:	The removal of soil sediment and rock in the natural environment. This may be as a result of natural processes such as weathering or through anthropogenic processes such as deforestation and poor farm management practices.
Eutrophication:	A natural or human-caused process whereby water bodies receive excess nutrients (phosphorus and nitrogen specifically) that stimulate excessive aquatic plant and/or algae growth. Nutrients can come from natural sources such as erosion of soils or stream banks, or human sources (fertilizers, urban runoff, sewage treatment plant discharges, etc.).
Eutrophic water body:	A lake, stream or any other natural or man-made water body that has high levels of nutrients in its water, is highly productive and supports high growth rates of aquatic vegetation and/or algae.
Evaporation:	The transfer of water from the earth's surface into the atmosphere under influence of solar radiation and heat, and wind.
Evapotranspiration:	The transfer of water from vegetation into the atmosphere.
Farming activities:	(See agricultural activities)
Freshet:	High water levels resulting from heavy rains or snowmelt. Usually associated with a spring thaw event.
Groundwater:	Water located beneath the surface, usually in aquifers or other porous spaces.
Groundwater discharge:	The flow rate of groundwater through an aquifer usually expressed in cubic meters per second.
Habitat:	An ecological or environmental area that is inhabited by a particular organism and that influences or is utilized by that organism.
Hardness:	In regards to water, hardness measures the concentration of dissolved minerals such as calcium and magnesium. Hard water has a high mineral concentration.
Infiltration:	Water entering the ground via pores in the earth's surface.
Invasive species:	A non-indigenous plant or animal, e.g., Eurasian milfoil (Also see: native species)
Lot- level practices:	In regards to stormwater, these are changes that can be made on a lot or property to reduce the quantity or improve the quality of stormwater runoff, e.g., installation of rain barrels.
Macrophytes:	Aquatic plants that grow in or near the water.
Marsh	A marsh is an area with <2m of water over substrates. Often with standing or flowing water for much or all of the growing season. Tree and shrub cover is ≤ 25% and cover of emergent hydrophytic macrophytes is greater than or equal to 25%.
Meadow Marsh	Areas with <2m of water over substrates. Often seasonally flooded with soils drying out by mid-summer. Tree and shrub cover is ≤ 25% and area is dominated by emergent hydrophytic macrophytes. Represents the wetland-terrestrial interface.

Mesotrophic water body:	A lake, stream or any other natural or man-made water body that has moderate levels of nutrients in its water and consequently moderate plant growth.
Heavy metals:	In regards to water quality, this refers to metals located within the water column as a result of natural or anthropogenic processes. Heavy metals are usually toxic for aquatic organisms and humans, e.g., lead, cadmium, thallium and mercury.
Moraine:	A geographic feature consisting of a mound of earth and rock pushed up in front of an advancing glacier.
Naturalization:	(See restoration)
Native species:	A species that is indigenous to an ecosystem in that it occurs there naturally without any human intervention.
Nutrients:	In terms of water quality, this refers to the chemicals that aquatic vegetation requires for vital functions. Nutrients include phosphorus, nitrogen, potassium and some other chemical elements.
Oligotrophic water body:	A lake, stream or any other natural or man-made water body that has very low levels of nutrients, such as phosphorus and nitrogen, in its water and, as a result, low productivity with few aquatic plants.
Petroleum hydrocarbons (PHCs):	A group of several hundred chemicals that originally come from crude oil. These chemicals are present in many petroleum products made from crude oil. PHCs are a mixture of chemicals, but all of them are made mainly from hydrogen and carbon and therefore called hydrocarbons.
Polycyclic aromatic hydrocarbons (PAHs):	A group of over one hundred different chemicals made up of only hydrogen and carbon. They are the standard product of the incomplete burning of carbon-containing materials like oil, wood, garbage or coal. Automobile exhaust, industrial emissions and smoke from burning wood, charcoal and tobacco contain high levels of PAHs. Several PAHs, such as anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene and some others are carcinogenic.
Precipitation:	The transfer of water from the atmosphere to the earth's surface in the form of rain, snow, hail, dew, etc.
Provincially significant wetland (PSW):	Based on the guidelines for wetland management (MNR, 1984), these are wetlands classed as 1 through 3 in the wetlands policy (Section 3 of the Planning Act).
Recharge:	In regards to groundwater, recharge refers to water being added to a groundwater system such as an aquifer.
Restoration:	Returning an altered landscape back to its original form through physical restructuring and the reintroduction of native species. For example, shoreline restoration or naturalization refers to the removal of non-natural features such as lawns and break walls and the addition of native plant species.
Riparian zone/area:	The interface between land and a stream or lake.
Secchi disk:	White and black disk 20 centimeters in diameter used to measure water transparency in lakes. The disc is lowered into the water on the line. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the Secchi depth and is related to water turbidity in the lake.

