KINGS COUNTY

LAKE MONITORING PROGRAM

2018 SEASON

Municipality of the County of Kings

PREPARED AND PRESENTED TO THE TAC BY

Jérôme Marty, PhD

Freshwater ecologist.

EXCECUTIVE SUMMARY

This report provides an assessment of the health of the 13 lakes monitored as part of the Kings County Lakes Monitoring Program (KCVLMP). For 22 years, volunteers have collected detailed information to assess changes in water quality and evaluate the health of the lakes using a water quality index (WQI). This information is valuable because it does allow to understand how the limnology of these lakes have changed over a long period of time. It is also a valuable dataset because there are very few consistent and comprehensive datasets that exists for lakes in Nova Scotia; and also no comparable programs that are designed and run by citizens volunteering to collect the data.

Additional information that made it to the report in 2018

This year, the report benefited from the input of two summer interns that helped with sampling and drafting a survey for volunteers to collect additional information on individual lakes. In addition, using the database from the Planning department at the County, maps of each lake were produced, with information on zoning (land use) such as the number of residences along the lakes. This information was added in the results section of the report. Finally, to complement the new maps, the definition of each zone can be found in the land-use bylaw presented in the appendix at the end of the report.

The unique characteristics of the Kings County Lakes

Over the years, the Technical Advisory Committee (TAC) has indicated the need to highlight the unique features of the Kings County lakes. Three main facts would be applicable to almost all lakes in this study. First, the amount of ions, measured as conductivity (the sum of constituents, salinity) is extremely low in all of the lakes. This means that the lakes have a low concentration in nutrients, as such, primary production (plant production) is limited. TAC members have observed that the conductivity values observed in the King County lakes are among the lowest in the world.

Secondly, the Kings County lakes are characterized by the brown colour of the water, that is due to the high concentration in dissolved organic carbon (DOC). This colour is of natural origin and is not an indication of poor water quality. It is the results of the presence of wetlands in the drainage basin, and in particular Sphagnum bogs that are very common in Atlantic Canada. Only 2 lakes have clear waters (Sunken and Tupper lakes, with a colour value lower than 20); and Lake George is slightly coloured. It is important to note that in coloured lakes, Secchi depth is not a good indicator of trophic state (as it is for clear waters). Variations in colour in the lakes can be observed from year to year and season to season, depending on the precipitation driving the flushing rate of the Sphagnum bogs.

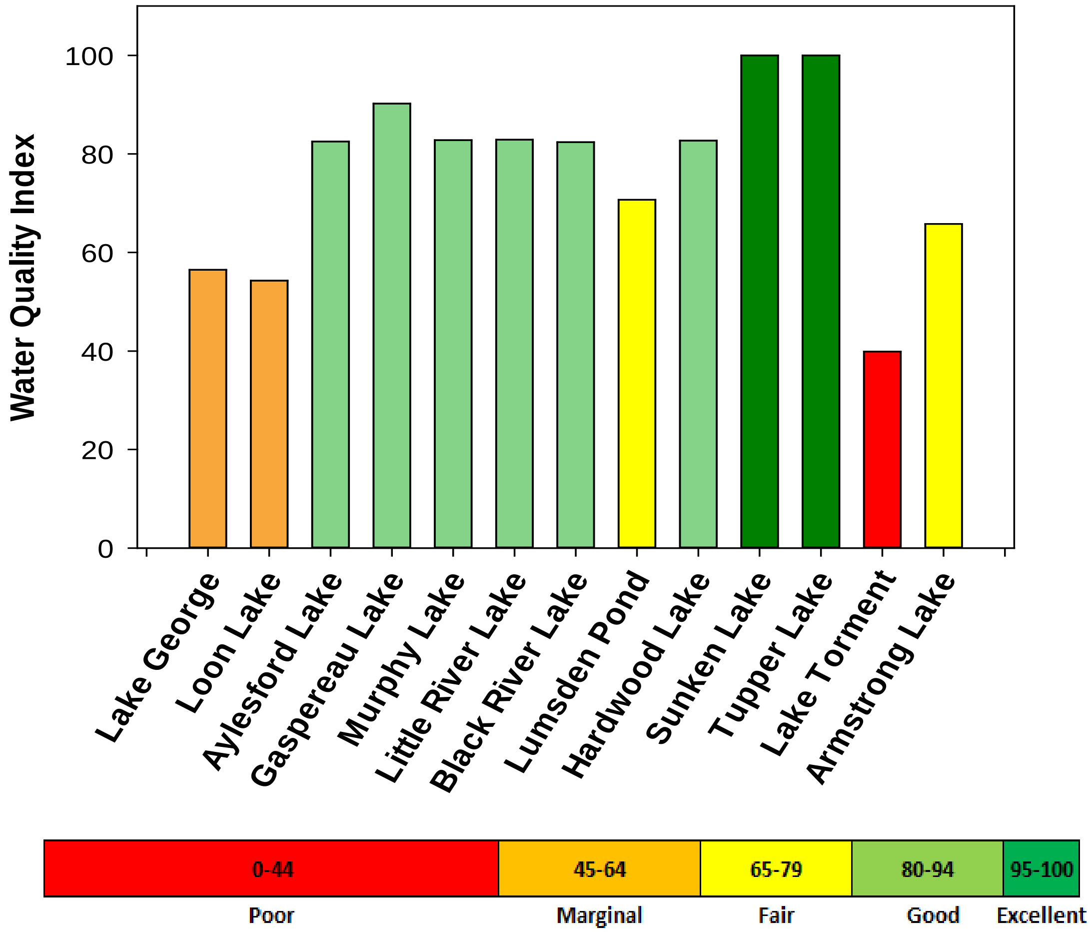
Finally, TAC has observed that the concentration in DOC is generally very high in the Kings County lakes. As indicated above, this is a key natural feature of the lakes that not indicative of poor water quality. In lakes Torment and Armstrong, this concentration exceeds 10 mg/L, a value that is among the highest in the world and this means that the DOC concentration exceeds that of salinity in some the Kings County lakes.

As such, there are limitations applying the WQI: Kings County lakes are very different from ‘normal’ lakes, for which the WQI was originally developed. As such, the WQI values presented in this report are the result of a modified calculation that does not include the influence of colour in the water quality rating. WQI values presented in this report are only applicable to Kings County lakes and may not compare well to other values derived from lakes in other regions.

In 2018, the results were very similar to those recorded in 2017. The Kings County lakes continue to show nutrient (as total phosphorus and total nitrogen) levels most of the time below guideline values. Until 2016, the lakes showed an increase in chl.a, a trend that was not observed in both 2017 and 2018. As for the last years, no relationship between nutrient concentrations and algal biomass was observed and this year again, it is not possible to relate the decrease in chl.a to a decrease in nutrients.

The WQI values for 2018

The WQI values ranged from poor (Lake Torment) to excellent (Sunken and Tupper lakes) and overall most lakes have a good water quality rating. The main reason for the poor and marginal ratings is related to the exceedances in chl.a values, above guidelines.



Although nutrient levels are low in most of the KCVLMP lakes, it is important to note that productivity can be high in some of the lakes and as such local residents should continue and maintain programs aiming at reducing nutrient loading to the lakes. Although most of the WQI rating was good in 2018, it does not mean that the lakes will remain in good health if nutrient loading was to increase in the future or climate change effects to lake biological, physical and chemical processes.

Table of Contents

Acronyms

CCME	Canadian Council of Ministers of the Environment
Chl. a	Chlorophyll. a
DOC	Dissolved Organic Carbon
OECD	Organization for Economic Cooperation and Development
pH	Power of Hydrogen (H^+)
QA/QC	Quality Assurance / Quality Control
RPD	Relative Percent Difference
SD	Secchi Depth
TN	Total Nitrogen
TP	Total Phosphorus
WQI	Water Quality Index

Acknowledgements

This report receives the feedback and review of the members of the Lake Monitoring Program Technical Steering Committee:

- Emily Lutz– Councillor for District 7
- Kyle Hicks – Nova Scotia Power
- Stephanie Walsh – Nova Scotia Power
- Darrell Taylor – Nova Scotia Environment
- Andrew Sinclair – Nova Scotia Environment
- Wesley White – Saint Mary's University
- Anne Muecke – Griffiths Muecke Associates, Citizen Member
- Joe Kerekes – Scientist Emeritus, Environment Canada
- Reg Newell – Nova Scotia Department of Natural Resources
- Drew Peck – Citizen Member

This program would not be successful without its volunteers. The volunteers who sampled the lakes between 1999 and 2018 are as follows:

Mike Armstrong
Jim Gray
Andy Bryski
Terry Bryski
Susan Bryski
Delmar Jordan
Kurt Arsenault
Dave Sheehan
Kelly Sheehan
Pamela Zwicker
Paul Devries
Gloria Armstrong
Arnold Forsythe
Barry Davidson
Michael Lowe
Marion Schlaich
Mike Ryan
Mark Raymond
Gary Weisner
Wendy Weisner
Ray Cote
Gary Henderson
Bob Pearce
Carl Kent
Vivian Kent
Ben Raymond
Zack Raymond
Drew Peck
Warren Peck
Patti-Dexter Peck
Bob Church
Terry Church
Mark Richardson
Rayden Richardson
Ken Smiley
Mary Claire Smiley
Own Smiley
Denise Young

1 Introduction

The Kings County Lake Monitoring Program is an initiative begun by the Municipality of the County of Kings in 1997. It was started based on input from a multi-stakeholder group composed of members of all three levels of government and community groups. This group was assembled to address concerns on the impact of development of lake shorelines in Kings County. The data collected by the volunteered group informs on long-term changes in Kings County Lakes. Based on this long-term monitoring, trends are valuable to detect and understand changes that may not be detected using a limited number of sampling years. The Volunteer Water Quality Monitoring program was initiated to help calibrate this model and foster environmental awareness within the community.

There are five overall goals for the program (Municipality of the County of Kings, 2009). These goals are:

- To address citizens' concerns regarding lakeshore development impacts to Kings County lakes by working with lake associations and municipal, provincial and federal departments;
- To put planning tools in place to evaluate the effectiveness of controls on development around lakes and to aid decision making;
- To consider municipal planning and approval activities in the context of predetermined water quality objectives for Kings County lakes;

- To document long-term changes in water quality in the lakes and provide an assessment of the health of the lakes, which in turn can inform on their use.

Water sampling occurs once a month for each lake from May to October and is conducted by volunteers. The monitoring has been conducted every year since 1997 and currently thirteen lakes are sampled regularly as part of the Kings County Lake Monitoring Program. Quality Assurance and Quality Control (QA/QC) sampling was added to the protocols in 2011. Duplicate samples were collected from ten of the lakes in September 2018 and submitted for laboratory analysis. Two new lakes, Lake Torment and Armstrong Lake, were added to the lake monitoring program in July of 2014. The list of lakes sampled in 2018 is presented in Table 1-1 and Figure 1-1.

The program lakes are all within the boundaries of Kings County and are located in the Gaspereau River watershed, with the exceptions of Lake Tupper, which falls within the Cornwallis Watershed and Hardwood, Torment, and Armstrong lakes, which fall within the LaHave River watershed.

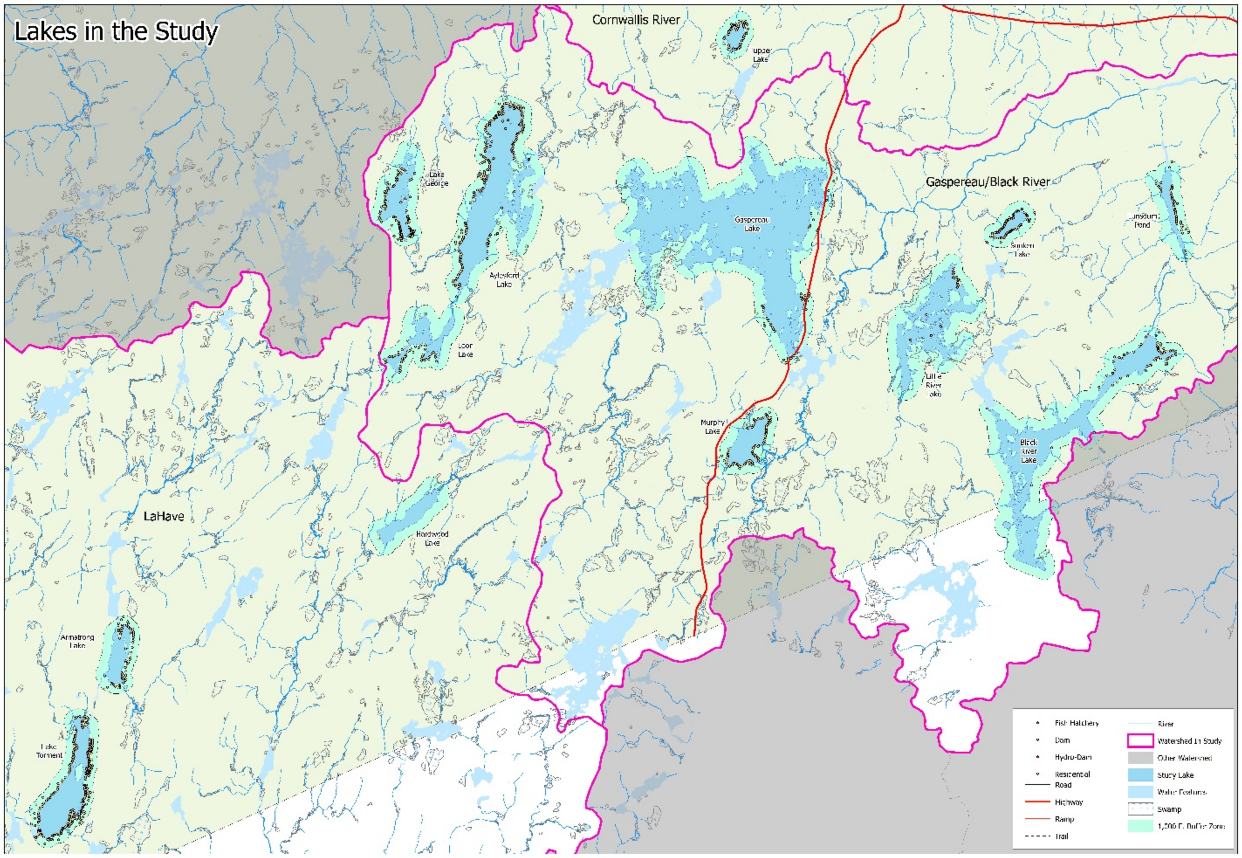


FIGURE 1-1 LAKES OF THE KINGS COUNTY LAKE MONITORING PROGRAM (SOURCE: MUNICIPALITY OF THE COUNTY OF KINGS)

All of the lakes are located on the South Mountain, south of the Annapolis and Gaspereau valleys.

Eight of the thirteen lakes are directly connected via surface flow and eventually drain into the Gaspereau River. Hardwood, Torment, Armstrong, Tupper and Sunken lakes are not part of this system; Hardwood, Torment and Armstrong Lakes are in the LaHave River watershed, Tupper Lake is part of the Cornwallis River watershed and Sunken Lake drains directly into the Gaspereau River without being connected to any of the other lakes (See Figure 1-2).

The drainage order for the lakes draining to the Gaspereau River is summarized on Table 1-1 and on Figure 1-2. The relative position of each lake is indicated with a number. Since Lake George and Loon Lake both drain into Aylesford Lake, they were both given a 1. The same number is also used for Gaspereau and Murphy Lakes. To facilitate review of potential drainage order trends, data for each lake in this report is presented in the same sequence as their drainage order.

It is important to note that the water flow is regulated in some of the lakes and therefore, systems located on the former Little Black River are not typical lakes due to the presence of a hydroelectric dam. The presence of the dam may affect the quantity of water located downstream as well as the thermal structure of these lakes. Furthermore, it is possible that the water quality of lakes facing flow regulation differs from that of natural lakes, due to different water residence time (flushing) and increased contact with the shoreline (contributing additional particles and nutrient). At this point the report does not provide an analysis of impact of flow regulation but this could be added pending more information on patterns in changes in flow regime from the regulator.

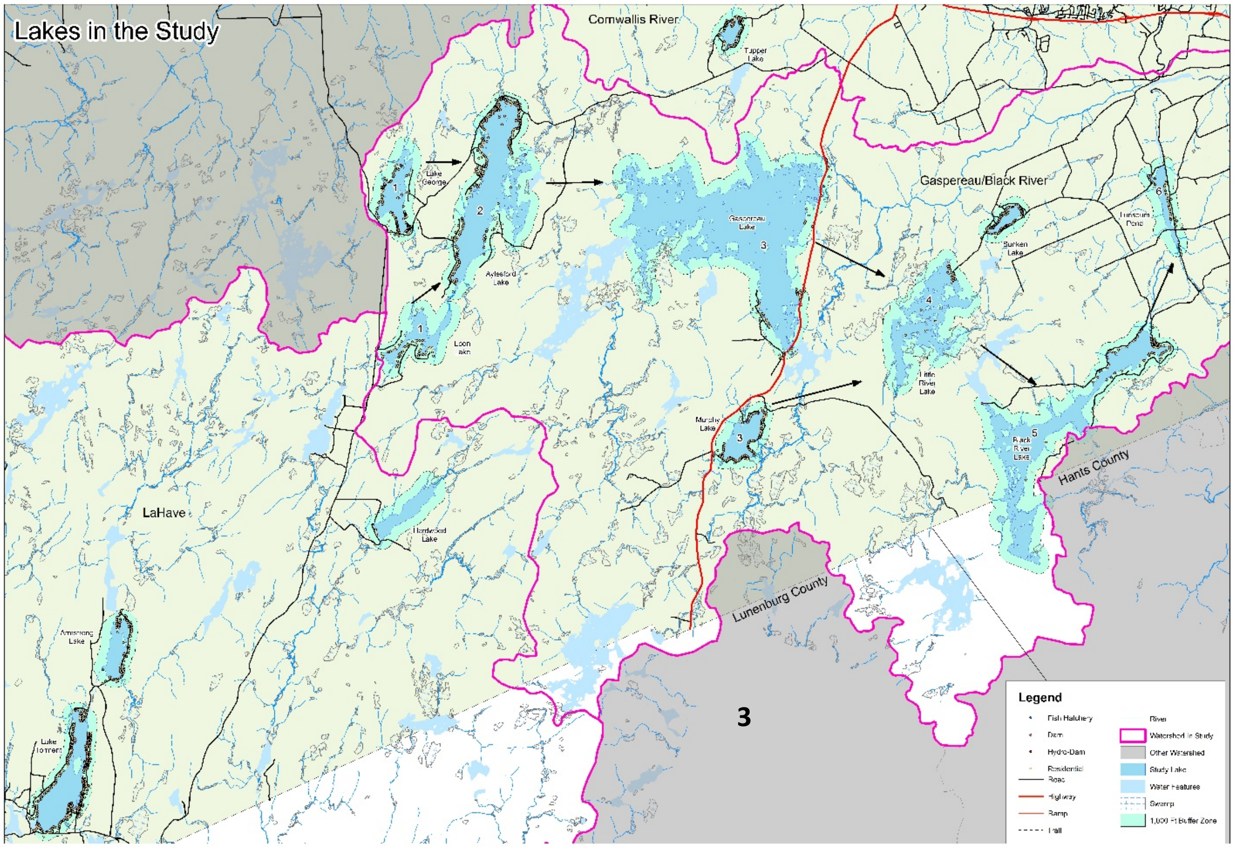


FIGURE 1-2 DRAINAGE MAP THE LAKES

TABLE 1-1 NAMES AND COORDINATES OF THE LAKE MONITORING LOCATIONS

DRAINAGE	LAKE NAME	LATITUDE	LONGITUDE
1	Lake George	44°56’12”N	64°41’48”W
1	Loon Lake	44°54’0”N	64°40’0”W
2	Aylesford Lake	44°57’00”N	64°40’00”W
3	Gaspereau Lake	44°58’30”N	64°32’30”W
3	Murphy Lake	44°54’30”N	64°31’0”W
4	Little River Lake	44°57’0”N	64°28’0”W
5	Black River Lake	44°58’24”W	64°27’30”W
6	Lumsden Pond*	45°1’30”W	64°23’45”W
-	Hardwood Lake	44°50’36”N	64°38’0”W
-	Sunken Lake*	44°59’39.46”N	64°27’0.30”W
-	Tupper Lake*	45° 1’0.76”N	64°35’23.71”W
-	Lake Torment	44°43’41.15”N	64°44’22.18”W
-	Armstrong Lake	44°46’28.84”N	64°44’26.31”W

*Coordinates were estimated using Google Earth.