Sediments:	Any particulate matter that can be transported by flowing water, and eventually deposited on the bottom of a water body.
Sewershed:	The total area of land that drains to a sewer system.
Stormwater:	A term used to describe water that originates during a precipitation event. Usually used to define water that flows through storm sewer systems in urban areas.
Stormwater management control:	A device or system used to treat stormwater quality or quantity. Examples are oil grit separators, infiltration trenches, etc.
Stormwater management facility:	A constructed wet pond, dry pond or wetland used to detain stormwater in order to treat for quality or quantity. Water quality treatments primarily rely on the settling of sediments.
Subwatershed:	A subsection of a watershed. (Also see: watershed)
Surface water:	Precipitation that does not soak into the ground or return to the atmosphere but instead flows through streams, rivers, lakes and wetlands.
Suspended sediments:	Sediments that are still situated within a water column. (Also see: Sediments)
Sustainable development:	A pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations.5
Swamp	A treed wetland consisting of greater than 25% living tree cover or 70% dead tree cover
Swamp Coniferous	A swamp where the tree cover is made up of > 75coniferous trees
Swamp Deciduous	A swamp where the tree cover is made up of > 75% deciduous trees
Swamp Mixed	A swamp where the tree cover is >25% coniferous trees and >25% deciduous trees
Swamp Thicket	A swamp where tree cover is ≤ 25% and hydrophytic shrub cover is >25%.
Total phosphorus (TP):	A measure of both soluble and insoluble phosphorus forms within a water column. The insoluble component is primarily decaying plant and animal matter or soil particles. Soluble phosphorus (e.g., orthophosphates) is dissolved in water column in molecular form. It is readily available to aquatic plants and algae.
Transpiration:	Evaporation from aerial parts of a plant such as the leaves. (Also see: Evaporation, Evapotranspiration)
Urban area:	An area with an increased density of human-created structures and population when compared to surrounding areas. In Canada, an urban area is defined as having more than 400 people per square kilometer and has more than 1,000 people in total.
Warm water fish:	Fish species that prefer warmer water temperatures such as muskellunge and smallmouth bass.
Water budget:	A summary of the quantity of water in the atmosphere, ground and surface water systems within a watershed.
Water quality:	An integrated index of chemical, physical and microbiological

characteristics of natural water that determines suitability of water for the aquatic life and various human uses.

Watershed: The total area of land that drains to a river or other large body of water.

Wet deposition: Materials deposited on the surface by precipitation.

Wetland: 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. The four major types of wetlands are swamps, marshes, bogs and fens.

Woodland: Treed areas that provide environmental and economic benefits such as erosion prevention, water retention, provision of habitat, recreation and the sustainable harvest of woodland products.

Appendix 1

2004 Visitor Statistics for CKL

Tourism Parameter	Percentage
Same day vs. Overnight Visitors	
Same day Visitors	44%
Overnight Visitors	56%
Origin of Visitors	
Ontario	93%
Other Province	4.3%
United States	2%
Other	1%
Visiting Purpose	
Pleasure	69%
Visiting Friends and Relatives	27%
Business	<0.1%
Visiting Season	
January to March	29%
April to June	23%
July to September	27%
October to December	25%
Overnight Visitor Accommodations	
Roofed Commercial Buildings	14%
Campgrounds/Trailer Parks	28%
Private Homes/Cottages	55%

Source: (The Tourism Company and CKL, 2008)

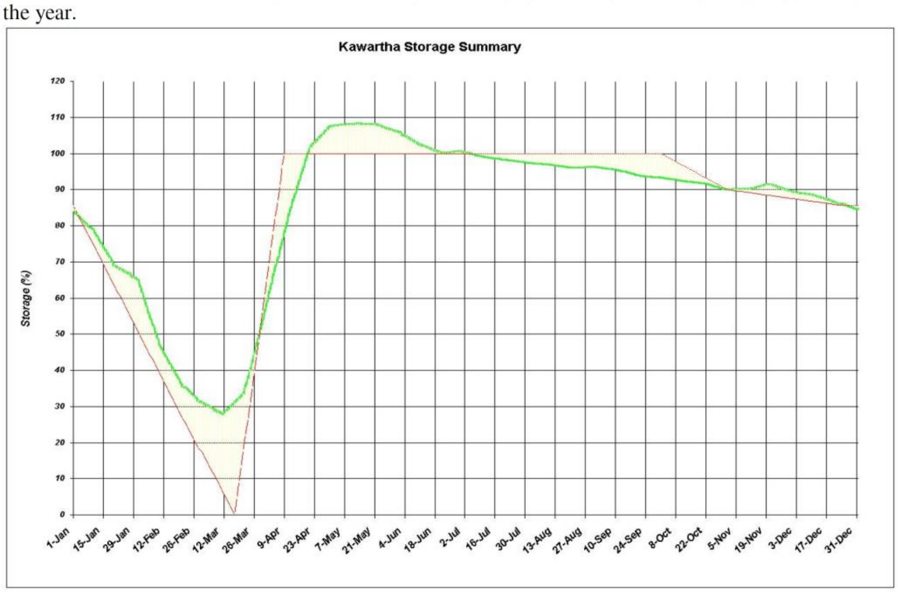
Appendix 2

Recreation-Based Industries Serving Balsam and Cameron Lakes

Industry	Businesses
Resorts & Campgrounds	• Arkadia Trailer Park and Cottages • Balsam Resort • Royal Resort • Woodland Cottages • Sandy Beach Resort and Trailer Court • Sunny Acres Resort • Fenelon Falls Trailer Park
Fishing Charters & Guiding Service	• A Reelpro Guide Service • Bass Class Professional Fishing School • Blitzcreek Pro Fishing Charters • Crooked Lake Wilderness Lodge • Living the Dream Musky Charters • Kawartha Lakes Fishing Charters • Kawartha Lakes Outdoors • Kawartha Lakes Guiding Service
Boat and Water Sports Rentals	• Buckeye Marine • Buckeye Surf & Snow • Fenelon Falls Marina • Fees Landing Marina • Castle Building Centre • Kawartha Outfitters • Kawartha Lakes Marina • Norland Marine • Rosedale Marina • Sturgeon Lake Marina • Thompson's Marina
Marinas	• Pride of Balsam Lake Marina • Rosedale Marina • Thompson's Marina • Fenelon Falls Marina
Bait & Tackle	• Kawartha Lakes Outdoors • Kawartha Lakes Bait and Tackle • Marks Worm Warehouse • Canadian Tire - Fenelon Falls • Long Beach Live Bait & Tackle • Canadian Tire – Lindsay • Emm's Sports Outdoors • Kawartha Lakes Trading Post • Norland Convenience Bait & Tackle
Outdoor Outfitters	• Emm's Sports & Outdoor Adventures • Down to Earth Adventure Outfitters • Buckeye Surf & Snow • Kawartha Lakes Sports • Kawartha Outfitters • Lindsay Sportsline • Dalrymple Dock & Leisure • Canadian Tire - Lindsay • Canadian Tire - Fenelon Falls

Appendix 3

Water Level Management of the Kawartha Sector of the Trent River Watershed

Trent River Watershed - Kawarthas		
COMPONENTS		• Include Katchewanooka, Clear, Stony, Lovesick, Deer Bay, Chemong, Buckhorn, Pigeon, Sturgeon, Scugog, Cameron and Balsam Lakes.
WATERSHED CHARACTERISTICS	**Size**	• The easterly watershed of the Trent-Severn Waterway • 12,200 square kilometres.
	Physiography	• Lies off the southern limit of the Canadian Shield in rolling countryside. • One third of the basin lies in the Canadian Shield. • Two thirds lie in the rolling farmlands of southern Ontario.
	Water Sources	• Rain, snow and ground water. • The reservoir lakes in the Haliburton Highlands.
	Runoff /Evaporation	• Rainfall run-off is slow. • Evaporation losses in the summer are high due to the shallowness of the lakes.
	Dams	• Because of the greater size of the Kawartha Lakes, and the greater volumes of water feeding into these lakes, the Kawartha Lake dams are larger. The dam at Buckhorn, for example, has four 15 metre radial sluice gates, while the Young's Point dam has six vertical gates.
BASIS OF WATER MANAGEMENT		Water levels decline over the winter to accommodate spring runoff. Levels are maintained at navigation levels during the summer and fall by supplementing local water supply with water from the Reservoir Lakes. The following shows the 30 year average percentage of storage capacity throughout the year. 
WATER MANAGEMENT APPROACH	**Winter**	• The larger Kawartha Lakes are drawn down from January 1 to March 15. • Normally, this ensures that all the lakes are at their natural low levels prior to the spring freshet. • Some dams have all their logs out, and the final level attained varies with the natural inflow during the winter. • Winters with high inflows mean that some lakes would not drop as far as we would like, thus reducing flood storage. • Dry cold winters with low inflow can cause some lakes to drop lower than normal. This causes problems on the dams because there is not enough water to run over the spillways to keep stoplogs from freezing in.
	Spring	• During spring, flows are managed to mitigate flooding and to bring the lakes to navigation levels. In some locations, flows are also managed to accommodate spring spawning fish.
	Summer	• Summer flows on the Kawartha Lakes are generally the result of reservoir storage. • Since evaporation takes more from the Kawarthas than can be replenished by natural precipitation and ground water inflows, additional water must be supplied to these lakes from the reservoir lakes.