Most of the lakes in this region are dystrophic lakes, also known as humic or brown water lakes. Lakes of this type are common in forested areas, especially in the boreal and Acadian forest regions. Lakes of this nature are characterized by a brownish water colour due to the presence of humic material responsible for acidity. They tend to have low lime (bicarbonate) levels (Cole, 1983; Makie, 2004). The low pH does not necessarily reduce the trophic level of coloured lakes, and productivity can be higher than in clear water lakes under certain conditions (Kerekes and Freedman, 1989).

Humic lakes are typically low in nutrient and therefore have a low productivity. This is due to the low lability of organic matter originating from the watershed. On the other hand, humic lakes are also very sensitive to changes in the watershed as they derived most of their inputs from land. Changes in land-use such as deforestation and residential development are key drivers influencing the trophic status of humic lakes. On the boreal shield, natural drivers also influence water quality of humic lakes: the presence of beaver dam increases flooding which in turn provide additional nutrient in waters (Roy et al., 2007), and finally, fires (and to a high extend clear cutting) are reported to contribute to nutrient loading via export from the soil (Carignan et al. 2000).The cumulative impacts of local disruptions and global changes such as temperature increase has overall raised concerns in many humic lakes. Over the last decade, increasing occurrences of algal blooms (such as cyanobacteria) and abundant growth of vascular plants (macrophytes) are being reported in humic lakes, highlighting the need to better understand their potential impacts.

Several humic lakes are being monitored in Nova Scotia. For example, of the 18 lakes currently monitored in Kejimkujik National Park and National Historic Site, 11 are dystrophic (Parks Canada, 2010). In addition, dystrophic lakes are also found in Yarmouth, Clare and Argyle Counties for which water quality index values are calculated accounting for high dissolved organic matter concentrations (Water Quality Survey of Fourteen Lakes in the Carleton River Watershed Area**,** 2016). The relationship between TP, chl.a and Secchi depth in coloured lakes does not appear to have the same correlation as in clear water lakes (Centre for Water Resources Studies and Stantec, 2009). When low oxygen levels are found in non-dystrophic lakes, this is usually used as an indicator of poor water quality. This cannot be generalized to dystrophic lakes, as they naturally have anoxic conditions at lower depths (Kevern et al., 1996; Cole, 1983). The low colour results for Sunken and Tupper lakes suggest that these lakes are not dystrophic (Parks Canada, 2008).

2 Methodology

The following description of methodology is similar to that described in previous recent years and was updated for 2018 following yearly review comments from the Technical Advisory Committee (TAC).

As for previous years, thirteen lakes were sampled during the 2018 field season. Sample collection and field measurements were undertaken by volunteers once per month beginning in May and ending in October.

Sampling was usually completed on the third Sunday of each month at as close to 12:00 pm as possible, weather permitting. If more than 25 mm of rain fell within the previous 24 hours, sampling was delayed several days. This is because rainfall can affect the sample results by increasing turbidity due to the transport of sediments from the watershed into the lake. Taking water samples under these conditions would impair the comparability between samples. Samples were gathered within the last two weeks of each month.

The samples were taken at the deepest point of the lake, which was marked by a buoy. The coordinates of the site locations are listed in Table 1-1. A boat was anchored or tied to the buoy and the Secchi depth (SD) was measured (Figure 2-1). Sampling consisted in the collection of 2 samples made of water collected at 2 different depths for each lake: samples were taken near the surface and either 1 m from the bottom or at 2x the Secchi depth (whichever was the shallower measurement). These two samples were then combined into one bottle prior to be sent to the laboratory. This procedure was then repeated to obtain the second sample. Depth samples were not taken closer than 1 metre to the lake bottom. Water temperature readings (surface and bottom), air temperature, weather conditions and station water depth were also documented.

Samples were analyzed for chl.a, total phosphorus (TP), total nitrogen (TN), dissolved organic carbon (DOC), alkalinity, pH, colour, turbidity, conductivity and orthophosphorus (Phosphate). The water samples were sent to the Environmental Services (ES) Lab at the QEII Health Services Centre and the Analytical Services lab of the New Brunswick Department of Environment. All parameters, with the exception of total phosphorus and chl.a, have been analysed at the QEII Centre for the duration of the program from 1997-2011. Phosphorous samples were sent to the ES Lab at the QEII from 1997-2004. The results from 2004 analyzed in this lab displayed high variability, producing anomalies in the data that were difficult to explain (Brylinsky, 2008). A decision was made to change laboratories, and phosphorous samples were then sent to the Analytical Services Lab in New Brunswick from 2005-2011 (Centre for Water Resources Studies and Stantec, 2009). The change in laboratories resulted in a reduction of variability of results, although Brylinsky noted that anomalies remained in the 2007 and 2008 data. The Centre for Water Resources Studies and Stantec (2009) noted that although the phosphorus results produced by the Fredericton lab display more realistic trends, the level of detection at this lab may not be adequate and suggests employing another lab to obtain more accurate results. At the end of 2011 the ES Lab at the QEII updated its equipment and TP testing was resumed at that lab.

From 1997 to 2005, chl.a was also sent to the Environmental Services lab at the QEII and analysed using the fluorometric method. However, because this method was not accredited at this lab, it was discontinued and chl.a samples were sent to the Analytical

Services Lab in New Brunswick. This lab employed the spectrophotometric method; chl.a results were analysed at this location from 2006-2008. It was found by the Centre for Water Resource Studies and Stantec (2009) that the spectrophotometric method overestimated the results when compared to the fluorometric method. In 2009-2011, chl.a results were once again sent to the QEII for analysis using the fluorometric method (Centre for Water Resources Studies and Stantec, 2009). Since the end of 2011 the ES Lab at the QEII has not offered chl.a testing. Beginning in the 2012 sampling season the ES Lab has filtered all chl.a samples and then forwarded them to the New Brunswick lab for final analysis.

FIGURE 2-1 A SECCHI DISK USED TO TAKE A SECCHI DEPTH READING AT MONITORED LAKES

Currently, all samples are sent to the QEII lab for analysis, whereas the chl.a samples are shipped to the ALS laboratory in Winnipeg, ALS (starting in 2016). In 2016, the protocol for laboratory analysis was verified and only frozen filters are sent for analyses, following standard protocols. Although previous reports have discarded laboratory data from 2004 due to suspected anomalous results in phosphorus, we have included the 2004 data in this report as the trends displayed appear to indicate that these results may not be anomalous.

Quality control/quality assurance sampling was conducted in 2018 through the collection of duplicate samples from ten of the thirteen regularly sampled lakes.

FIGURE 2-2 SAMPLING DEVICE USED TO COLLECT WATER SAMPLES FROM MONITORED LAKES

2.1 Parameters Measured

2.1.1 Total Phosphorus, chl.a, Secchi Depth, Total Nitrogen

In clear water lakes, TP, chl.a and Secchi depth (SD) can be used to determine the trophic state, or level of aquatic vegetation (Carlson and Simpson, 1996). Total nitrogen (TN) can also be used for this purpose in some cases. Although these indicators are normally related and can predict each other, the relationship is not defined for coloured lakes. The Kings County Lakeshore Capacity Model (KCLCM) uses lake characteristics to predict springtime concentrations of TP, which are then used to predict chl.a. Sample data collected from the lakes in the Gaspereau River watershed suggests that the assumed phosphorous-chl.a relationship used in the model does not exist for these lakes and is therefore not appropriate (Centre for Water Resources Studies and Stantec, 2009). Kerekes (1981) found the increase in chl.a in response to increases in phosphorous levels appears to be less in coloured lakes than in clear water lakes, as some of the phosphorous in coloured lakes is chemically bound to humic substances and is therefore less available for algal production. Irrespective of the influence of colour and weaker nutrient/chl.a relationships, phosphorus is still considered the key driver of algal production and chl.a levels in Nova Scotia lakes as well as freshwater lakes generally worldwide (Vollenweider and Kerekes, 1982). TP and TN are measured in mg/L, chl.a is measured in mg/m^3 and SD is measured in metres.

2.1.2 Dissolved Organic Carbon

Dystrophic lakes are characterized by high levels of humic materials and organic acids, which are generally indicated by DOC content. Lowered productivity and increased susceptibility to acidification and toxic metals can result from changes in DOC levels. Increases can also lower dissolved oxygen by increasing bacteria metabolism (Government of British Columbia, 2001). Elevated DOC levels can be caused by the breakdown of forest materials that have been washed into a lake, such as leaves and evergreen needles. DOC content tends to be inherent to both lake and river systems; thus water quality parameters are generally based on whether or not the levels fluctuate beyond regular background levels. This means water quality parameters will be unique to each system. DOC is measured in mg/L.

2.1.3 pH and Alkalinity

pH is a measure of the dissolved hydrogen ion content in the water. The greater the hydrogen ion concentration, the more acidic the system. pH is measured on a scale of 1 to 14. Lower pH is more acidic while higher pH is more alkaline; pH 7 is neutral. The pH scale is logarithmic, meaning every unit decrease represents a tenfold increase in acidity. Levels of pH below 5 have been known to have adverse effects on fish species such as salmon or trout. Alkalinity is a measure of the ability of water to resist lowering pH, also known as its buffering capacity. It is determined by the concentration of carbonates, bicarbonates and hydroxides and is usually a result of the surrounding geology. It can be expressed in terms of equivalents of carbonate or bicarbonate, or in the amount of calcium carbonate present (Mackie, 2004). Dystrophic lakes typically have low calcium content and are more likely to be acidic (Cole, 1983). Therefore, most of the dissolved carbon in humic lakes is under the form of dissolved CO_2. There are few established guidelines for alkalinity (Parks Canada, 2008) and it shares many properties with pH, thus alkalinity is not measured in the Kings County Lake Monitoring Program.

2.1.4 Turbidity and Colour

Turbidity is a way of expressing the suspended sediment load of a water body. It is a measurement of the extent to which light will penetrate the water column. Turbidity gives an indication of the amount of suspended sediments in the water because light is less likely to penetrate as far in cloudy (i.e. 'turbid') waters. It is measured by passing a beam of light through the water column and measuring the amount of light that is scattered and absorbed. Elevated sediment levels can block light from getting to aquatic plants, impair the functioning of fish gills and interfere with feeding mechanisms of zooplankton. It is measured in nephelometric turbidity units (NTU). Lake colour is a parameter that can indicate the types of particulate matter present in the water column (Mackie, 2004). For instance, lakes with a blue colour tend to be clearer, with low amounts of sediments; lakes with a greenish colour likely contain considerable amounts of blue-green algae and if lakes display a reddish-brown colour, this indicates high levels of organic material (Mackie, 2004). Colour is measured in true colour units (TCU).

2.1.5 Conductivity

Conductivity is commonly used in water quality assessments as a general indicator of the amount of ions present in the water. It measures the ability of water to conduct an electrical current between two electrodes 1 cm apart. In general, the greater the amount of dissolved solids, the higher the conductivity. Conductivity is measured in milliSiemens per centimetre (mS/cm). Conductivity is not generally used as a water quality parameter as it is dependent on many other parameters (Mackie, 2004): for example hard waters due to high content in bicarbonates will have a high conductivity compared to soft waters. This being said, conductivity can be a proxy for pollution when a source of nutrient is reaching a water body.

2.1.6 Water Temperature

Temperature readings were taken at two different depths for each lake; at the surface and near the lake floor. Water temperatures above 20˚C can be stressful for cold water species such as trout and salmonid species and these species must have a well-oxygenated, cooler hypolimnial layer in the summer to survive (MacMillan et al., 2005). Water stratification occurs when the water above the thermocline does not mix with the water below the thermocline. When the water column is stratified, the deeper layer (the hypolimnion) is isolated from the mixed surface layer and could show low level of oxygen due to respiration. Oxygen depletion, and in particular anoxia (less than 2% oxygen compared to surface water) create an environment that is not favourable for aquatic life. From 1999-2010, dataloggers were installed at two depths (above and below the thermocline) in some of the lakes to determine if stratification exists in those lakes (see past publications for lake stratification results at: http://www.county.kings.ns.ca/residents/lakemon/archives.asp). As of 2011 however, dataloggers were no longer installed at these lakes.

2.2 Establishing Water Quality Objectives

Thirteen lakes are monitored as part of the Kings County Lake Monitoring program. Each lake has unique properties and varying levels of shoreline development; thus, each lake is examined separately. The 2018 averages for each parameter were compared against the historical average from 1997 to 2017 (including data from 2004 which was omitted in previous years). Water quality guidelines have been developed for many parameters (i.e. total phosphorus, Secchi depth, and pH) by organizations such as Parks Canada, the British Columbia Ministry of Environment and the Canadian Council of Ministers of the Environment (CCME). These guidelines generally refer to clear water lakes, although Parks Canada has determined guidelines for coloured lakes in Kejimkujik National Park (Parks Canada, 2010). For some parameters within the monitoring program (TP, Secchi depth, pH, colour and dissolved organic carbon), the objectives are determined by deviations from historic values due to lack of specific guidelines for these parameters in coloured lakes.

2.2.1 Phosphorus

As per the recommendations of the Centre for Water Resources Studies and Stantec (2009), averages for the values of total phosphorus from 1993, and 1997 to 2018 for each lake were calculated. Although the Kings County Lake Monitoring Program has not yet formally adopted this phosphorus objective, it was used here as an interim measure as no other relevant phosphorus guidelines could be found for dystrophic lakes. The most common provincial guideline for total phosphorus limit is 20 µg/L. In order to capture potential deviation to baseline levels, the total phosphorus water quality objective for each lake was calculated as 150% of the baseline (average) level, not exceeding 20 µg/L. The calculated thresholds for total phosphorus are presented in Table 2-1.

TABLE 2-1 AVERAGE HISTORIC TOTAL PHOSPHORUS VALUES AND WATER QUALITY OBJECTIVES.

LAKE	TOTAL PHOSPHORUS AVERAGE (UP TO 2018) (µG/L)	TOTAL PHOSPHORUS OBJECTIVE (µG/L)
George	10	13.9
Loon	12	18.1
Aylesford	10	15.6
Gaspereau	12	17.8
Murphy	12	17.4
Little River	14	**20 (21.6)**
Black River	11	16.4
Lumsden	12.5	18.9
Hardwood	13	19.1
Sunken	9.4	18.9
Tupper	11.4	16.8
Torment	17	**20 (25.4)**
Armstrong	18	**20 (27)**

** **BOLD** = 150% of background levels exceeding the maximum 20µg/L guideline value*

2.2.2 Chl.a

The guideline for chl.a is 2.5 µg/L (2.5 mg/m^3) and was established by the Municipality of Kings in its Municipal Planning Strategy.

2.2.3 Secchi Depth, pH and Colour

Guidelines for Secchi depth, colour and pH were determined by analyzing all data from 1997 to 2016 for the 25th and 75th percentile values. These values were used as the lower and upper water quality guidelines. Kejimkujik National Park and National Historic Site used a similar procedure to determine water quality objectives for the brown water lakes within the park (Parks Canada, 2010).

2.2.4 Total Nitrogen

There is not a definitive water quality guideline for total nitrogen in surface water in Nova Scotia. Kejimkujik National Park is located in central southern Nova Scotia and contains a number of coloured lakes. Eighteen lakes have been monitored for many years and a guideline of 350 µg/L established for oligotrophic, brown-water lakes (Parks Canada, 2010). This guideline was used in the analysis of the Lake Monitoring Program data as Kejimkujik lakes are more similar to lakes in Kings County than surface water used to establish other guidelines.

2.2.5 Dissolved Organic Carbon

Dissolved organic carbon does not have a consistent water quality guideline for the protection of aquatic life. Lake-specific guidelines were used in this report and determined using historical averages and 20% of this average; the lower value was determined using the historical average minus 20% and the upper value by the historical average plus 20%. Ideally, the average is of five samples taken within one month (Government of British Columbia, 2001); however, due to the sample protocol for Kings County, this schedule is not possible. A DOC guideline for brown-water lakes in Kejimkujik National Park and

Historic Site was established as <19 mg/L (Parks Canada, 2010). This value was not used as a guideline in the lake-by-lake analysis as it is not as representative as the lake-determined objectives. Previously, the Parks Canada guideline (19 mg/L) was used in calculating the Water Quality Index score as a definitive cut-off was needed across all lakes, based on the recommendation of the Technical Advisory Committee (TAC), DOC has been removed from the calculation of the WQI from 2013 on to future years.

2.2.6 Turbidity

The guideline for turbidity was developed by Parks Canada (2010) for assessing brown-water and clear lakes in Kejimkujik National Park. Acceptable turbidity measurements must be <1.3 NTU.

Guidelines and their sources for parameters measured in the Kings County Lake Monitoring program are in each lake's report cards.

2.3 Water Quality Index

The Water Quality Index (WQI) is a tool that was developed by the CCME and can be used as a broad, albeit very basic, indicator of water quality. Data for a series of variables are compared to a guideline value or range using an excel application and a score from 0 to 100 is produced, 0 indicating very poor water quality, 100 indicating excellent water quality. The WQI score is based on three factors: the number of parameters that failed to meet guidelines, the frequency that a particular parameter failed to meet its guideline and the magnitude each value deviated from the parameter guideline (CCME, 2001).

The parameters used in this calculation were pH, TP, total nitrogen, chl.a, and turbidity. Prior to the 2014 report, calculations of WQI also included DOC, Secchi depth, and colour. In previous years' calculation, the inclusion of such variables yielded poor to marginal water quality rating. The WQI was developed as a general tool although humic lakes (ie lakes with high dissolved organic matter content) may not be accurately represented. In humic lakes, DOC concentrations are higher than in clear water lakes due to the high connectivity between water and the watershed. However, it is important to recognize that this DOC has little impact on the trophic state of lakes because it is not providing a nutrient source available for production. In fact, high DOC concentrations (or high colour) will limit algal growth via light limitation in the surface layer of the water column. Therefore, starting in 2014, we excluded variables related to humic content of the water to only keep variables related to trophic state. As a consequence, current calculations cannot be directly compared to those reported in years prior to 2014. Prior to the 2011 report, the guideline for total nitrogen was 900 µg/L. This guideline has been lowered to 350 µg/L which is the cut-off used by Parks Canada for brown-water lakes in Kejimkujik National Park (2010). The results of the water quality index are shown in each report card with a corresponding colour associated with a water quality rating.

2.4 Quality Assurance / Quality Control

Various duplicate and blank samples have been collected since 2011 for quality assurance and quality control purposes. When analyzing the data received each year, a review of observations exceeding the normal range of variation for each variable is conducted. When an unusual value is found, a review of the original data entry and questions to the laboratory are asked before deciding to keep or exclude the value from the analysis.

3 Results

The following section present for each lake, a report card summarizing the 2018 data as well as an interpretation and recommendation for lakes showing a poor rating in water quality.

The Water Quality index (WQI) developed by the CCME was calculated using the following variables: chl.a concentrations, Total Phosphorus, Total Nitrogen, pH and turbidity. As indicated earlier, other variables were considered in the past but were removed from the calculations because of the limitations of the WQI in coloured waters. For example, the WQI is designed to use colour or DOC as a parameter defining water quality. Although high DOC values may be observed for high trophic status lakes, it is generally not DOC associated with a humic content. Therefore, variables such as colour and DOC, which are naturally high in humic, coloured lakes were not considered in the WQI, but are still presented in the lake summary table, and compared to guidelines values.

The following section provides includes an interpretation of the data collected for each lake sampled as part of this study including and illustrated with a summary table of all water quality parameters, histograms of the trends in WQI until 2018, as well as histograms of the trends in the concentration in chl.a, TP and estimates of colour.

3.1 Land use associated with each lake

This year, data on land use was added to the report to provide a better understanding of the number of residences and activities (dams, agriculture, aquaculture) occurring within the boundaries of the lakes. The number of civic points correspond to the number of lots around the lake, and most have a property built on them (Residential Civic point). The residences are shown in individual maps for each lake below. The number of industrial properties is very low in the area, with Transportation, Transmissions and Storage (TR Civic Pt) being the most common. These sites are dams. The Table 3.1 below provides the detailed land use metrics for each lake.