Trent River Watershed - Kawarthas		
	Fall	• In the Kawarthas, the smaller navigation route lakes, (Canal, Mitchell, Cameron, Lower Buckhorn and Lovesick) are lowered to winter levels between October 15 and December 1, to avoid problems of access and to reduce water control costs. • The larger Kawartha Lakes are allowed to drop to the middle or bottom of their navigation range.
SPECIAL CONSIDERATIONS		• The flows from the Crowe Watershed are managed by the Crowe Valley Conservation Authority (CVCA). Although there are good communications with the CVCA, the CVCA manages flows and water levels to meet its objectives. Therefore there can be a significant uncontrolled contribution of water from the Crowe Watershed into the TSW. Water from the Kawarthas needs to be controlled in relation to the Crowe flows to prevent downstream flooding.
ISSUES	**Navigation**	• Water levels are maintained at levels that provide sufficient depth for safe boat navigation. • Water is required for lock operations.
	Flooding	• During extreme flood conditions (400-450 m3/s at Peterborough), a decision may be made to flood the Kawartha Lakes above normal in order to prevent much more serious flooding downstream of Peterborough. • After the flow peak has passed, logs are placed back in the Kawartha dams as the lakes decline, until they are slightly under filled. • Then, when flows start to drop off, care is taken to catch enough water to top up the lakes.
	Water Quality	• Flows are required to dilute and flush pollutants through the system thereby maintaining water quality and reducing undesirable weed and algae growth. • Water levels need to be maintained at sufficient levels over municipal water intakes.
	Fish & Wildlife	• Spring flooding can adversely affect nesting loons. • Post freshet spring flows need to be sufficient to protect spring spawning fish (e.g. walleye). • Slow fall drawdown of Mitchell Lake is needed to avoid stranding fish.

Source: (Ecoplans Limited, 2007)

Appendix 4

Surface Water Quality Standards and Guidelines

Parameter	Objective/Guideline	Authority
Chlorides	128.0 mg/L	Canadian Water Quality Guidelines for the Protection of Aquatic Life
E.coli	100 cfu/100 mL	Provincial Water Quality Objectives
Nitrate	2.93 mg/L	Canadian Water Quality Guidelines for the Protection of Aquatic Life
Total Nitrogen	1.0 mg/L	Alberta Surface Water Quality Guidelines
Total Phosphorus	0.030 mg/L	Provincial Water Quality Objectives (Streams)
Total Phosphorus	0.020 mg/L	Provincial Water Quality Objectives (Lakes)
Total Phosphorus	0.010 mg/L	Provincial Water Quality Objectives (Lakes with natural TP concentration below 0.010 mg/L)
Total Suspended Solids	Background + 25 mg/L	Canadian Water Quality Guidelines for the Protection of Aquatic Life

Appendix 5

List of Documented Fish Species Within the BCLMP Planning Area, by Subwatershed

Fish Species	Staples River	Pearns Creek	Martin Creek South	Balsam Lake Tribs.	Cameron Lake Tribs.
Brook Stickleback	x	x	x	x	
Bass Sp.	x				
Northern Pearl Dace	x		x		
White Sucker	x	x	x	x	
Northern Redbelly Dace	x	x	x	x	
Finescale Dace	x		x		
Brassy Minnow	x	x	x		
Common Shiner	x		x		
Creek Chub	x	x	x	x	
Central Mudminnow	x	x	x	x	
Iowa Darter		x			
Pumpkinseed	x		x	x	
Fathead Minnow	x	x	x		
Blacknose Dace				x	
Rock Bass			x	x	
Largemouth Bass				x	
Yellow Perch	x	x	x		
Northern Pike	x				
Mottled Sculpin		x			
Bluegill			x		
Muskellunge			x		
Bluntnose Minnow			x		
Bullhead Sp.			x		
TOTAL	**14**	**10**	**17**	**9**	**N/A**
KRCA BCLMP (2013)	x	x	x	x	
OMNR Stream Surveys (1976-77)	x	x	x	x	
OMNR ARA Data (exported 2006)			x		