TABLE 3-1 NUMBER OF RESIDENCES AND MAIN INDUSTRIAL ACTIVITIES THE KINGS COUNTY SAMPLED LAKES.

Name	Civic Points	Rs Civic Pt	TR Civic Pt**	AG Civic Pt	MA Civic Pt**
Armstrong Lake	65	65	0	0	0
Aylesford Lake	240	223	3	0	2
Black River Lake	76	65	3	1*	4
Gaspereau Lake	59	53	3	0	0
Hardwood Lake	3	3	0	0	0
Lake George	145	141	0	0	0
Lake Torment	285	278	1	0	0
Little River Lake	22	21	0	0	1
Loon Lake	48	46	1	0	0
Lumsden Pond	50	46	3	0	0
Murphy Lake	108	106	1	0	0
Sunken Lake	86	84	0	0	0
Tupper Lake	57	54	1	0	0

* This would be the fish hatchery
** These are the dams

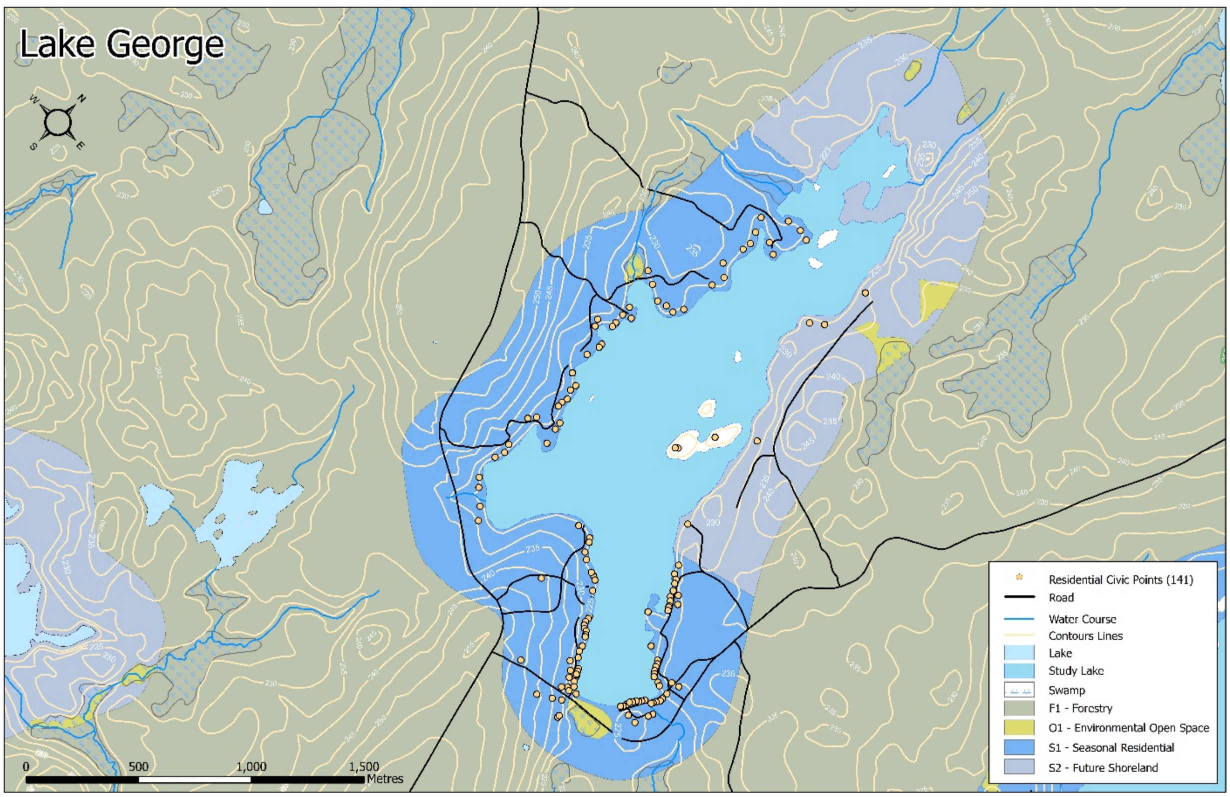
Term	Description
AG	Agriculture
MA	Manufacturing
RS	Residential
TR	Transportation, Transmissions and Storage

Statistical analyses (correlations and multiple regressions) were conducted using on one hand the number of residences and development, the proportion of the land occupied by these development and activities and, on the other hand all variables used to calculate the WQI values. The hypothesis was that a higher number of properties (and activities) may explain the differences in nutrients and chl.a concentration between lakes. These calculations were done using the 2018 data as well as with the last 5 years averages.

The results from these analyses are showing that none of the land use metrics had a significant influence on nutrient and chl.a concentrations. Furthermore, no significant relationship was found between land use data and WQI values. As noted for each lake, the concentrations in nutrient has been stable for many years (in particular for TP).

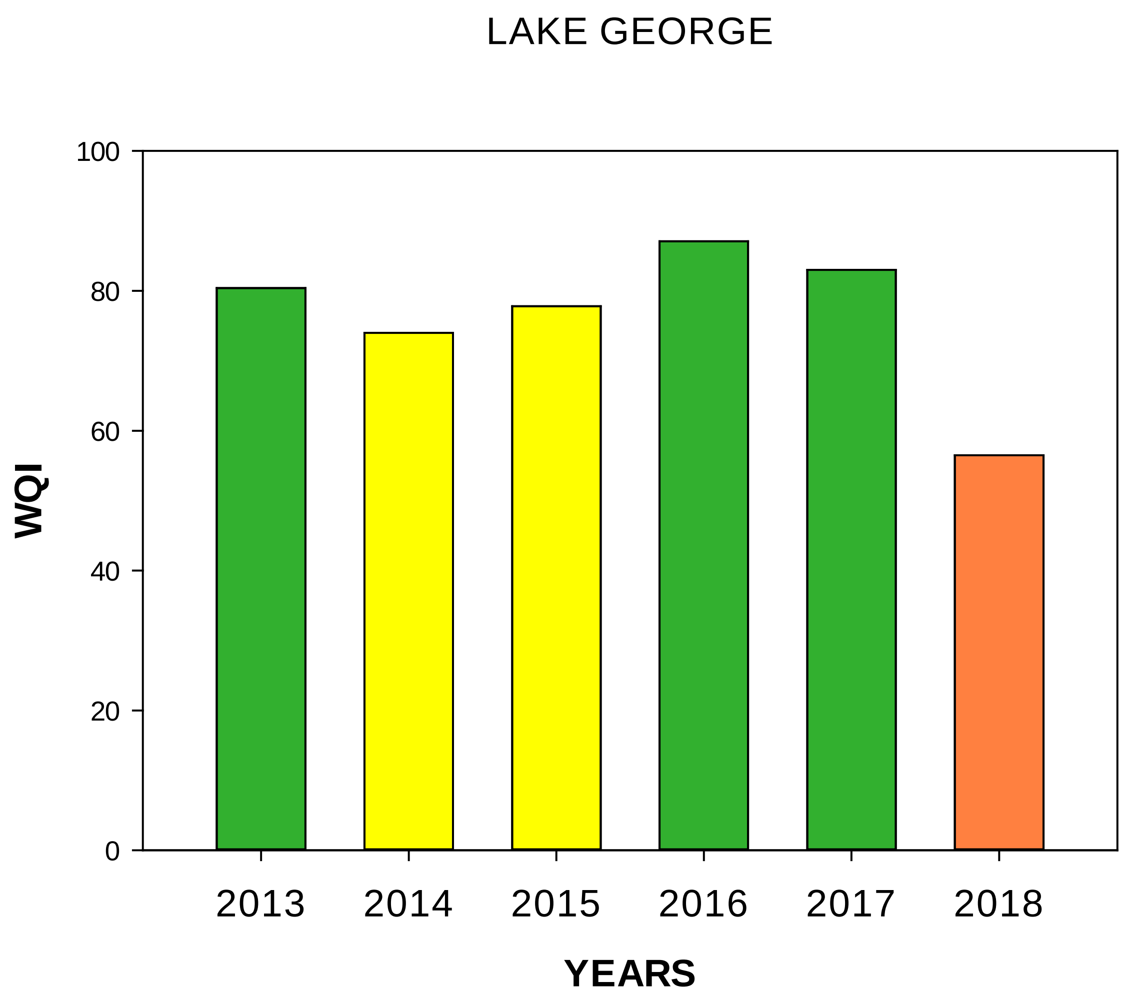
3.2 Lake George

Among the Kings County lakes, Lake George is the first lake in term of drainage. It is a fairly small lake (Lake surface area about 153 ha) and fairly shallow, with a maximum depth of 9 meters. Around the lake, there are 2 main zone types, with most of the properties located in the seasonal residential zone. The zones are equally distributed around the lake. This lake has been sampled as early as 1993, which is one of the longest time series for the Kings County lakes monitoring program.



Water Quality Index (WQI):

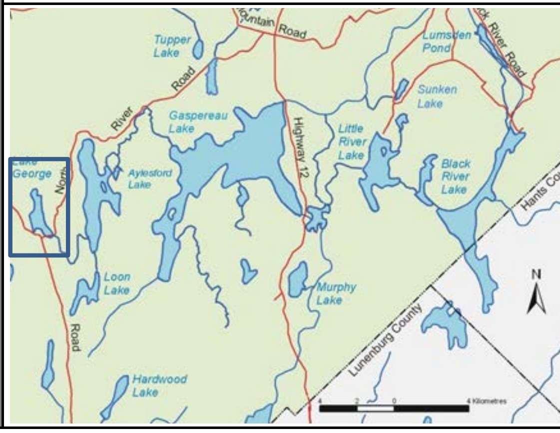
The water quality value for Lake George was 56.5, corresponding to a marginal water quality rating. This value is the lower compared values measured since 2013 and indicate that the lake may be in a transitioning trophic state.



Summary report card:

In 2018, Lake George showed exceedances in TP (Maximum of 18 μg/L compared to guideline at 14 μg/L) which promoted higher algal biomass and turbidity (also exceeding guideline values at the same date). The concentration in chl.a in the lake was an average 3.1 μg/L, which is above guideline and above the long term average of 2.5 μg/L. The decrease in WQI in Lake George (from good in the last two years to marginal) indicate the need to pursue monitoring to assess if the trophic state of lake is changing or not.

LAKE GEORGE



56.5

Drainage Order = 1

Elevation = 231 m

Lake Area = 153 ha

Max Depth = 9.5 m

1993-2018 Trends:

WQI change (1Y and 5Y): -32 and -30%

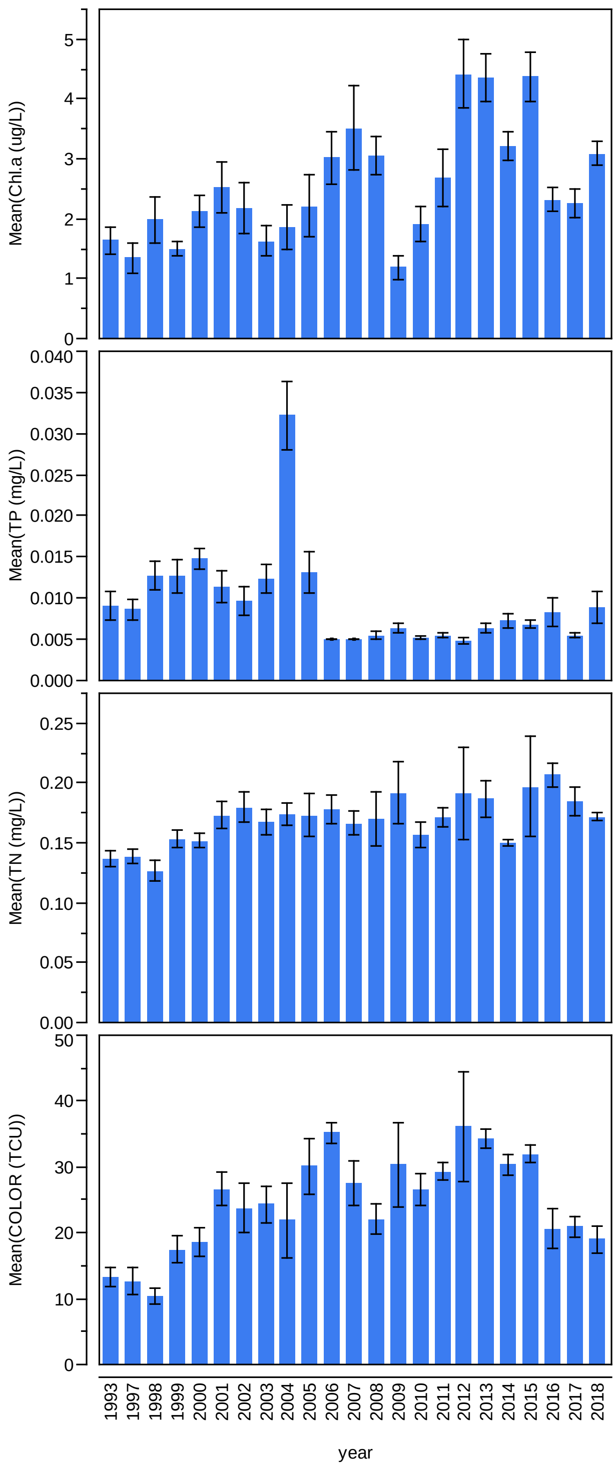
	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	14.1	2,5	3.5-5.3	6.3-6.7	2.9-4.1	17-31	350	1,3
2018 average	8,8	3,1	4,7	6,7	**3**	19	171	1,4
2018 (min - max)	(5 - **18**)	(2.5-**3.7**)	(4.4-5)	(6.6-**6.8**)	(2.4-3.5)	(14-27.1)	(160-180)	(0.6-**4.7**)
1993-2017 average	9,40	2,50	4,40	6,50	3,56	24,70	168	0,72

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

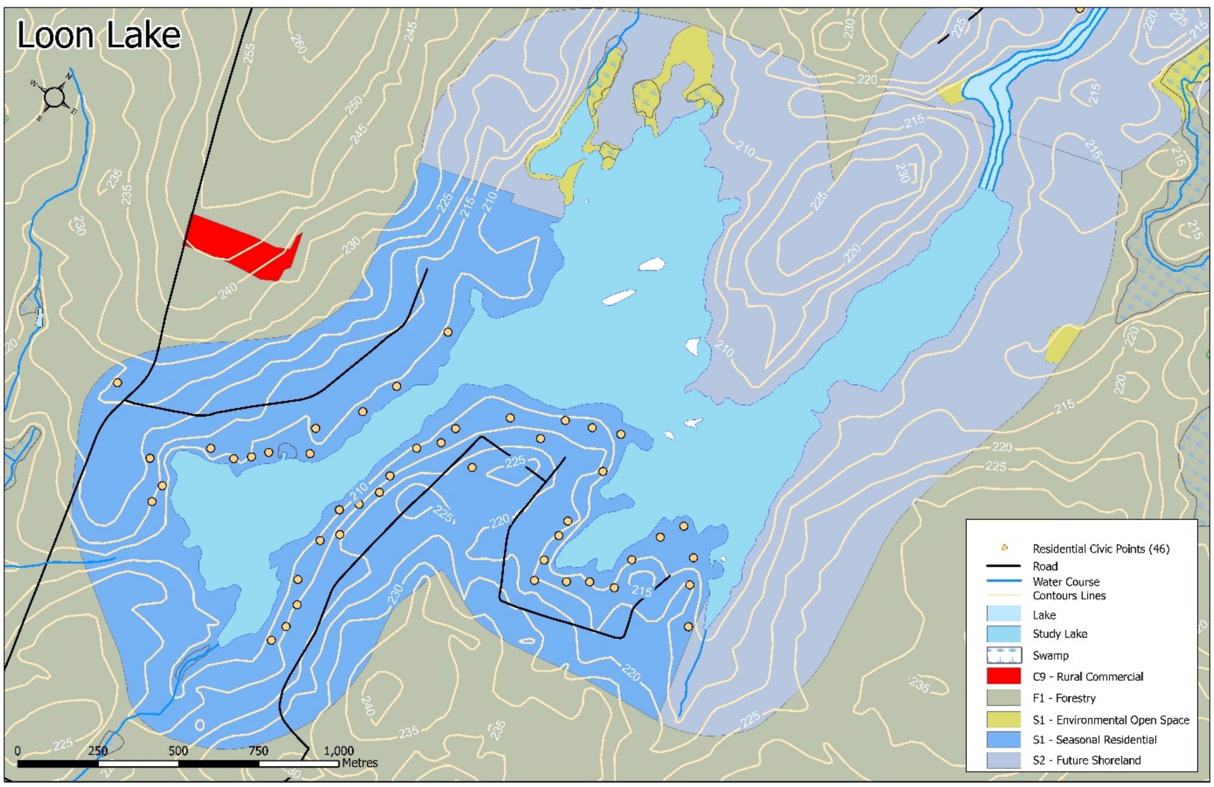
In 2018, the decrease in chl.a observed for the last 2 years (2016 and 2017) was not observed. As observed in previous years, the variation in Chl. a does not follow the trends although the year, the highest TP value was recorded when chl.a reached its maximum.

Lake George: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



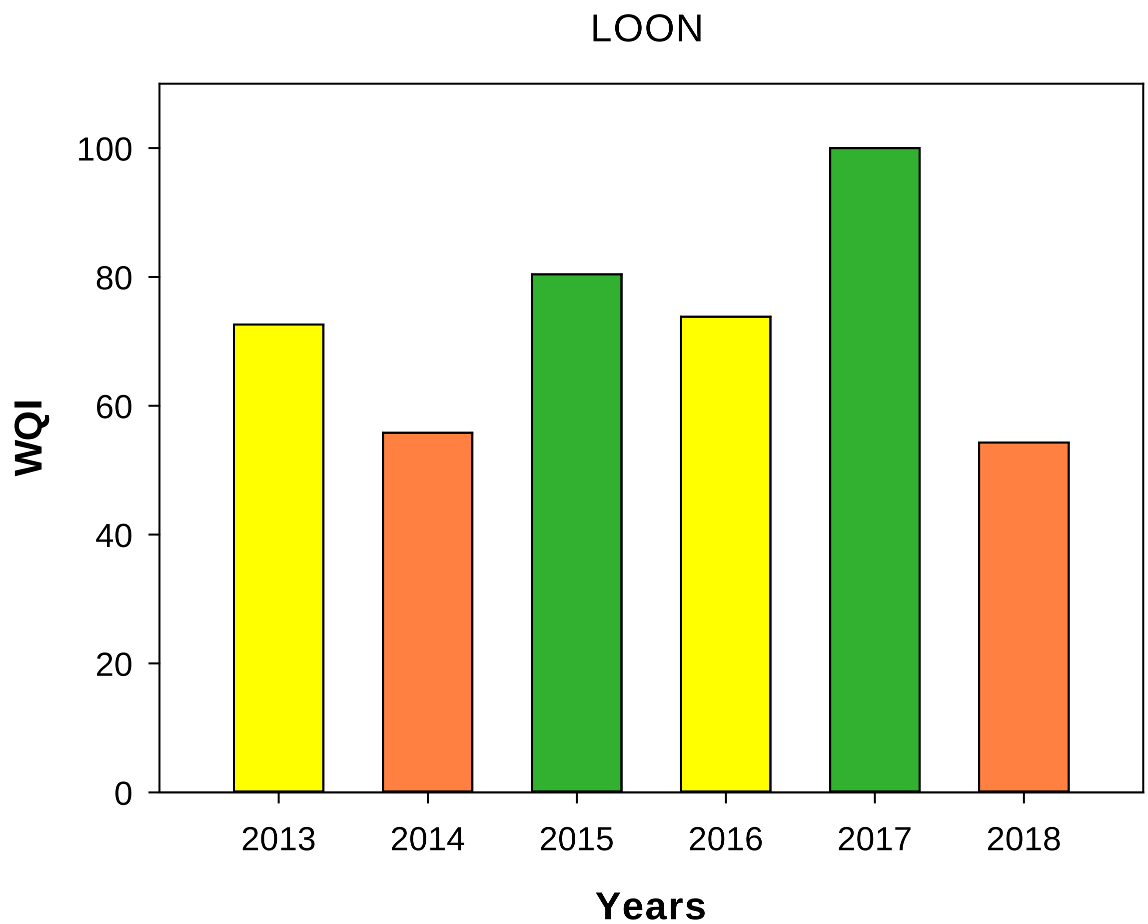
3.3 Loon Lake

Loon Lake is a small (90 ha), shallow (max depth 8.1m) Lake which is connected to the much larger Lake Aylesford. With Lake George, Loon Lake are the most upstream lakes of chain of lakes sampled in this study. Based on satellite imagery, the watershed of Loon Lake is mostly forested, although clear cutting activities may have occurred in the past. There is a mature riparian zone around the lake There are less than 50 residences on Lake loon, all located in the southern section of the lake.