Appendix 6

Fishes captured at present vs. historical comparison sites

	SR1976_01		SR1976_02		SR1976_03		SR1976_04		PC1976_01		PC1976_02		MCS1976_01		MCS1976_02		MCS1976_03		BEX1977_01	
	2013	1976	2013	1975	2013	1975	2013	1976	2013	1976	2013	1976	2013	1976	2013	1976	2013	1976	2013	1976
Brook Stickleback		x	x	x	x		x		x		x	x		x	x	x	x	x		x
Bass Sp.		x																		
Northern Pearl Dace				x		x		x									x			
White Sucker						x				x							x			x
Northern Redbelly Dace					x	x	x	x			x	x				x	x	x		
Finescale Dace						x	x								x	x	x	x		
Brassy Minnow						x					x	x				x				
Common Shiner						x														
Creek Chub			x		x	x											x	x		x
Central Mudminnow			x		x		x	x	x	x	x				x		x	x	x	x
Iowa Darter										x										
Pumpkinseed			x											x					x	
Fathead Minnow					x		x										x	x		
Blacknose Dace																				x
Rock Bass													x						x	
Largemouth Bass																			x	
Yellow Perch	x		x						x		x		x							
Northern Pike			x																	
Mottled Sculpin									x											
Bluegill													x							
Muskellunge													x							
Bluntnose Minnow													x							
Bullhead Sp.																	x			
TOTAL	**1**	**2**	**6**	**2**	**5**	**7**	**5**	**3**	**4**	**3**	**5**	**3**	**5**	**2**	**3**	**4**	**8**	**6**	**4**	**5**

Appendix 7

Benthic macroinvertebrate raw counts (pooled for each site) and summary data for 16 bioassessment sites

Class/Order Name	Family Name	BCL2 34-20	BCL2 34-11	BCL2 34-36	BLC2 34-40	BCL2 34-32	BCL23 4-10	BCL2 34-28	BCL23 4-44	BCL2 34-08	BCL2 34-12	BCL2 34-26	BCL2 34-21	BCL23 4-24	BCL2 34-16	BCL2 34-29	BCL2 34-47	TOTAL (#)	TOTAL (%)
Acarina (Mites)	Unknown	1	1	1	1	1		3			2							**10**	**0.20**
Amphipoda (Scuds)	Crangonictidae														9			**9**	**0.18**
Amphipoda (Scuds)	Gammaridae	6	14	6		1	4	43			119	1	258	9	30	10	3	**504**	**10.15**
Amphipoda (Scuds)	Hyallelidae										39							**39**	**0.79**
Anisoptera (Dragonflies)	Libellulidae	1	4					3	3		3							**14**	**0.28**
Coleoptera (Beetles)	Dytiscidae		4		2		3		11	28	1	1			22	4	10	**86**	**1.73**
Coleoptera (Beetles)	Elmiidae	89			18				10	1	1		2					**121**	**2.44**
Coleoptera (Beetles)	Haliplidae		1							5	3			5			1	**15**	**0.30**
Coleoptera (Beetles)	Hydraenidae						1											**1**	**0.02**
Coleoptera (Beetles)	Unknown	1					1										1	**3**	**0.06**
Decapoda (Crayfish)	Unknown									1								**1**	**0.02**
Diptera (TrueFlies)	Ceratopogonidae	5	4			1	2		3	1	9	1			1	2	12	**41**	**0.83**
Diptera (TrueFlies)	Chironomidae	45	55	100	139	187	9	15	28	167	48	13	4	5	67	44	164	**1090**	**21.95**
Diptera (TrueFlies)	Dolichopodidae										2							**2**	**0.04**
Diptera (TrueFlies)	Simulidae	3		1			9			19					34	14	4	**84**	**1.69**
Diptera (TrueFlies)	Stratiomyidae	2															5	**7**	**0.14**
Diptera (TrueFlies)	Tabanidae	1			1				2	7	4		1		2	1		**19**	**0.38**
Diptera (TrueFlies)	Tipulidae	3		1			1					1	1		1			**8**	**0.16**
Emphemeroptera (Mayflies)	Caenidae	38	1															**39**	**0.79**
Emphemeroptera (Mayflies)	Siphlonuridae	19							1	6				52	33	125	9	**245**	**4.93**
Emphemeroptera (Mayflies)	Tricorythidae										13							**13**	**0.26**
Emphemeroptera (Mayflies)	Unknown			3	3		62	2	21	1		1					1	**94**	**1.89**
Gastropoda (Snails)	Hydrobiidae				1		2	148			39		1		1			**192**	**3.87**
Gastropoda (Snails)	Lymnaidae	18	14				13			11		3		7	3		8	**77**	**1.55**
Gastropoda (Snails)	Physidae		25				15	5	1	3		3	2	6	7		2	**69**	**1.39**
Gastropoda (Snails)	Planorbidae	1	29			1	5	43		1	5	1		19	8	2	57	**172**	**3.46**

Gastropoda (Snails)	Vivparidae		5	4																**9**	**0.18**
Hemiptera (TrueBugs)	Notonectidae										1									**1**	**0.02**
Hirudinea (Leeches)	Glossiphonidae				2									2						**4**	**0.08**
Hirudinea (Leeches)	Unknown		1																	**1**	**0.02**
Isopoda (SowBugs)	Asellidae		7	29	7				12	16		6		17	1	11	6			**112**	**2.26**
Lepidoptera (Aq.Moths)	Crambidae																10			**10**	**0.20**
Nematoda (Roundworms)	Unknown		1								1					3	1			**6**	**0.12**
Oligocheatae (Aq.Earthworms)	Unknown		4	2	23	3		3	3	6	5	3	30	15	3	14	3	1		**118**	**2.38**
Pelecypoda (Mussels)	Sphaeridae		14	75	37	75	9	32	40	8	9	3	248	3	2	18	5	19		**597**	**12.02**
Plecoptera (Stoneflies)	Chloroperlidae		23			4				115	8									**150**	**3.02**
Plecoptera (Stoneflies)	Nemouridae															12		2		**14**	**0.28**
Plecoptera (Stoneflies)	Perlodidae		10		5	106		172		96	85				196	56	69	12		**807**	**16.25**
Plecoptera (Stoneflies)	Unknown									2										**2**	**0.04**
TERRESTRIAL (Ants)	Unknown																2			**2**	**0.04**
TERRESTRIAL (Spiders)	Unknown														3					**3**	**0.06**
TERRESTRIAL (Wasps)	Unknown										1	1				1				**3**	**0.06**
Tricoptera (Caddisflies)	Lepidostomatidae					2														**2**	**0.04**
Tricoptera (Caddisflies)	Lymnephilidae															2				**2**	**0.04**
Tricoptera (Caddisflies)	Odontoceridae									1							4	2		**7**	**0.14**
Tricoptera (Caddisflies)	Philopotamidae													1	12					**13**	**0.26**
Tricoptera (Caddisflies)	Phryganeidae		1			1									2					**4**	**0.08**
Tricoptera (Caddisflies)	Unknown							2					1					4		**7**	**0.14**
ZEBRAMUSSELS (Mussels)	Dreissendae													1						**1**	**0.02**
ZOOPLANKTON (Cladocera)	Unknown		1	6		1						2	11							**21**	**0.42**
ZOOPLANKTON (Copepoda)	Unknown			17	93															**110**	**2.22**
Zygoptera (Damselflies)	Coenagrionidae											4								**4**	**0.08**
TOTAL_SUM			**300**	**285**	**279**	**357**	**200**	**336**	**317**	**324**	**361**	**307**	**315**	**308**	**322**	**335**	**302**	**317**		**4965**	
RICHNESS(#taxa)			**25**	**17**	**12**	**14**	**6**	**17**	**11**	**16**	**20**	**20**	**13**	**13**	**14**	**21**	**16**	**19**		**52**	