Water Quality Index (WQI):

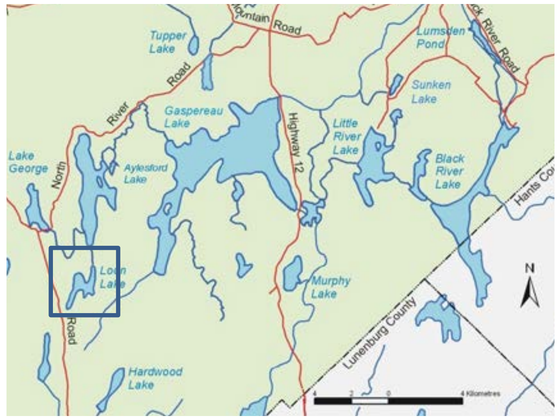
The Water Quality Index value for Lake Loon declined from 100 to 53.4 in 2018. This is the lowest value observed over the last 6 years. This result was due to exceedances in both TP and chl.a values.



Summary report card:

Although the mean value for the sampling season was below guideline, a very high concentration was observed (28 μg/L) which corresponded to a high chl.a value. The lake showed exceedances in several other parameters (DOC, pH, Secchi depth and turbidity), which suggest that the high TP value was not observed as the result of a sample contamination (due to algae in the sample for example).

LOON LAKE



54.3

Drainage Order = 1

Elevation = ~206 m

Lake Area = ~90 ha

Max Depth = 8.1 m

1993-2018 Trends:

WQI change (1Y and 5Y): -46 and -29%

	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	18.2	2,5	4.4-6.6	6-6.4	2.1-2.8	25-44	350	1,3
2018 average	13,1	**4,3**	5,7	6,4	2,7	29,6	205	**2,7**
2018 (min - max)	(6-**28**)	(2.1-**11.1**)	(5-**6.9**)	(6.2-**6.6**)	(2.5-**2.9**)	(20.2-39.1)	(190-240)	(0.75-**7.25**)
1993-2017 average	12,10	**3,40**	5,40	6,20	2,50	35,50	193	1,02

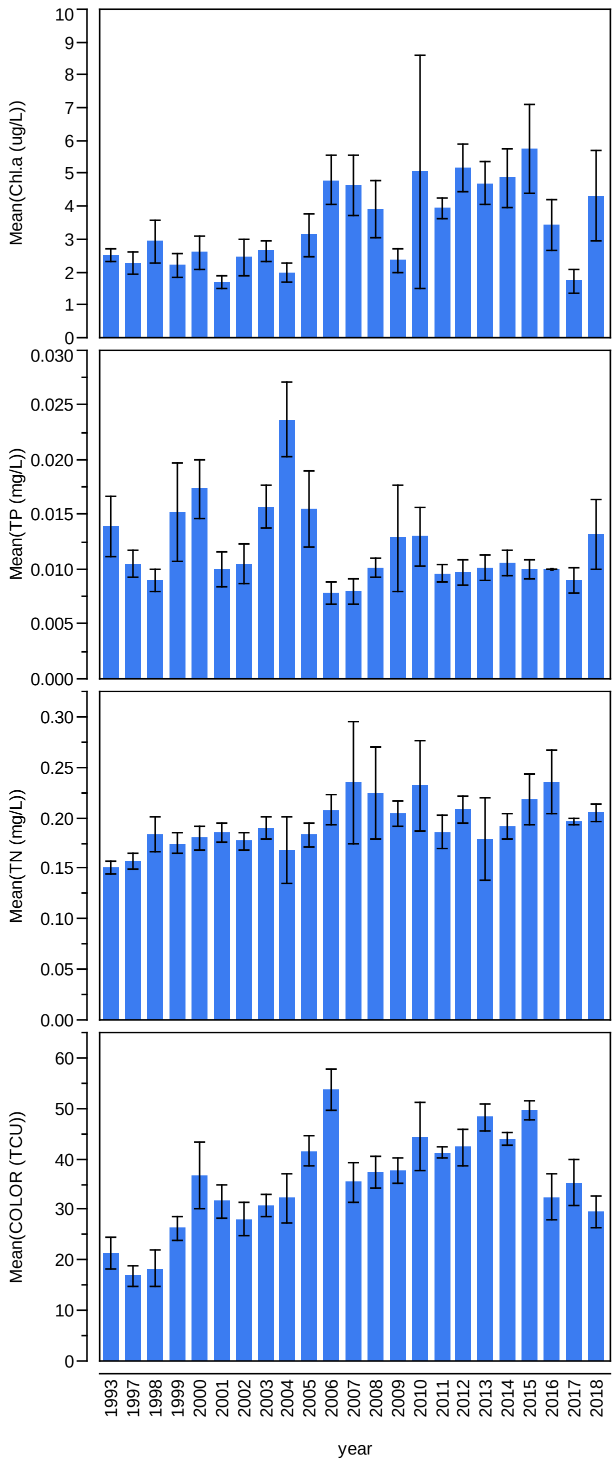
0-44	45-64	65-79	80-94	95-100
Poor	**Marginal**	**Fair**	**Good**	**Excellent**

Long-term trends:

The long-term trends for Lake Loon are showing that the decline in Chl.a reported in 2016 and 2017 was not observed in 2018: it came back to a level similar to 2010-2015. The concentrations in TP are close to 10 µg/L for the last 7 years, but increased to 13.1 µg/L in 2018, likely causing the increase in chl.a.

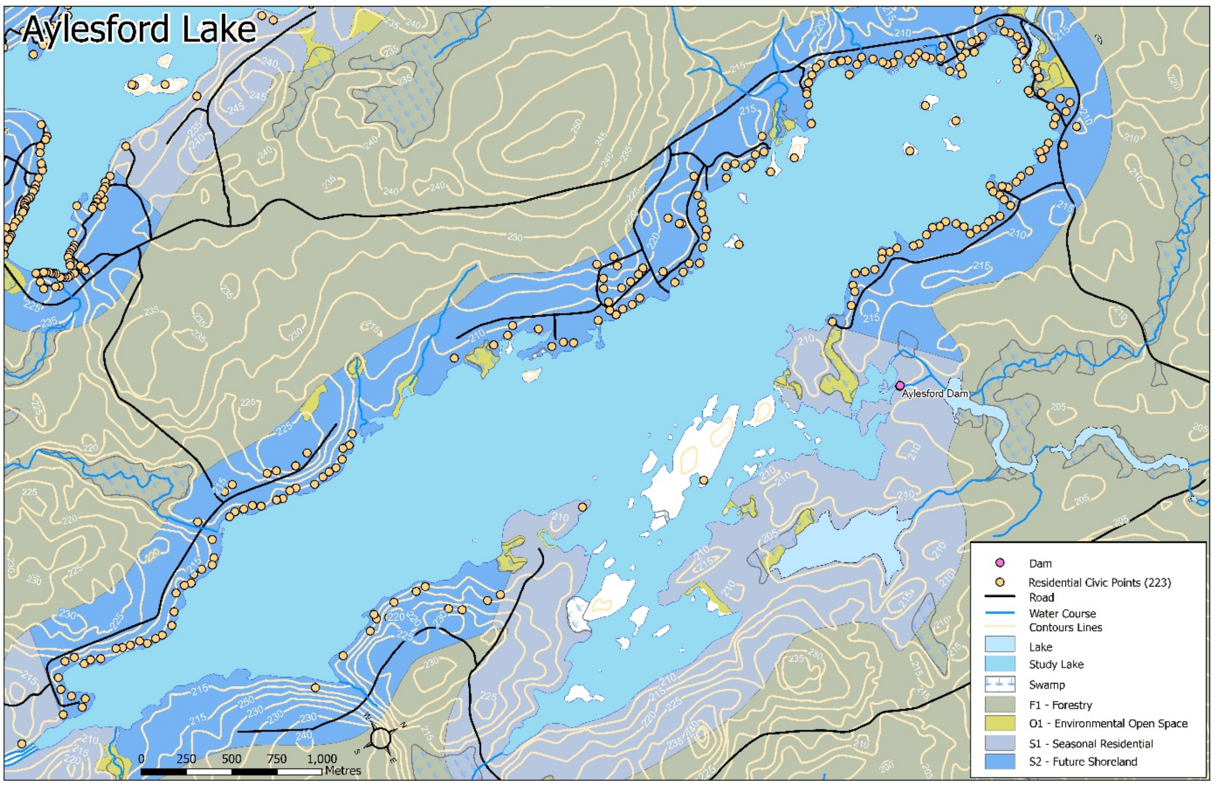
The values in colour declined observed in 2016 and 2017 was also reported in 2018.

Loon Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



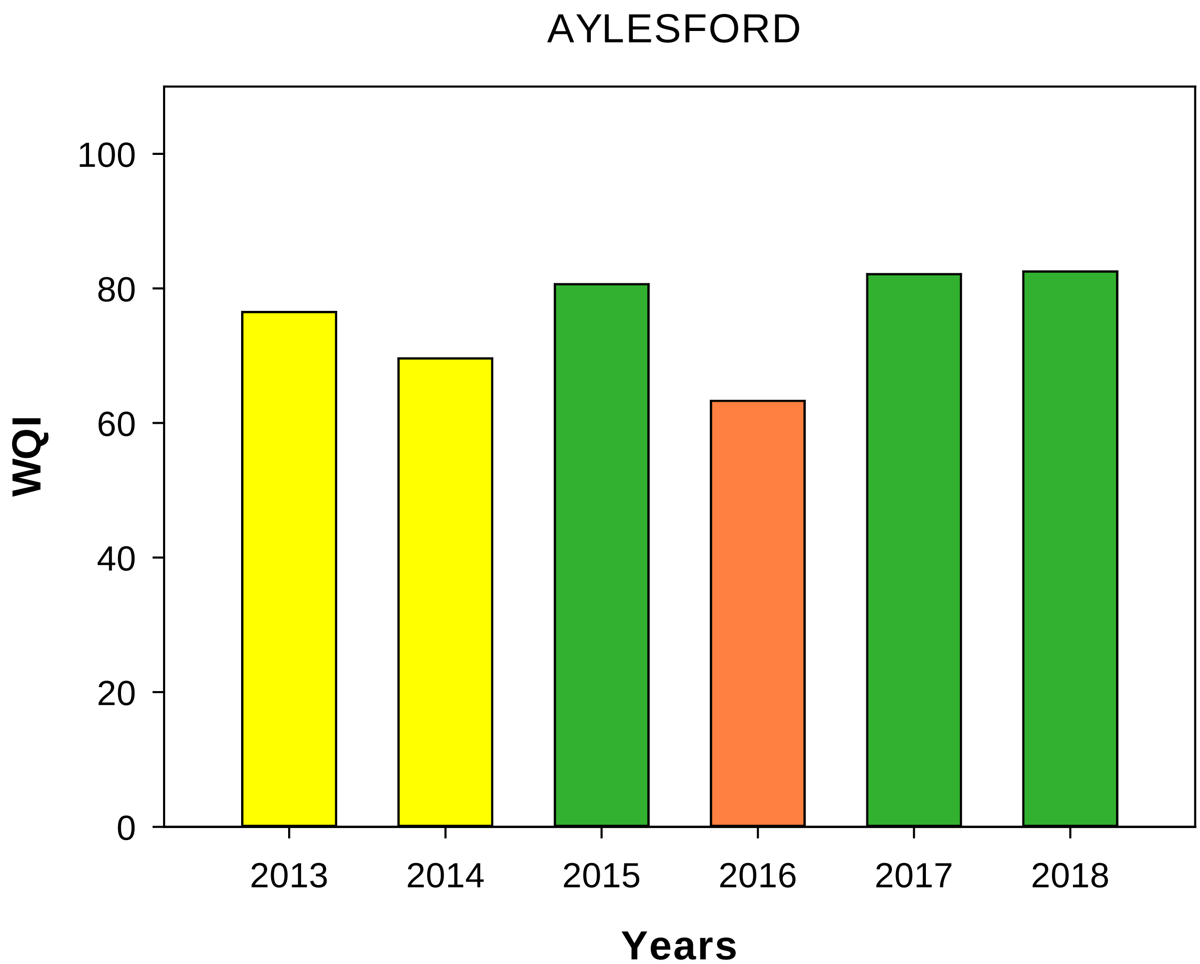
3.4 Aylesford Lake

Aylesford Lake is the third largest lake in this study with a surface area of 532 ha. It is a fairly shallow lake (given its size) with maximum depth of 12m. The lake is part of chain of several lakes, and is positioned as second order in drainage. The water of Aylesford Lake flows into the largest lake, Gaspereau. As for the other lakes in the area, Lake Aylesford is surrounded by forested areas. The majority of the lakes nearshore is developed with a dense number of residences.



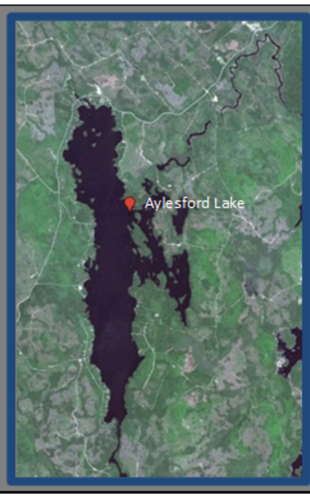
Water Quality Index (WQI):

The Water Quality Index for Lakes Aylesford was 82.7 (good rating) in 2018, a value similar to that measured in 2017. This is a 30% increase compared to 2016 and a similar value to that measured in 2015 (from 63 to 82). The only variable that showed exceedances slightly above guideline value was the chl. a concentration (mean value of 2.6 µg/L).

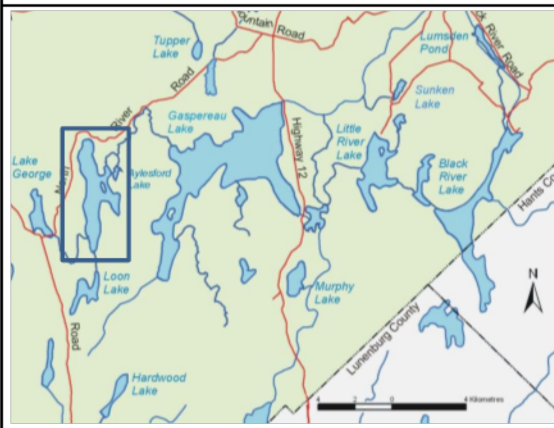


Summary report card:

Exceedances were observed in chl.a concentration, causing the mean value for 2018 to be slightly above guidelines (2018: 2.6 µg/L; guideline: 2.5 µg/L). This result was caused by high concentrations reaching 4.3 µg/L. All other variables were below guideline levels.



AYLESFORD LAKE



82.5

Drainage Order = 2

Elevation = 216 m

Lake Area = 532 ha

Max Depth = 12 m

1993-2018 Trends:

WQI change (1Y and 5Y): 0 and 11%

	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	15,6	2,5	4.4-6.6	6-6.3	2.2-3.2	24-45	350	1,3
2018 average	6,80	2,60	5,40	6,20	2,50	30,00	173	0,63
2018 (min - max)	(6-8)	(1-4.3)	(4.9-6)	(6 - 6.3)	(1.7-3.9)	(21-43)	(160-180)	(0.5-0.78)
1993-2017 average	10,50	3,00	5,50	6,20	2,70	34,00	185	0,66

0-44	45-64	65-79	80-94	95-100
Poor	**Marginal**	**Fair**	**Good**	**Excellent**

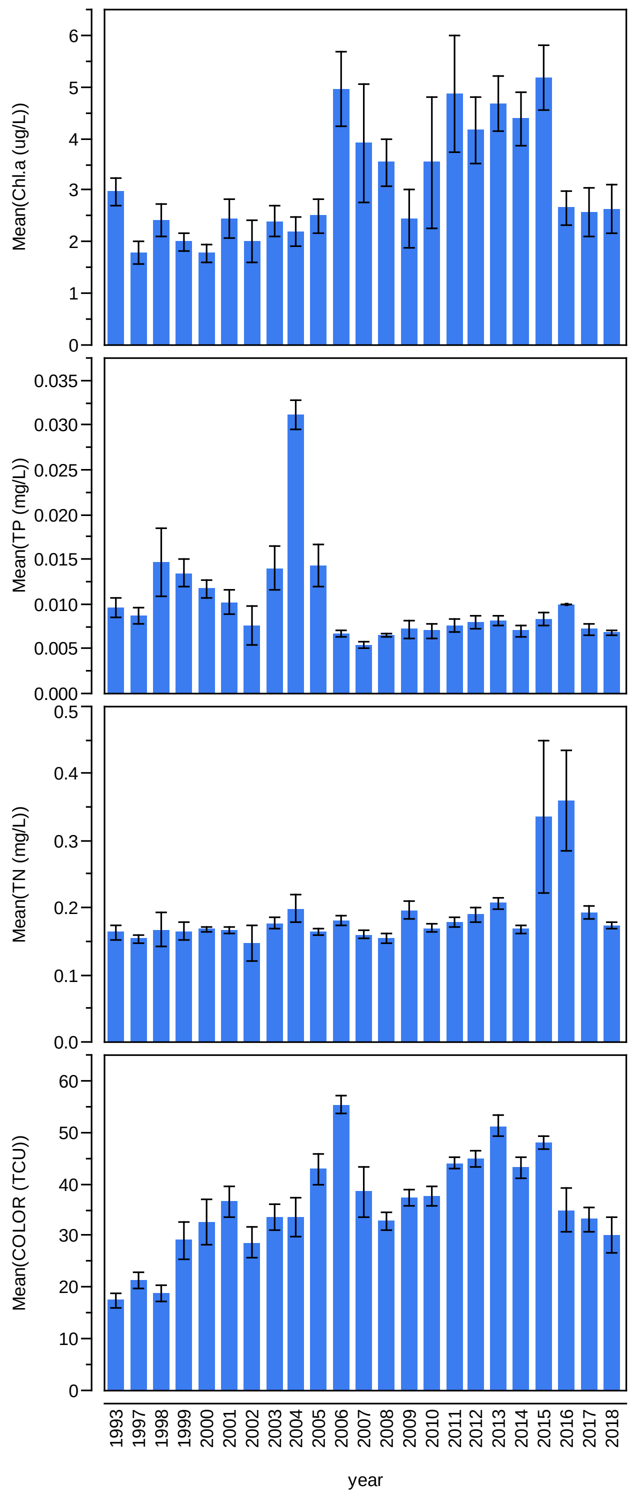
Long-term trends:

In 2018, the concentration in chl.a in lake Aylesford was similar to 2016 when a sharp decline was observed (almost 50%). The recent variation in chl.a was not related to changes in TP concentrations which have remain similar for the last 12 years, and below 10 µg/L.

The concentrations in TN peaked in 2015 and 2016, to levels above guidelines but have returned in 2018 to more frequent levels (less than 200 µg/L).

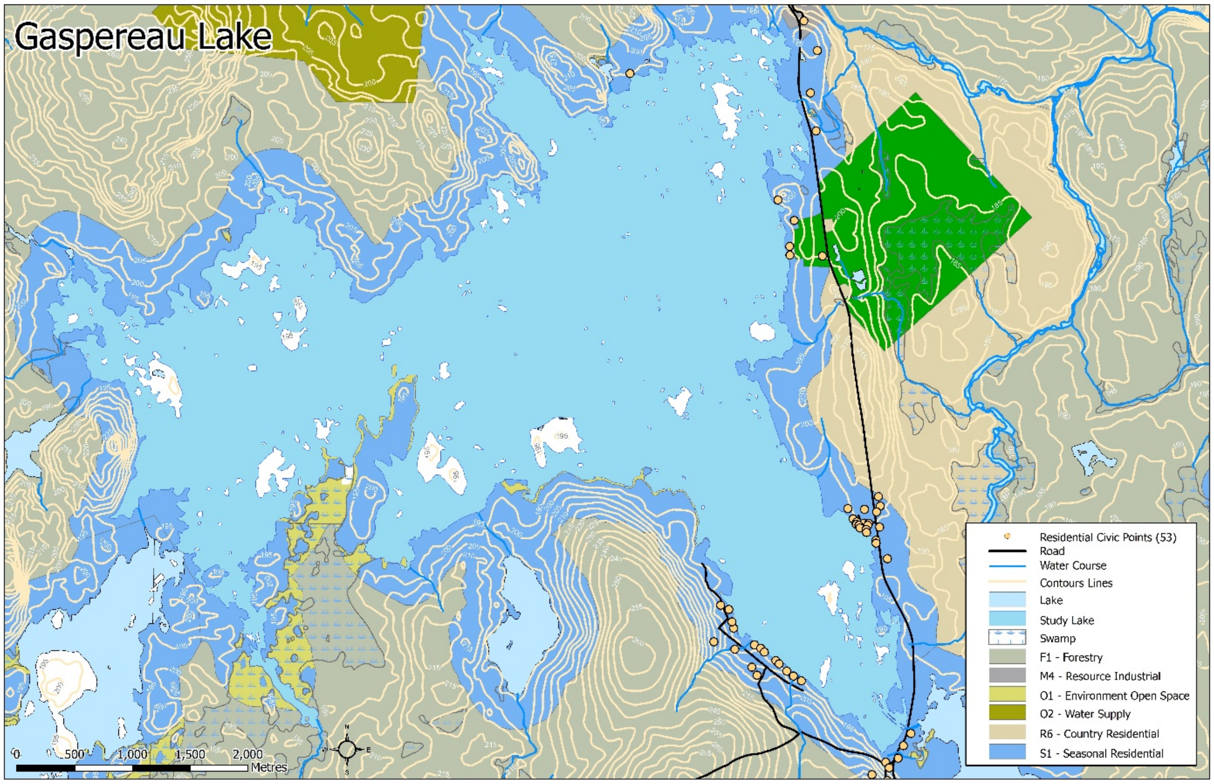
Consistent with several other lakes in the area, the mean value for colour has declined in the last 2 years, with similar values observed for 2016, 2017 and 2018.

Aylesford Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



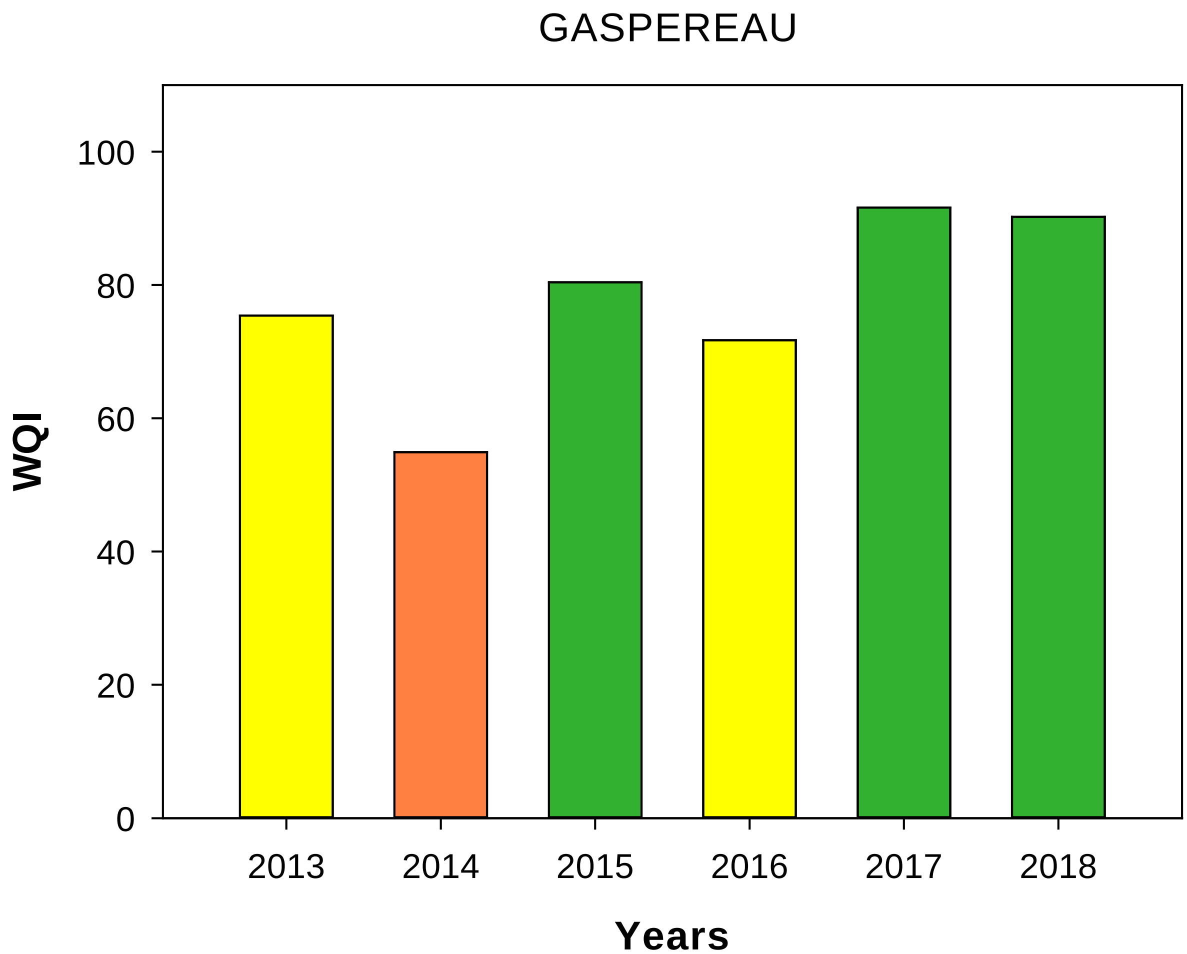
3.5 Gaspereau Lake

Gaspereau Lake is the largest lake in this study, with a surface area of 2,200 ha. For its size, it is fairly shallow, with a maximum depth of 10.9 m. Gaspereau Lake receives some of its water from Lake Aylesford (upstream), which shares similar water quality. Gaspereau Lake has a complex morphology and has a watershed mostly forested. Based on satellite imagery, this lake has little residential development in its watershed.



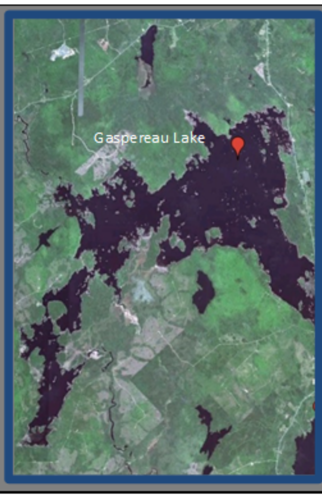
Water Quality Index (WQI):

In 2018, the WQI in Gaspereau Lake was 90.2, a good rating. This value is similar to that measured in 2017 and explained with similar water quality parameters.

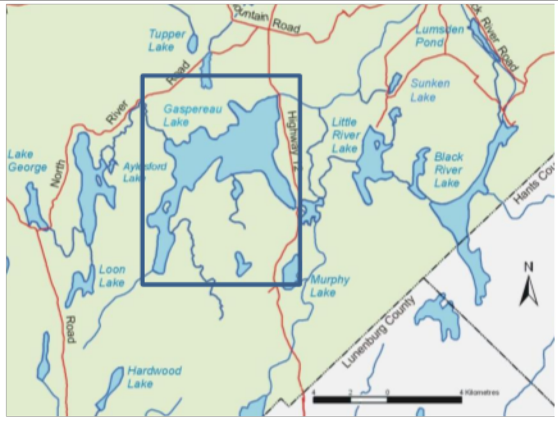


Summary report card:

The concentration in chl.a exceeded guideline significantly at one sampling date (maximum of 5 µg/L) and overall the mean chl.a concentration was also above guideline value (2.8 µg/L). Concentrations in chl.a were not related to nutrient concentration (TP and TN) which have remained fairly constant over the last 10 years.



GASPEREAU LAKE



90.2

Drainage Order = 3

Elevation = 175 m

Lake Area = 2200 ha

Max Depth = 10.9 m

1998-2018 Trends:

WQI change (1Y and 5Y): -2 and 21%

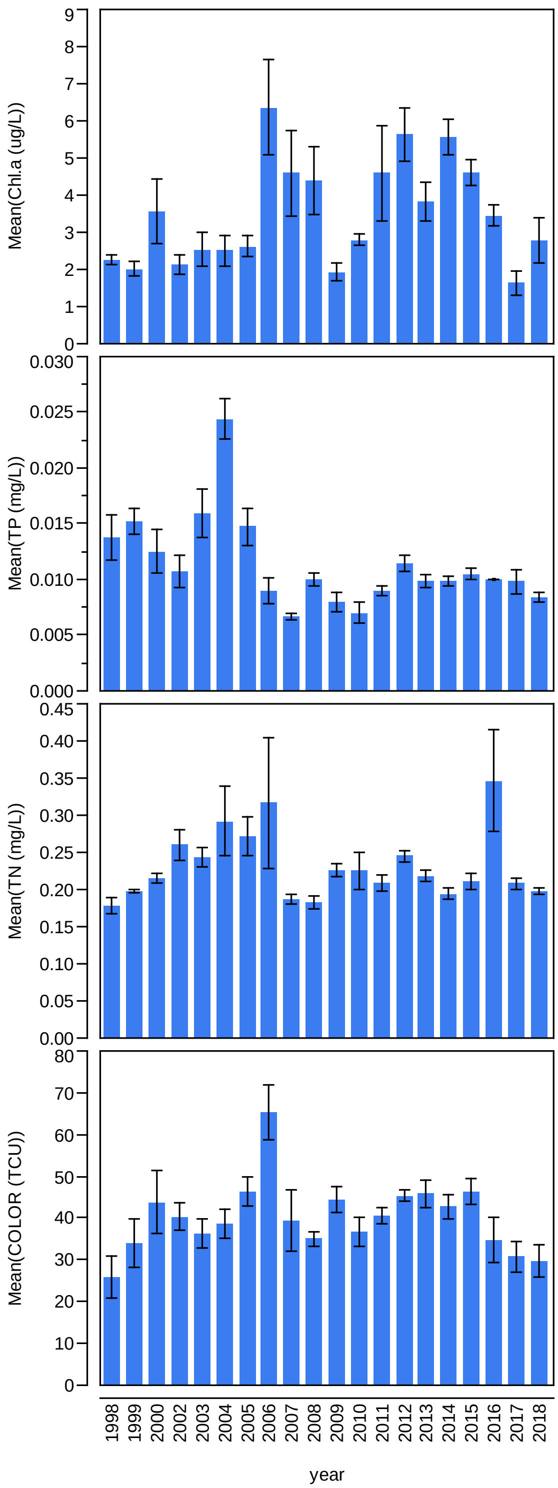
	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	17,5	2,5	4.6-6.9	6.1-6.4	1.7-2.2	33-48	350	1,3
2018 average	8,40	2,80	5,40	6,30	**2,60**	29,60	198	0,80
2018 (min - max)	(8-10)	(2.4-**5.0**)	(4.8-6)	(6.1 - 6.4)	(2.2-**2.9**)	(20-41)	(190-210)	(0.7-1.1)
1998-2017 average	11,90	**3,60**	5,70	6,30	1,96	41,00	236	0,99

0-44	**45-64**	**65-79**	**80-94**	**95-100**
Poor	**Marginal**	**Fair**	**Good**	**Excellent**

Long-term trends:

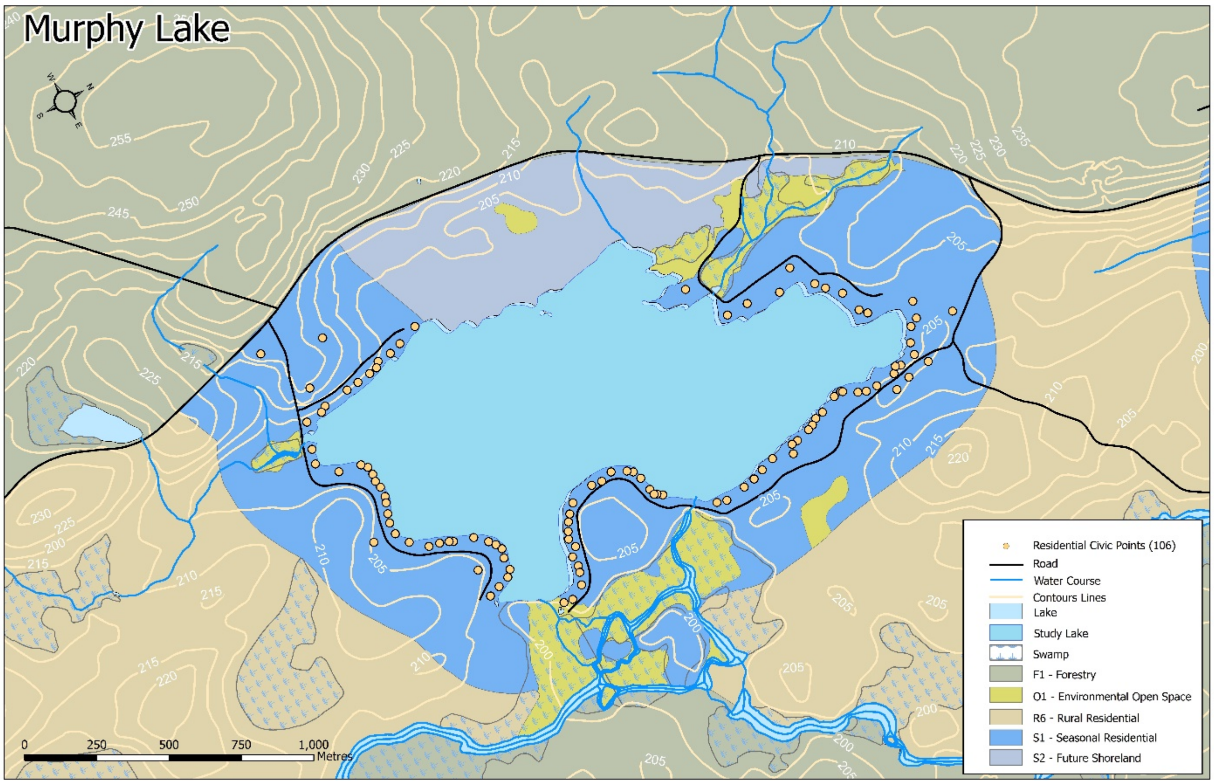
Long-term trends for Lake Gaspereau show that chl.a concentration has increased compared to 2017 but remains lower compared to past 10 years. As mentioned above, nutrients levels (TP and TN) have remained constant over the last decade. The value for colour continues to decline in 2018, as it did for the last 3 years.

Gaspereau Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



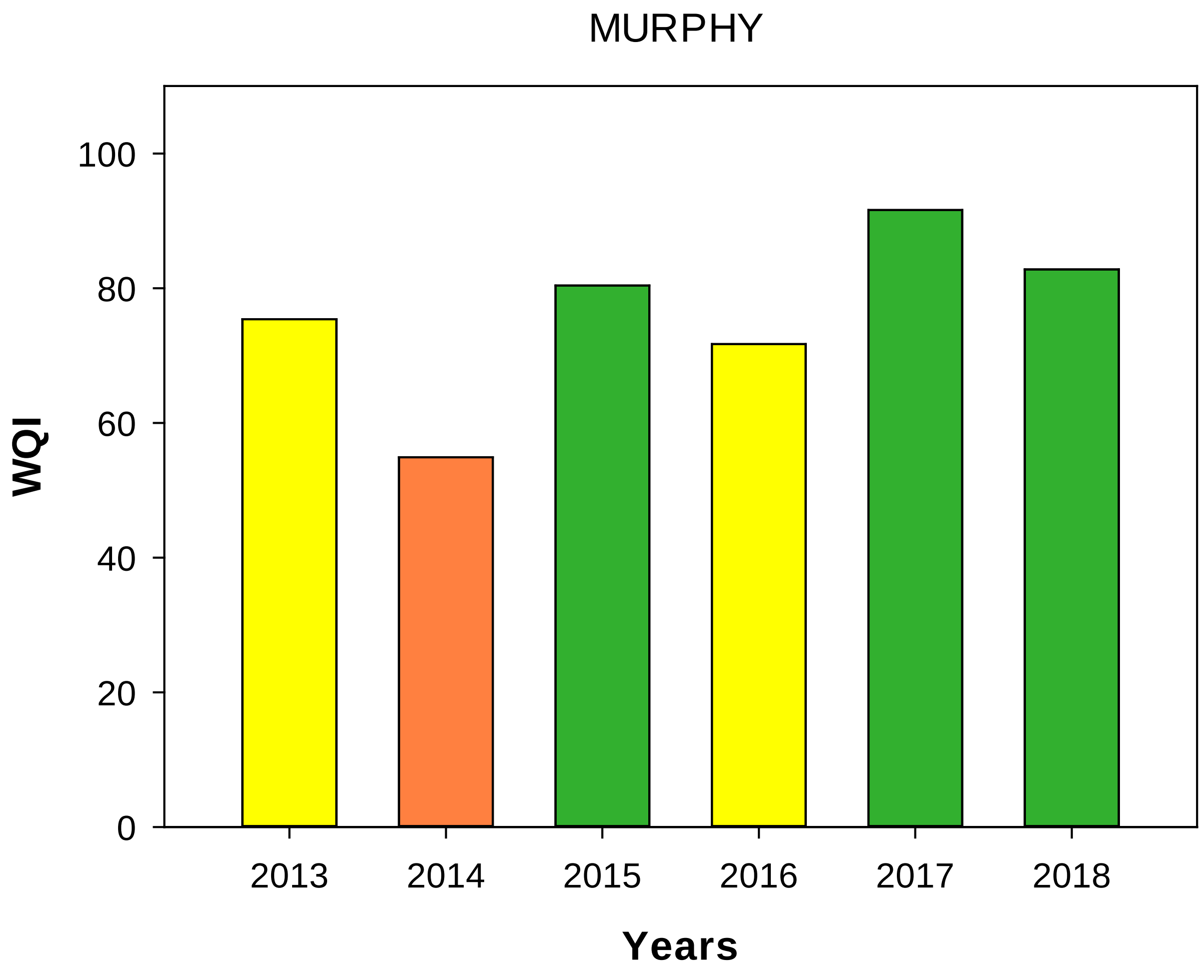
3.6 Murphy Lake

Murphy Lake is a fairly small (121 ha), and shallow (max depth: 6.8 m) lake. Its watershed is surrounded by a forested area on the western side. Residential development occupies most of the contour of the lake.



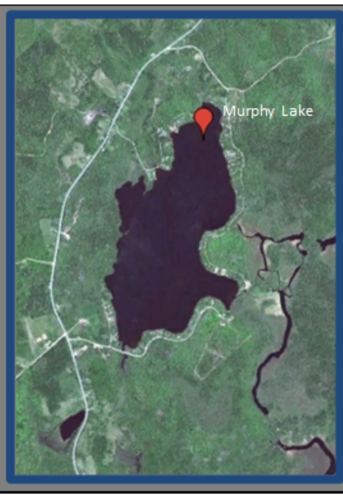
Water Quality Index (WQI):

The Water Quality Index of Murphy Lake was 82.8 in 2018, which is rated as a good water quality. This rating is similar to 2017 and is among the highest values observed in the last 6 years. This good rating is explained by a low frequency of values above guidelines: only Chl. a concentration exceeded guideline value once in 2018.