SENSITIVITY(%EPT)			**30.3**	**0.4**	**2.9**	**32.5**	**0.0**	**70.2**	**0.6**	**72.8**	**27.7**	**4.2**	**0.6**	**0.3**	**81.4**	**30.7**	**65.6**	**9.5**		**28.2**	
NON-BENTHOS(%)			**0.3**	**8.1**	**33.3**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**1.0**	**3.5**	**0.0**	**0.9**	**0.3**	**0.7**	**0.0**		**2.8**	
SIMPSONS_DIVERSITY			**0.69**	**0.86**	**0.74**	**0.72**	**0.12**	**0.69**	**0.73**	**0.77**	**0.72**	**0.79**	**0.37**	**0.29**	**0.60**	**0.89**	**0.75**	**0.69**		**0.65**	
TOL_NYSTATE(%TaxaWithValues)			**99**	**90**	**66**	**98**	**100**	**80**	**99**	**90**	**90**	**81**	**96**	**100**	**98**	**90**	**98**	**95**		**92**	
TOL_NYSTATE(IndexValue)			**5.00**	**6.35**	**6.22**	**4.66**	**6.00**	**3.55**	**7.03**	**2.44**	**4.76**	**6.31**	**6.21**	**6.22**	**3.18**	**4.99**	**4.13**	**5.71**		**5.17**	
TOL_NYSTATE(Grade)			**Good - B**	**Fairly Poor - D**	**Fairly Poor - D**	**Good - B**	**Fairly Poor - D**	**Excellent - A**	**Poor - D**	**Excellent - A**	**Good - B**	**Fairly Poor - D**	**Fairly Poor - D**	**Fairly Poor - D**	**Excellent - A**	**Good - B**	**Very Good - A**	**Fair - C**		**Fair - C**	

Appendix 8

Community Series Description

Community Series (Code -Descriptive Name)[1]	**Description of Community Series**	**Balsam Lake Watershed Area**		**Cameron Lake Watershed Area**	
		km²	**%**	**km²**	**%**
Cultural Areas					
AA - Active Aggregate	Barren, heavily disturbed open pit or quarry	0.12	0.08	0.56	0.5%
AI - Inactive Aggregate	Surface cover ≥ 25% or barren, currently unused open pit or quarry	0.04	0.02	0.51	0.5%
CUM – Cultural Meadow	Areas that have resulted from or are maintained by cultural or anthropogenic-based disturbances and often have a large proportion of non-native plant species. These areas are characterized by a tree and shrub cover each of less than 25%.	9.27	5.7	1.6	1%
CUP – Cultural Plantation	Areas that have resulted from or are maintained by cultural or anthropogenic-based disturbances and often have a large proportion of non-native plant species. These areas are characterized by tree cover > 60%.	0.24	0.15	0.4	0.3%
CUS – Cultural Savanna	Areas that have resulted from or are maintained by cultural or anthropogenic-based disturbances and often have a large proportion of non-native plant species. These areas are characterized by 25%< tree cover ≤ 35%.	3.16	1.9	1.4	1.3%
CUT – Cultural Thicket	Areas that have resulted from or are maintained by cultural or anthropogenic-based disturbances and often have a large proportion of non-native plant species. These areas are characterized by tree cover ≤ 25%; shrub cover >25%.	4.10	2.5	2.0	1.8%
CUW – Cultural Woodland	Areas that have resulted from or are maintained by cultural or anthropogenic-based disturbances and often have a large proportion of non-native plant species. These areas are characterized by tree cover between 35% and 60%,	2.8	1.7	1.4	1.2%
DIS – Disturbed Areas	No natural cover, areas that have been disturbed by human influences, e.g. trails	0	0	0	0
DMP – Landfill	Barren, land that is actively being used for waste disposal	0	0	0	0
IAG – Intensive	Annually cultivated, crop fields, gardens,	33.4	26%	41.2	37%

[1] Community series' refer to those described in the Ecological Land Classification for Southern Ontario manual, first approximation (Lee et. al. 1998), unless marked with a * which indicates a land use code that has been created by practitioners and accepted by the South Central Ontario Conservation Authorities terrestrial natural heritage discussion group (SCOCA), but which are not explicitly included in Lee et. al. (1998).