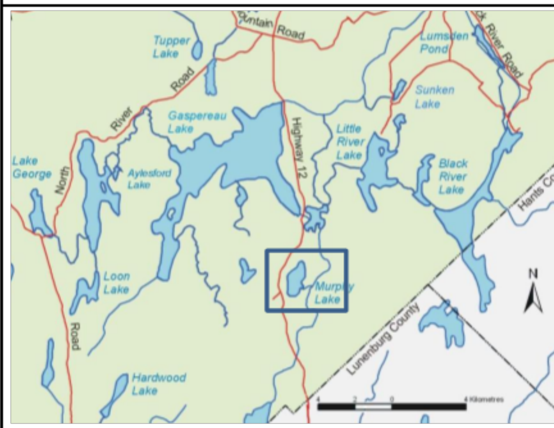


Summary report card:

The results observed in 2018 are similar to those reported in 2017. The lake has low phosphorous concentrations, close to 10 µg/L. Both TP and TN concentrations remains low and without significant positive (or negative) trends for the last decade in the lake.



MURPHY LAKE



82.8

Drainage Order = 3

Elevation = 207 m

Lake Area = 121 ha

Max Depth = 6.8 m

1997-2018 Trends:

WQI change (1Y and 5Y): 0 and 18%

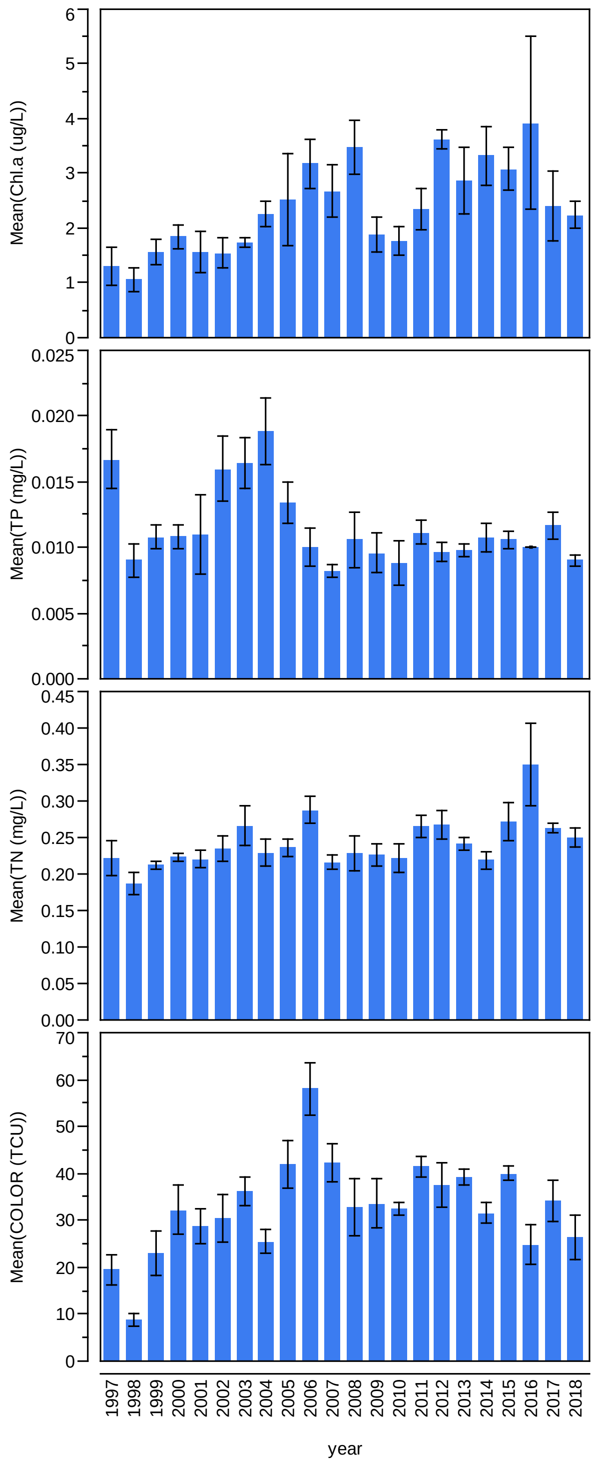
	Parameter							
	TP (µg/L)	Chl A (mg/m^3)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	17.2	2.5	4.9-7.4	6.5-6.9	1.7-2.3	25-42	350	1,3
2018 average	9,00	2,20	6,20	6,90	1,70	26,40	250	1,00
2018 (min - max)	(8 - 10)	(1.5-**2.9**)	(5.5-6.9)	(6.7-**7**)	(1.2-2.1)	(**16.6**-42)	(230-300)	(0.75-1.4)
1997-2017 average	11,60	2,40	6,20	6,70	2,00	33,60	243	**1,40**

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

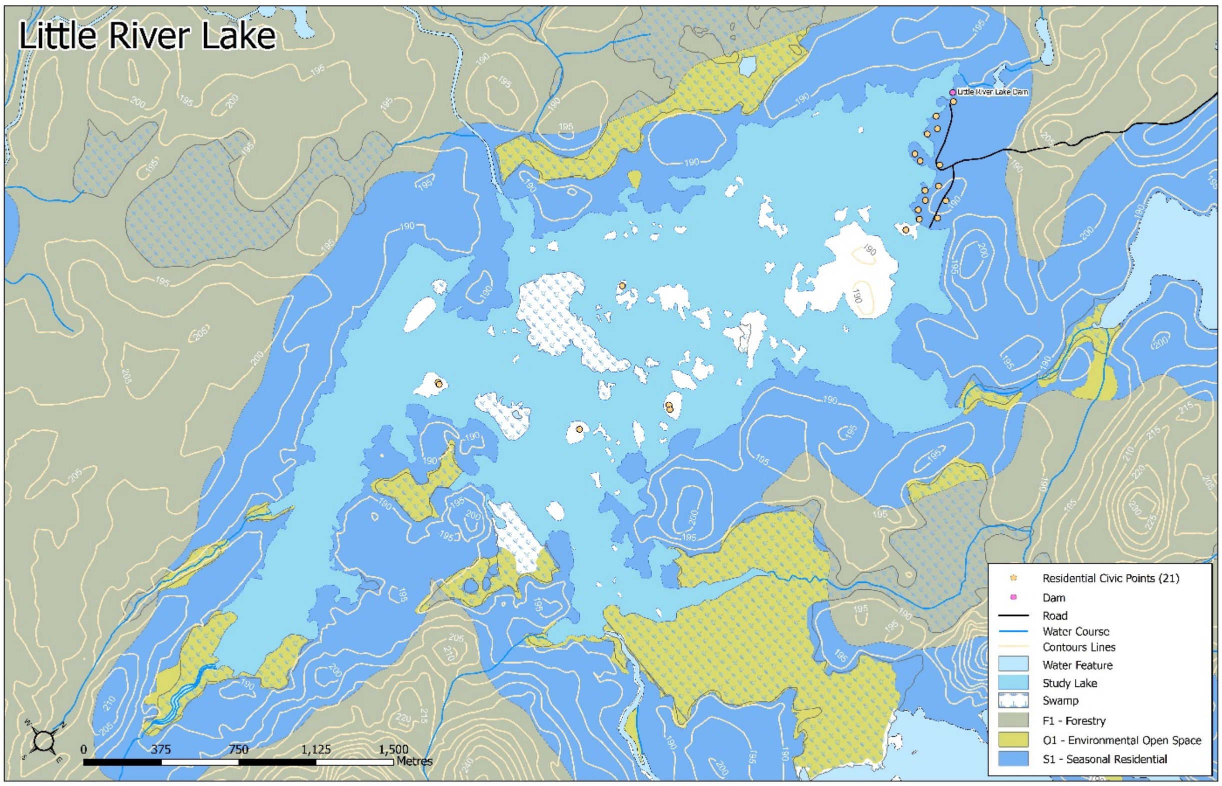
The long-term trends in chl. a concentration shows that the increase recorded 2016 is not observed in both 2017 and 2018. This decline in chl.a is about 50% compared to 2017. As reported in 2017, this decline is not related to a decline in TP, as it remained constant for the last 12 years. The mean TN concentration observed in 2018 is similar to the long term average close to 225 mg/L, a value below guideline.

Lake Murphy: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



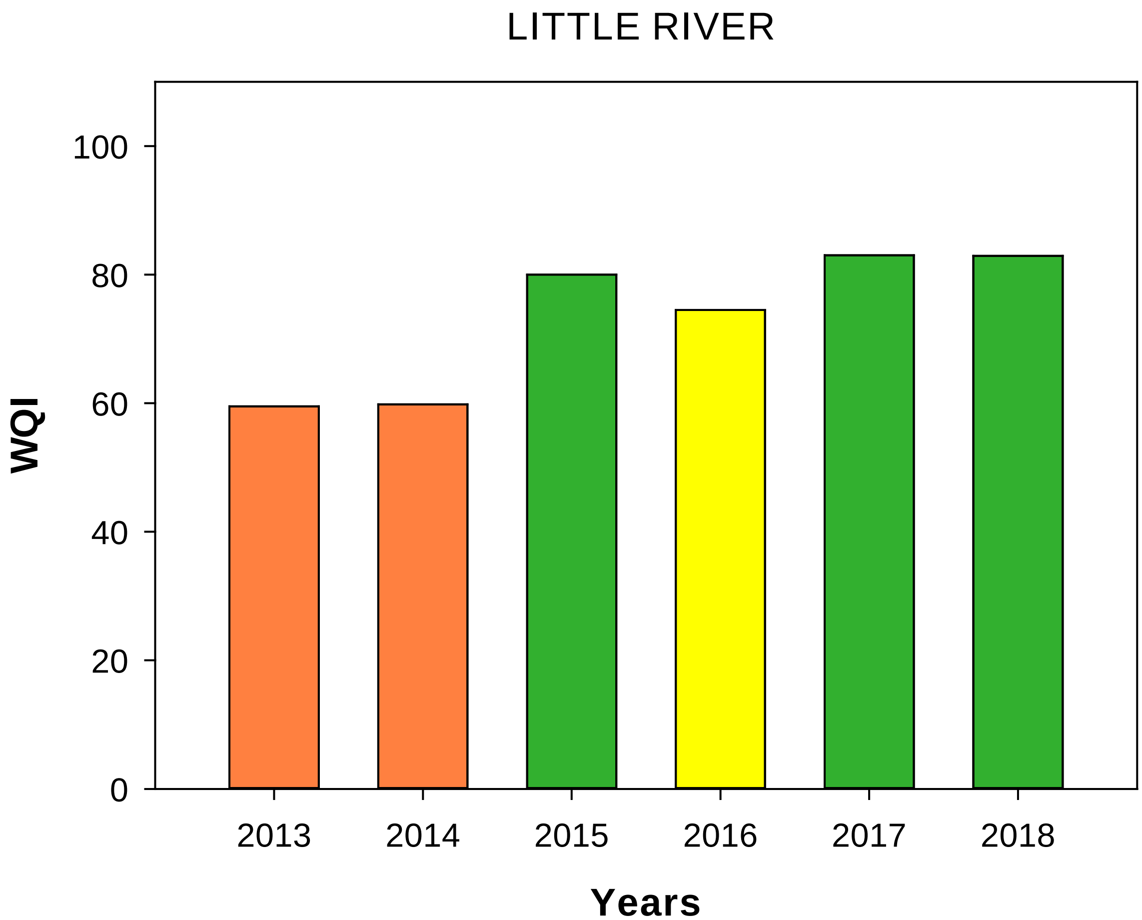
3.7 Little River Lake

Little River Lake is a medium size lake (surface: 520 ha) and has a maximum depth of 6.6m. Little River Lake is located between 2 much larger lakes: Lake Gaspereau upstream and Black River Lake downstream. It has almost no residential development.



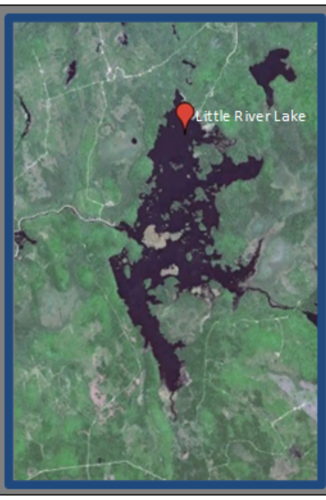
Water Quality Index (WQI):

In 2018, the Water Quality Index for Little River Lake was 82.9, indicative of a good water quality. This value is value is the same as in 2017. Similar to Murphy Lake, exceedances were observed only for chl.a that reached a value of 4.3 µg/L, once in the summer. None of the seasonal mean values exceeded the guidelines for this lake with the exception of chl.a (mean value of 3.2 µg/L).

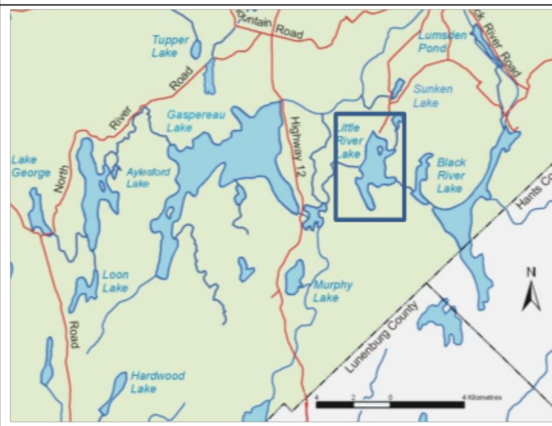


Summary report card:

The 2017 results for Little River Lake are comparable to those in Murphy Lake. There was one exceedance observed for chl.a (value of 4.3 µg/L) which led to a higher mean chl.a value, above guideline for this lake.



LITTLE RIVER LAKE



82.9

Drainage Order = 4

Elevation = 189 m

Lake Area = 520 ha

Max Depth = 6.6 m

1998-2018 Trends:

WQI change (1Y and 5Y): 8 and 26%

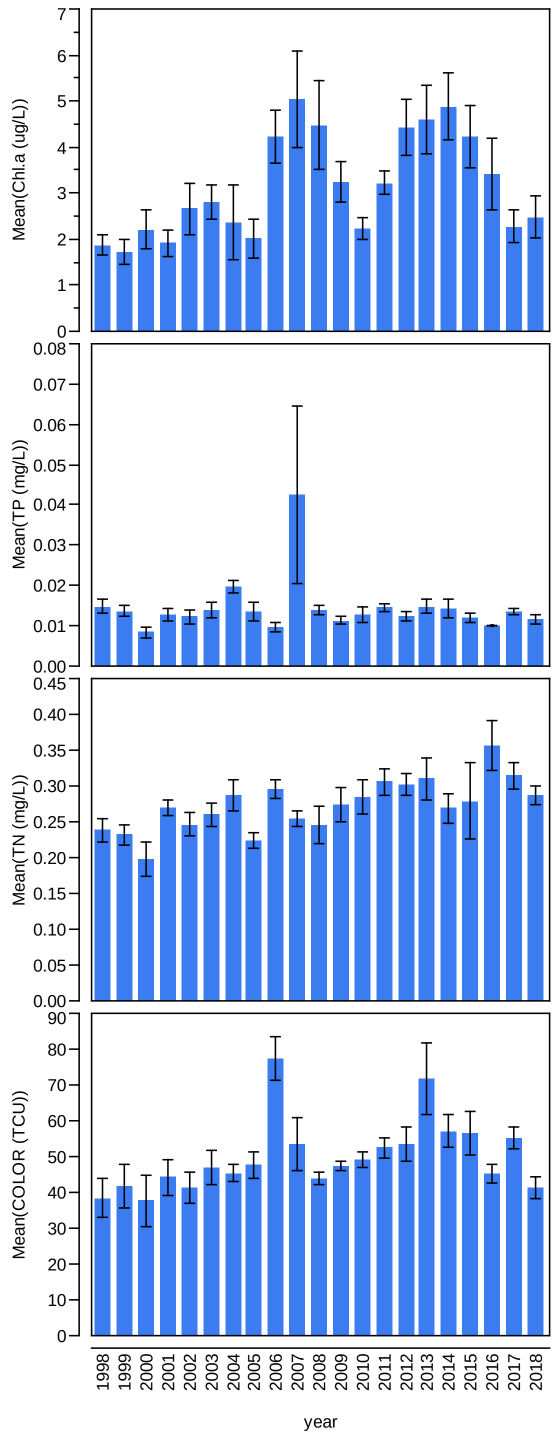
	Parameter							
	TP (µg/L)	Chl A (mg/m^3)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	20	2,5	5.2-7.8	6.1-6.5	1.8-2.4	43-55	350	1,3
2018 average	11,50	2,47	6,70	6,50	2,00	41,30	286	0,95
2018 (min - max)	(9-15)	(1.5-4.3)	(5.7-7.5)	(6.4-6.6)	(1.7 - 2.3)	(29.8-51)	(250-330)	(0.7-1.3)
1998-2017 average	14,10	3,20	6,50	6,40	2,12	49,30	266	1,00

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

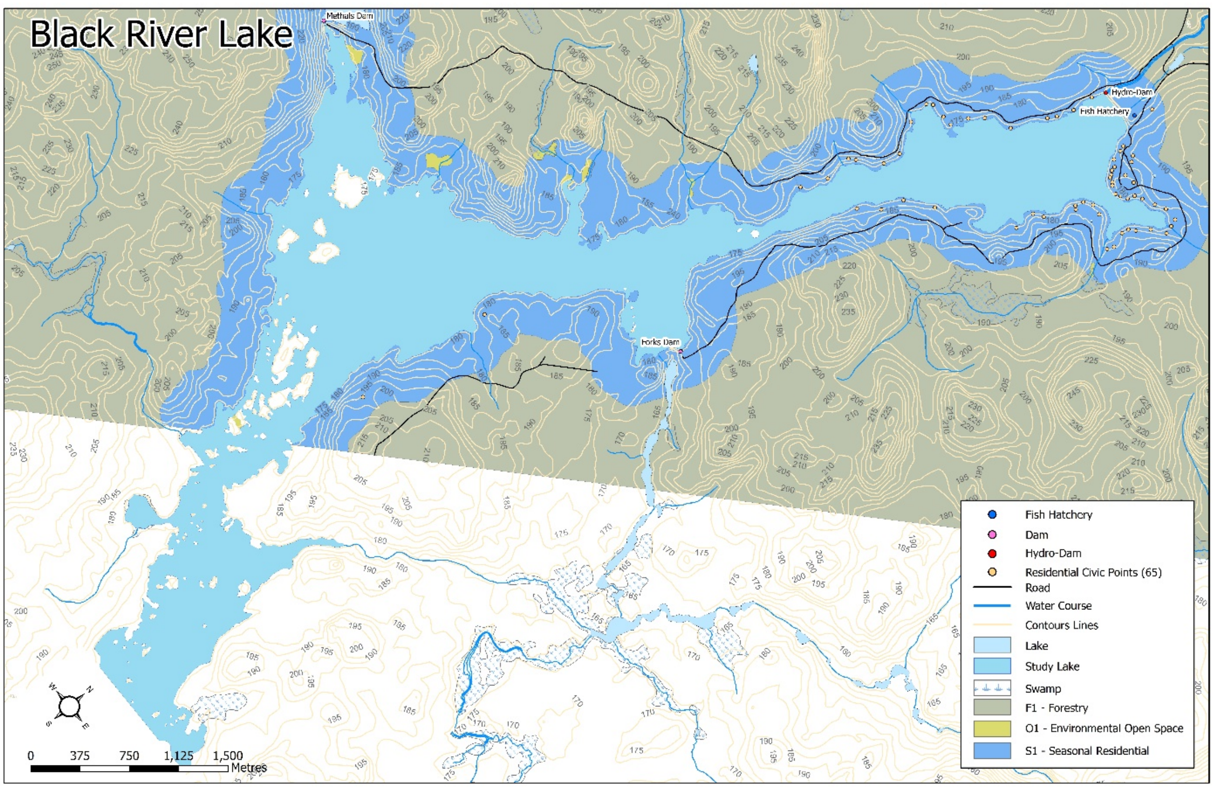
The long-term trend in chl.a is showing a decline between 2014 to 2017. In 2018, similar values were observed compared to 2017. No changes in TP concentration were recorded in 2018 compared to the last decade. The concentration in TN has decreased over the last 3 years. Both TP and TN values remain very low in the lake, consistently below guideline values.

Little River Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



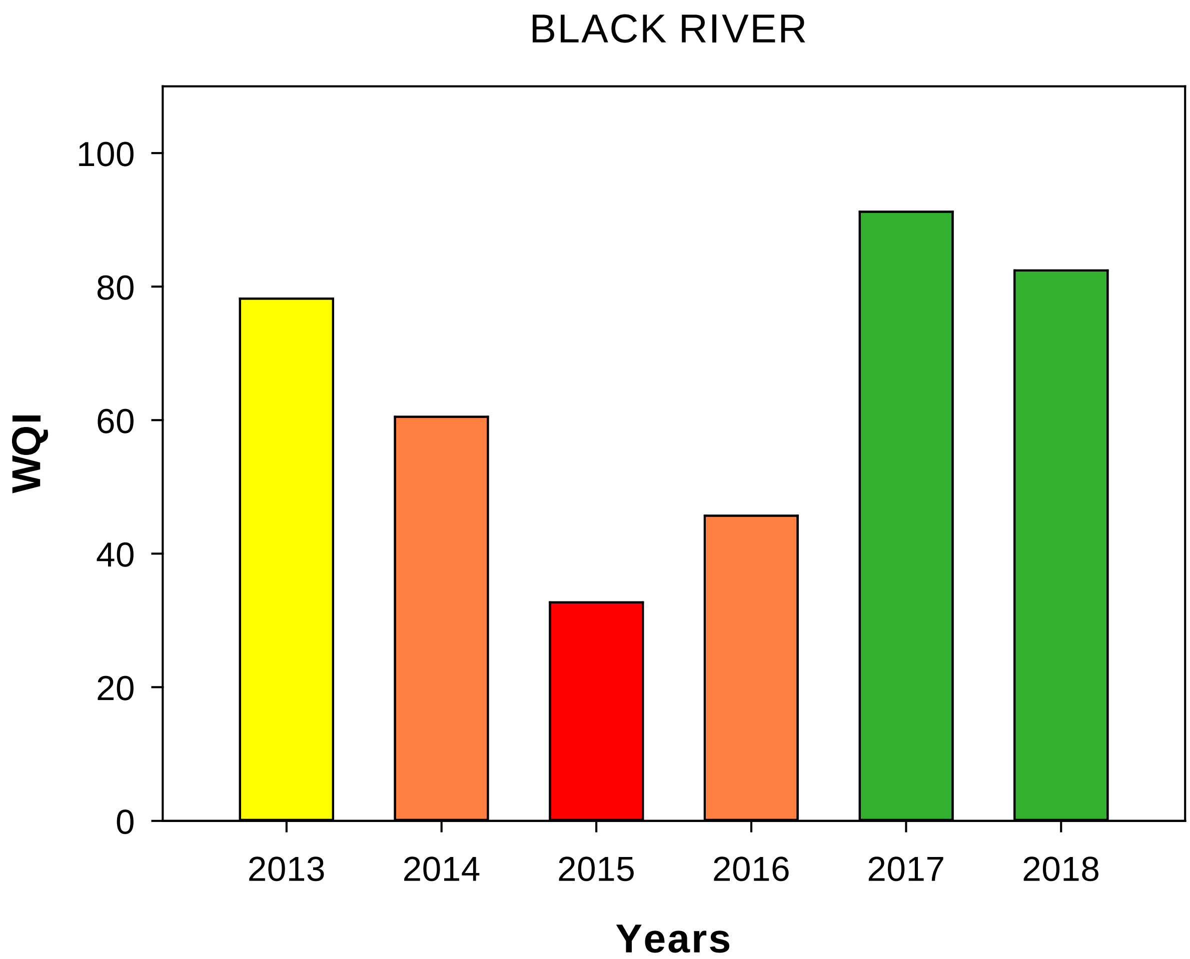
3.8 Black River Lake

Black River Lake is the second largest lake in this study (surface: 668 ha) and is also the deepest (max depth: 15 m). The lake has a long narrow shape and receives most of its water from Little River Lake. Compared to the other lakes in this study, Black River Lake is more coloured, because of higher content in dissolved organic carbon. The tea colour of the water may explain the name of the lake. Black River Lake water levels are managed by 2 dams and residential properties are found in a small number in the north east side of the lake.



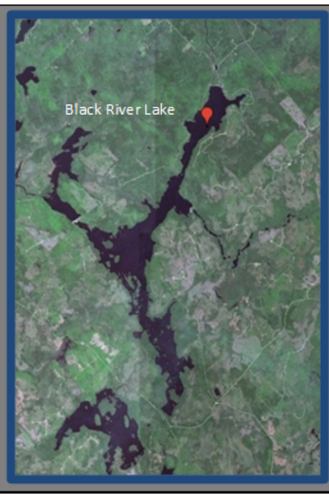
Water Quality Index (WQI):

The Water Quality Index value for Black River Lake in 2018 was 82.4 which is indicative of a good water quality. This value is similar to that recorded in 2017 and is a significant increase compared to 2016 (WQI of 45).

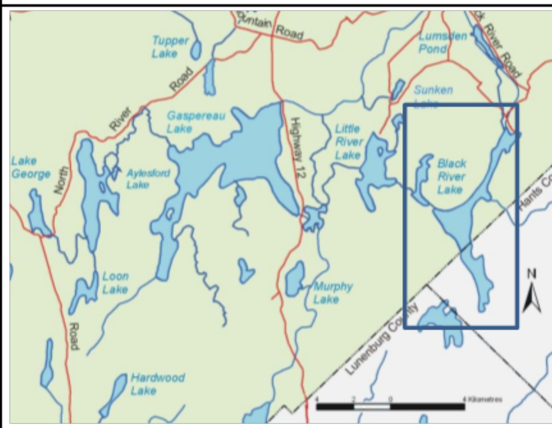


Summary report card:

Overall, an improvement of the water quality has been observed in this lake for the last 2 years. One variable exceeded guideline values in 2018: Chl. a value reached 4.5 µg/L and with a mean value of 2.8 µg/L (guideline: 2.5 µg/L)



BLACK RIVER LAKE



82.4

Drainage Order = 5

Elevation = 170 m

Lake Area = 668 ha

Max Depth = 15 m

1997-2018 Trends:

WQI change (1Y and 5Y):
-10 and 34%

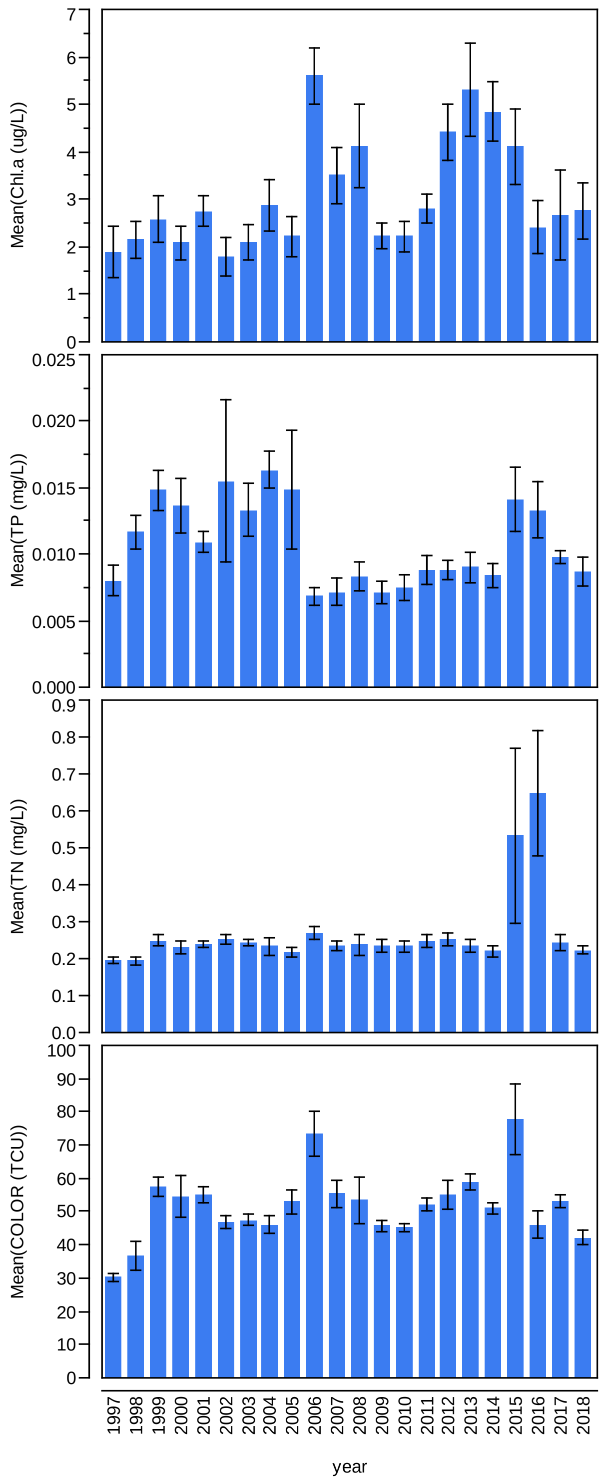
	Parameter							
	TP (µg/L)	Chl A (mg/m^3)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	16.2	2,5	5.3-8.0	6.1-6.5	1.6-2.3	44-56	350	1,3
2018 average	8,60	**2,80**	6,50	6,46	1,70	42,10	223	0,92
2018 (min - max)	(6-12)	(1.1-**4.5**)	(6.2-6.9)	(6.4-6.5)	(1.3-1.8)	(35.9-49.6)	(200-260)	(0.5-**1.4**)
1997-2017 average	10,90	**3,10**	6,60	6,30	2,00	52,60	270	1,00

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

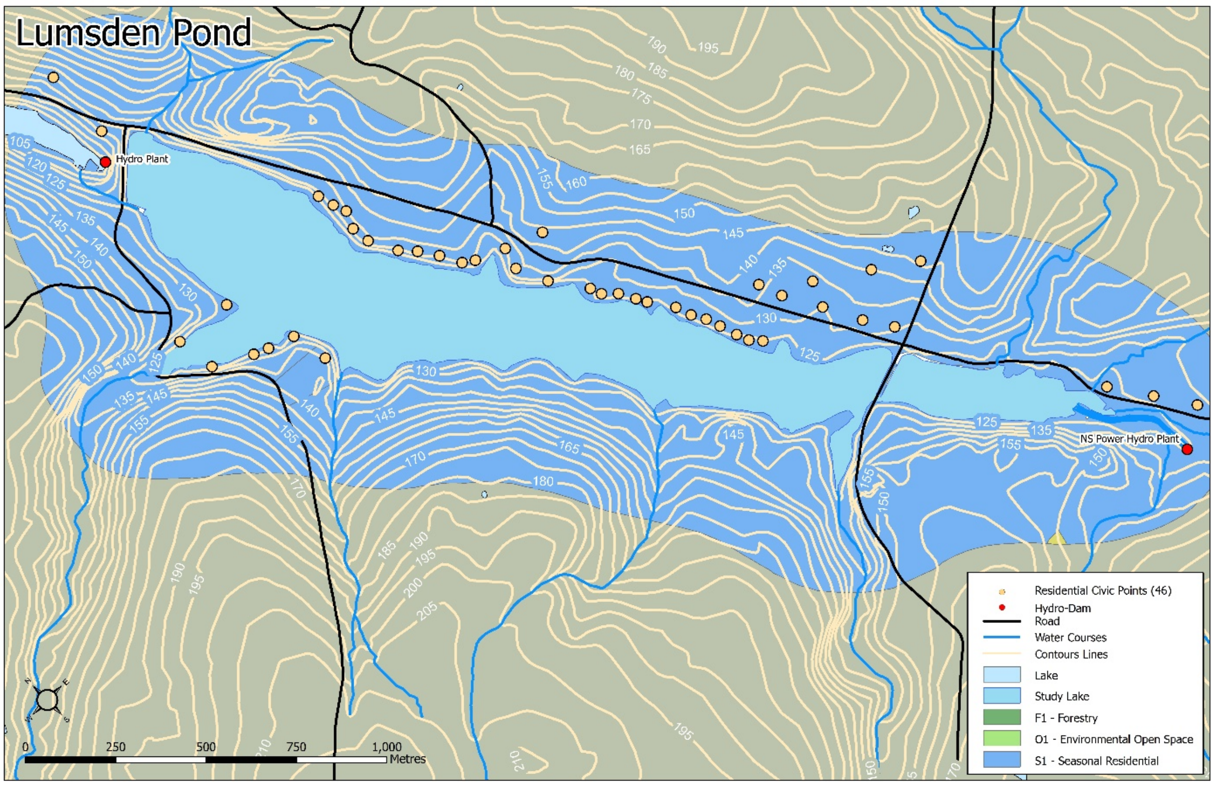
The mean concentration in chl.a declined in Black River Lake for 3 consecutive years, since 2016, compared to 2013-2015. The mean concentration in both TP and TN declined significantly in both 2017 and 2018 compared to 2015 and 2016.

Black River Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



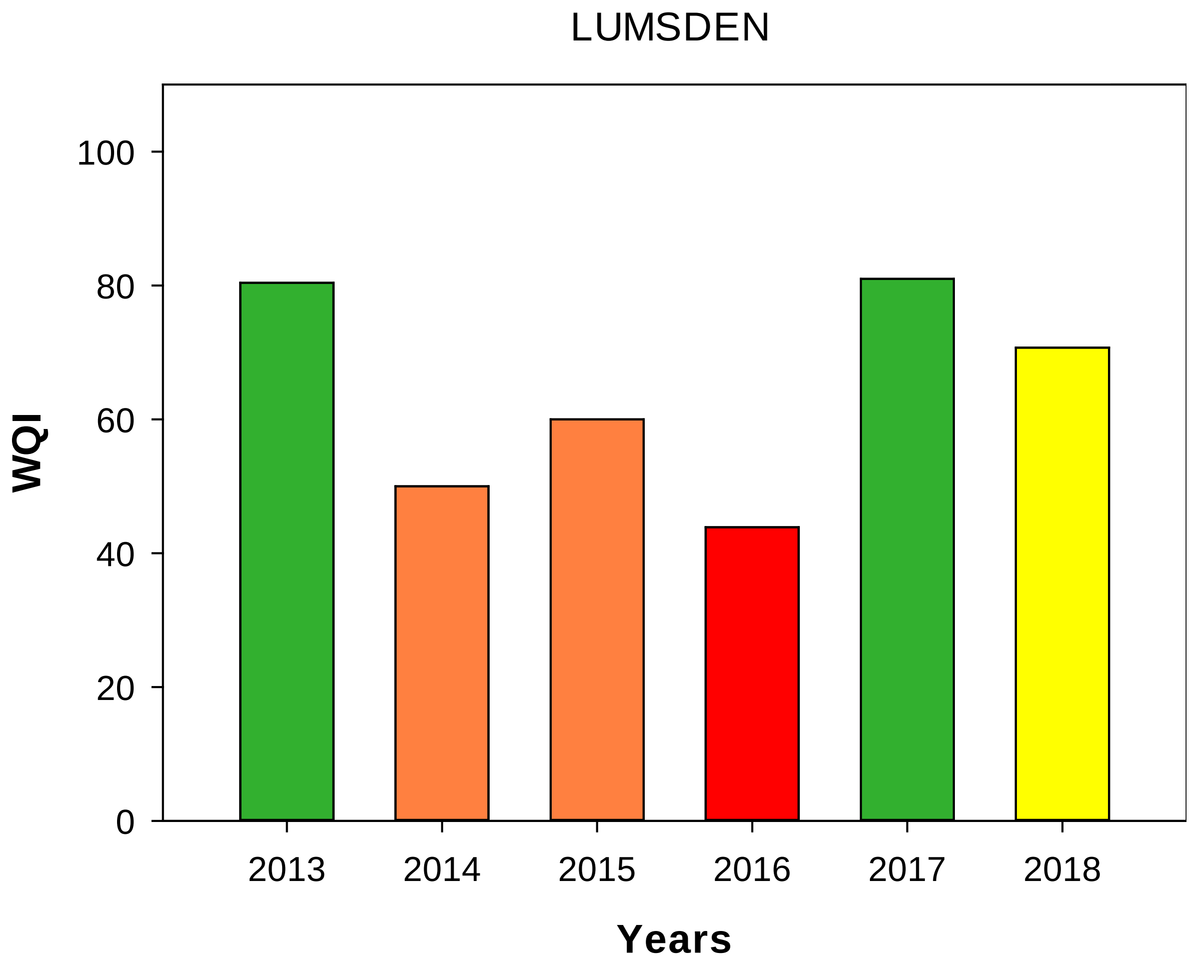
3.9 Lumsden Pond

Lumsden pond is an enlargement of a river system. This body of water is small (88 ha) and has a reported maximum depth of 19 m (which is unexpected given the surface and the fact that this is a pond). The pond is receiving water from Black River Lake and is the last system in the chain of lakes in this study. The pond has some residential development (east side of the lake) and also some agriculture development in its watershed. It is a regulated system, with water levels being managed by 2 hydro electrical dams.



Water Quality Index (WQI):

The Water Quality Index for Lumsden Pond was 70.7 in 2018, which corresponds to a fair water quality rating. This rating has dropped compared to 2017. There were 2 variables showing some exceedances compared to guideline values: chl. a and Turbidity. The mean value in chl.a remained above guideline values (mean: 5 µg/L; Guideline: 2.5 µg/L), with all values measured during the sampling season exceeding the guideline.

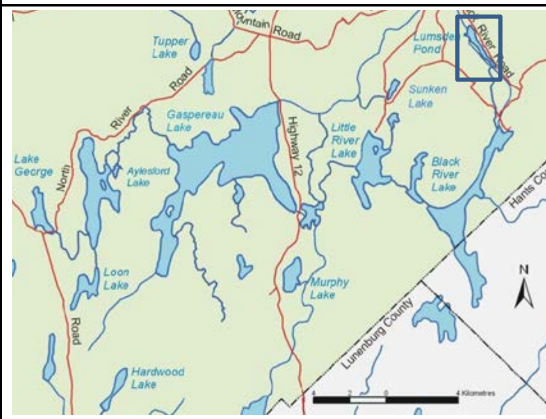


Summary report card:

In 2018, the water quality of Lumsden Pond was fair and several values are indicating that this lake sees excessive loading to TN that may promote algal production. It is possible that changes in water levels may contribute to a higher productivity of the lake Over time, Lumsden Pond has shown signs of mesotrophic conditions. In 2018, volunteers observed bloom-like algae on the nearshore areas of the lake. Additional observations would be needed to identify the species and to identify potential risks (in case of blue green algae).