Community Series (Code -Descriptive Name)[1]	Description of Community Series	Balsam Lake Watershed Area		Cameron Lake Watershed Area	
		km^2	%	km^2	%
Agriculture	nurseries, tree farms. Variable				
***MOS -** Manicured Open Space	Regularly maintained, gardens, parks, ski hills, cemeteries, open spaces. >2ha and resulting from or maintained by, cultural or anthropogenic-based disturbances	0.14	0.09%	7.4	0.1%
***NAG** – Non Intensive Agriculture	No cultivation, grasses, hay, pasture, grazing. Variable	26.9	17%	13.5	12%
***RD** – Rural Development	Variable. 0.2 ha < area < 2.0 ha containing development not associated with agriculture	8.4	5%	5.5	5%
***URB** – Urban Development	Variable. > 5 residential units in an area > 2 ha, generally residential	0.25	0.2%	0.65	0.6%
Natural Areas					
BO - Bog	Bogs are areas with ≤ 25% tree cover (trees over 2m) where substrate organic layer is > 40cm Sphagnum peat, rarely flooded, always saturated with water. The pH is moderate to highly acidic (<4.2).	0	0	0	0
BOO – Open Bog	Bog with tree cover ≤ 10%, shrub cover ≤ 25%	0	0	0.02	0.02%
BOT – Treed Bog	Bog with 10% < tree cover ≤ 25%	0	0	0	0
FOC – Coniferous Forest	Areas where tree cover is greater than 60%, and the canopy is comprised of greater than 75% coniferous tree species	17.6	11%	6.9	6%
FOD – Deciduous Forest	Areas where tree cover is greater than 60%, and the canopy is comprised of greater than 75% deciduous tree species	8.8	5%	2.9	3%
FOM – Mixed Forest	Areas where tree cover is greater than 60%, and the canopy is comprised of greater than 25% deciduous tree species and greater than 25% coniferous tree species	13.0	8%	5.5	5%
MAM – Meadow Marsh	Areas with <2m of water over substrates. Often seasonally flooded with soils drying out by mid-summer. Tree and shrub cover is ≤ 25% and area is dominated by emergent hydrophytic macrophytes. Represents the wetland-terrestrial interface.	0.94	0.6%	0.6	0.6%
MAS – Shallow Marsh	Areas with <2m of water over substrates. Often with standing or flowing water for much or all of the growing season. Tree and shrub cover is ≤ 25% and cover of emergent hydrophytic macrophytes is greater than or equal to 25%.	0.04	0.3%.	0.2	0.2%
OAO – Open Aquatic	Areas with water >2m deep. Plankton dominated with no macrophyte vegetation and no tree or shrub cover.	0.75	0.5%	0.3	0.3%
SAF – Floating-leaved Shallow Aquatic	Area with standing water <2m deep. No tree or shrub cover, and if emergent vegetation is present is not dominant. Greater than 25%	0	0	0	0

Community Series (Code -Descriptive Name)[1]	Description of Community Series	Balsam Lake Watershed Area		Cameron Lake Watershed Area	
		km²	%	km²	%
	cover of floating-leaved macrophytes. Often influenced by shoreline energy.				
SAM – Mixed Shallow Aquatic	Area with standing water <2m deep. No tree or shrub cover, and if emergent vegetation is present is not dominant. Greater than 25% cover of submerged and floating-leaved macrophytes. Often influenced by shoreline energy.	0.25	0.2%	0.01	0.01%
SAS – Submerged Shallow Aquatic	Area with standing water <2m deep. No tree or shrub cover, and if emergent vegetation is present is not dominant. Greater than 25% cover of submerged macrophytes. Often influenced by shoreline energy.	0	0	0	0
SBS – Shrub Sand Barren	Bare sand substrates not associated with distinct topographic features (i.e. sand dune), subject to periods of prolonged drought and disturbances (e.g. fire) Tree cover≤25%, shrub cover ≤ 25%	0	0	0	0
SWC – Coniferous Swamp	Areas with variable flooding where water depth is <2m and standing water or vernal pooling makes up >20% of the ground coverage. Tree cover is >25%, canopy height is greater than 5m, and conifer tree species make up >75% of the canopy. Hydrophytic shrubs and herbs present.	15.8	10%	12.7	11%
SWD – Deciduous Swamp	Areas with variable flooding where water depth is <2m and standing water or vernal pooling makes up >20% of the ground coverage. Tree cover is >25%, canopy height is greater than 5m, and deciduous tree species make up >75% of the canopy. Hydrophytic shrubs and herbs present.	1.52	0.9%	83.8	0.8%
SWM – Mixed Swamp	Areas with variable flooding where water depth is <2m and standing water or vernal pooling makes up >20% of the ground coverage. Tree cover is >25%, canopy height is greater than 5m, deciduous tree species make up >25% of the canopy, and coniferous tree species make up >25% of the canopy. Hydrophytic shrubs and herbs present.	7.0	4%	5.7	5%
SWT – Thicket Swamp	Areas with variable flooding where water depth is <2m and standing water or vernal pooling makes up >20% of the ground coverage. Tree cover is ≤ 25% and hydrophytic shrub cover is >25%.	4.6	3%	4.7	4%
Cultural Areas		91.8	56%	70.8	64%
Natural Areas		70.9	44 %	40.3	36%
Combined Areas of		89.6	56%	46.7	42%

Community Series (Code -Descriptive Name)[1]	Description of Community Series	Balsam Lake Watershed Area		Cameron Lake Watershed Area	
		km^2	%	km^2	%
Cover*					
Roads		2.9	2%	2.0	1.8%

* All natural areas + CUM, CUP, CUS, CUT, CUW

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