LUMSDEN POND

70.7



Drainage Order = 6

Elevation = 126 m

Lake Area = 88 ha

Max Depth = 19 m

1997-2018 Trends:

WQI change (1Y and 5Y): -13 and 12%

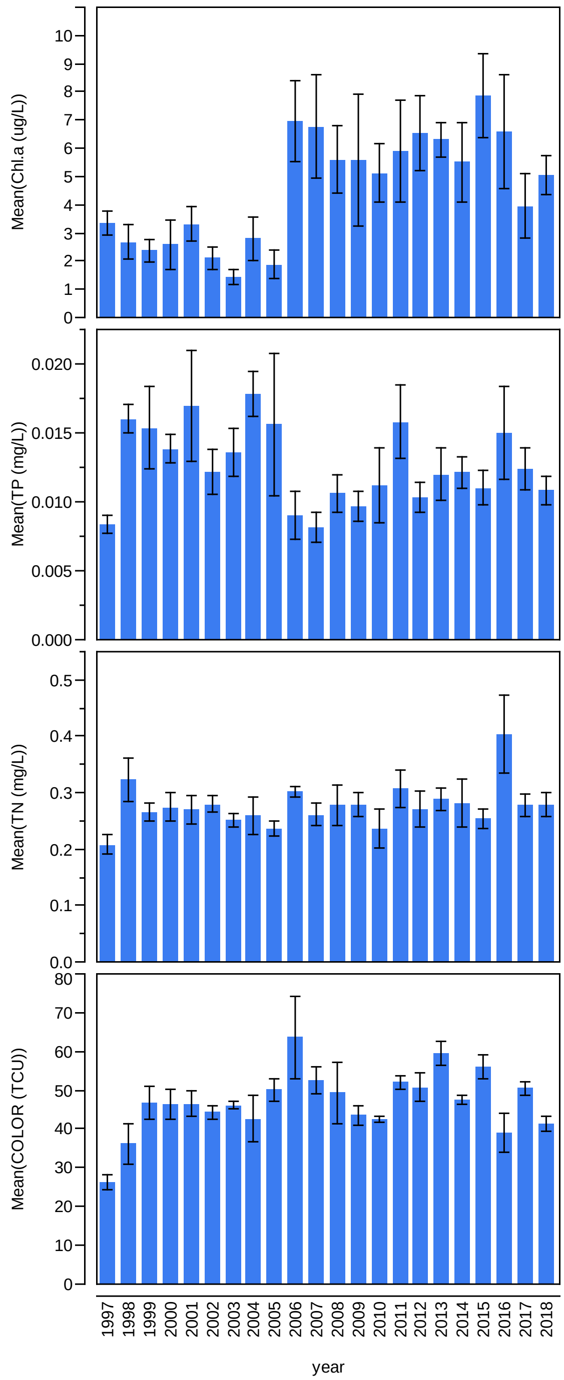
	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	18.8	2,5	5.0-7.6	6.2-6.6	1.6-2.0	40-51	350	1,3
2018 average	10,80	**5,04**	6,56	6,50	1,80	41,30	278	1,20
2018 (min - max)	(8-14)	(2.7-**7.2**)	(6.2-6.8)	(6.4 - **6.8**)	(**1.5-2.2**)	(36.4-49.1)	(220-**360**)	(0.7-**1.4**)
1997-2017 average	12,60	**4,50**	6,30	6,42	1,85	46,60	275	1,06

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

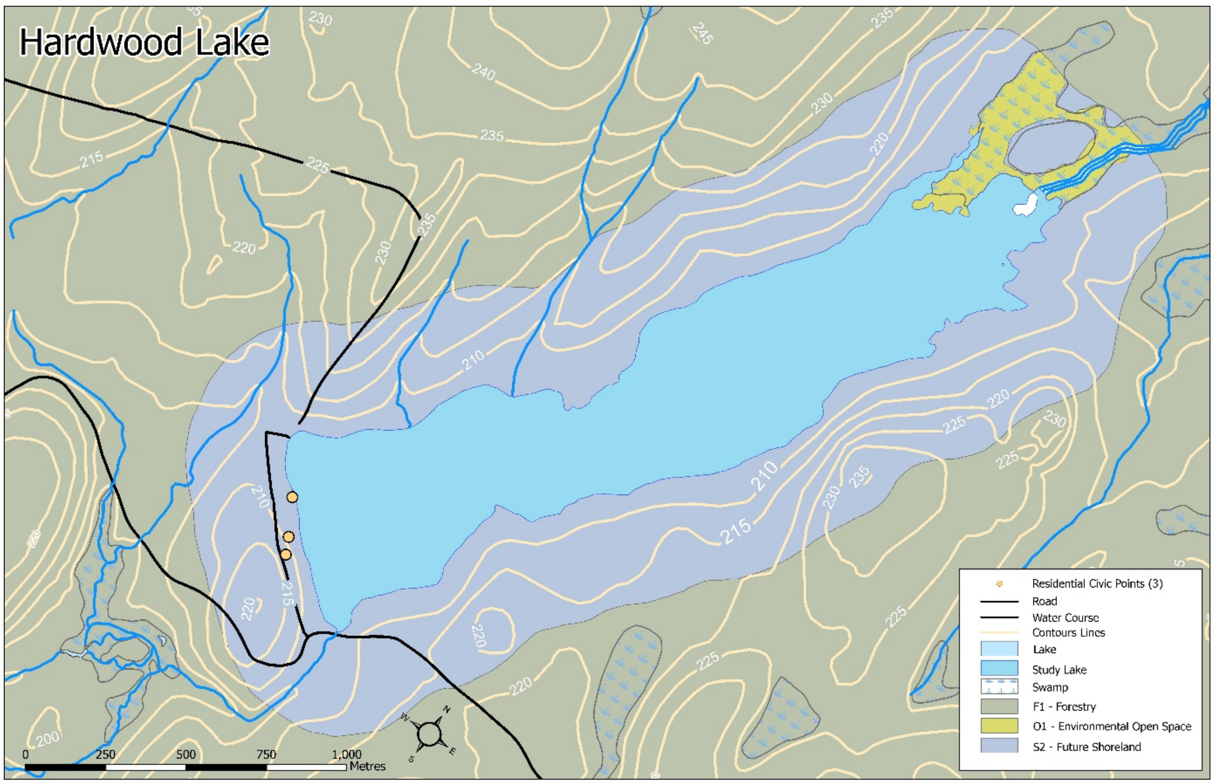
The histograms for Lake Lumsden are showing a decline in chl.a for the last 4 years. There was no significant change in TP and colour values in 2018 compared to the last 10 years.

Lumdsen Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



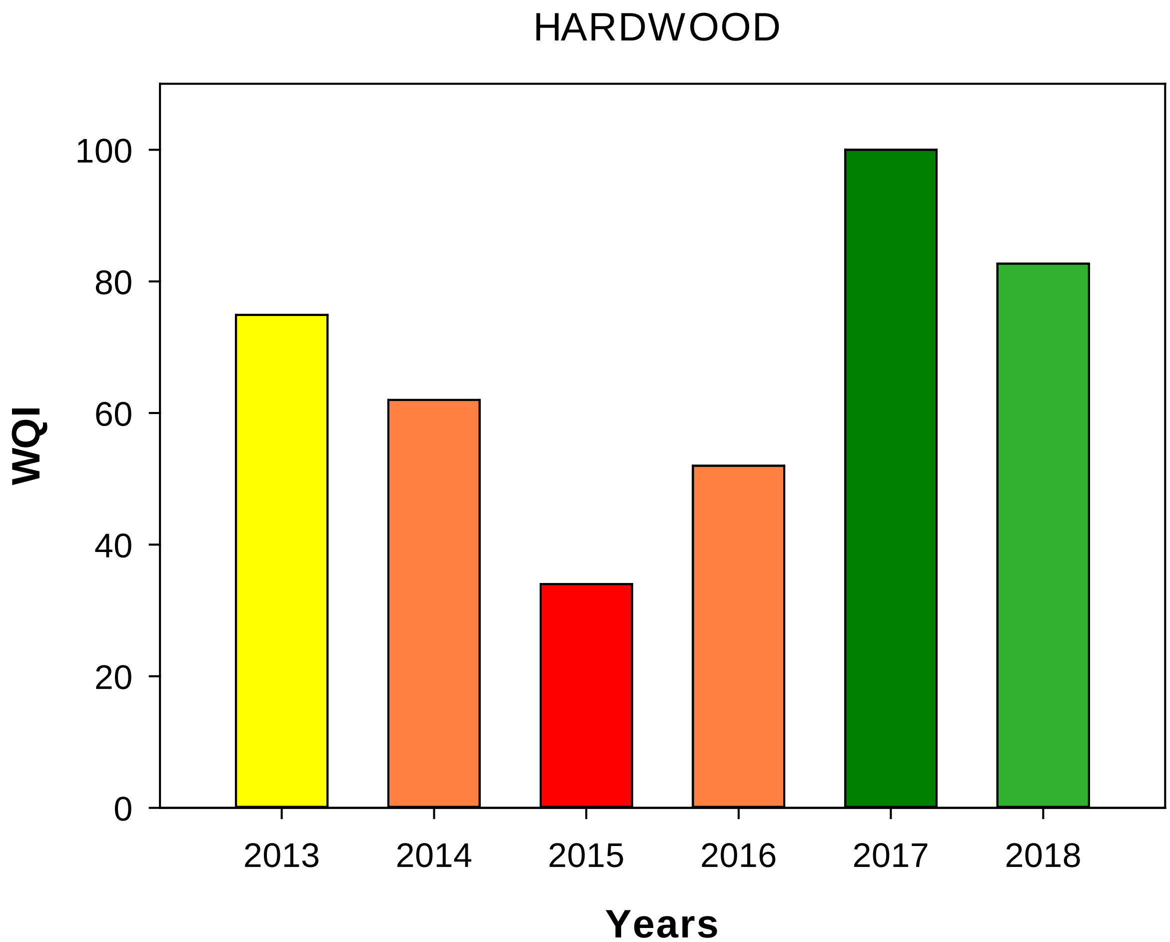
3.10 Hardwood Lake

Among the Kings County lakes, Hardwood Lake is not connected to any other lakes sampled as part of this study. It is a fairly small (120 ha), and shallow (max depth: 7m) lake. It has only 3 residences.



Water Quality Index (WQI)

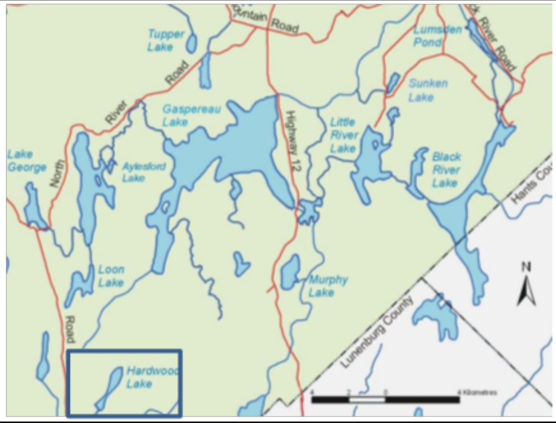
In Hardwood Lake, The Water Quality index (WQI) for 2018 reached the value of 82.7 (good). None of the mean values exceeded guideline values, but one exceedance was observed for chl.a (3.2 µg/L).



Summary report card:

In 2018, Lake Hardwood showed a few minor exceedances in chl.a, water colour, turbidity and Secchi depth. Beside chl.a , these values are not used to calculate the WQI and are not a sign of water quality deterioration.

HARDWOOD LAKE



82.7

Drainage Order = n/a

Elevation = 208 m

Lake Area = 120 ha

Max Depth = 7.0 m

1993-2018 Trends:

WQI change (1Y and 5Y):
-17 and 28%

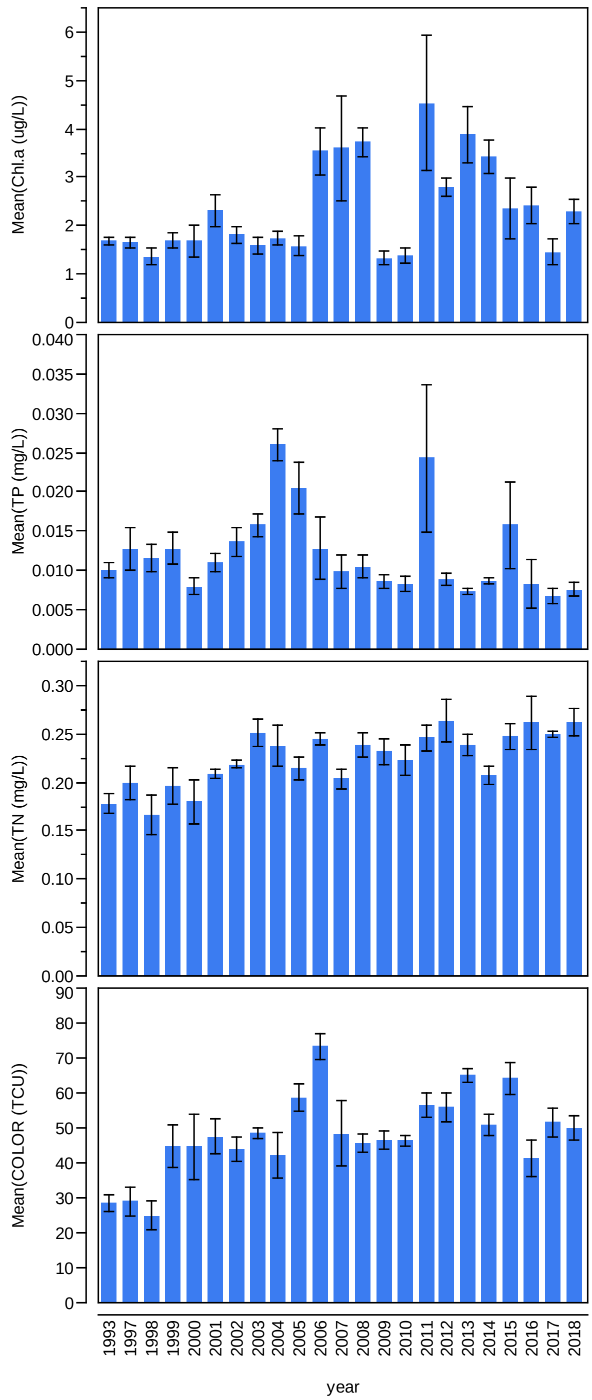
	Parameter							
	TP (µg/L)	Chl A (mg/m³)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	18.9	2.5	5.7-8.5	6.1-6.5	1.6-2.4	36-58	350	1,3
2018 average	7,60	2,30	8,40	6,40	2,00	50,00	262	1,20
2018 (min - max)	(0 - 10)	(1.8-**3.2**)	(7.5-**9.7**)	(6.4 - **6.7**)	**(1.5-2.7)**	(42-58)	(230-310)	(0.7 - **2**)
1993-2017 average	12,70	2,30	7,10	6,29	2,07	46,80	219	1,21

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

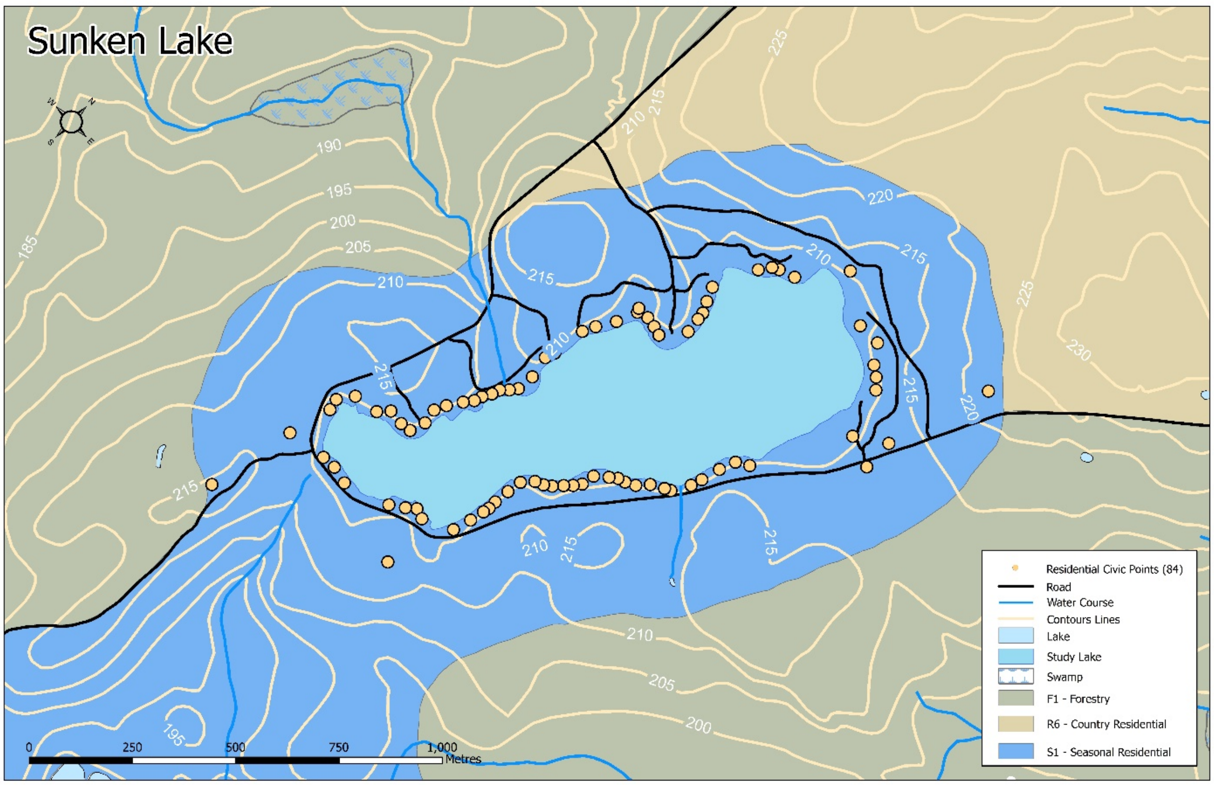
The 2018 data confirms the trends reported last year: nutrient levels are low in Hardwood Lake, with TP levels remarkably constant over the last decade, indicating low loading or changes in loading from the watershed. The mean concentration in total phosphorus in 2018 and 2017 is the lowest observed since the start of the project.

Hardwood Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



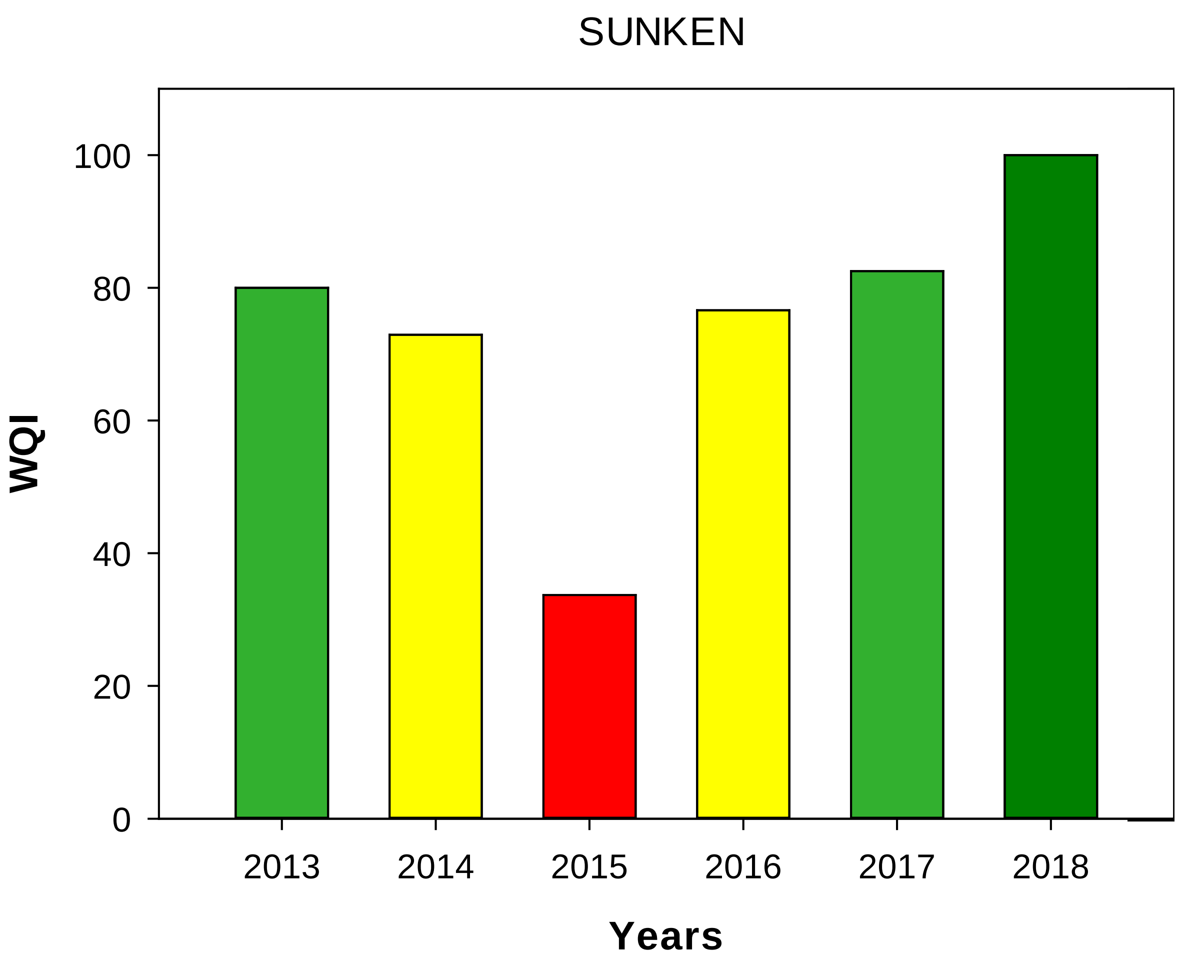
3.11 Sunken Lake

Sunken lake is a small (22.2ha), shallow (max depth: 7m) lake. It is connected to other much larger lakes from Kings County watershed. Depending on the direction of the flow, the water quality of this lake could be influenced by Gaspereau and/or Little River Lake. Sunken Lake has a large number of residences located near the water front.



Water Quality Index (WQI):

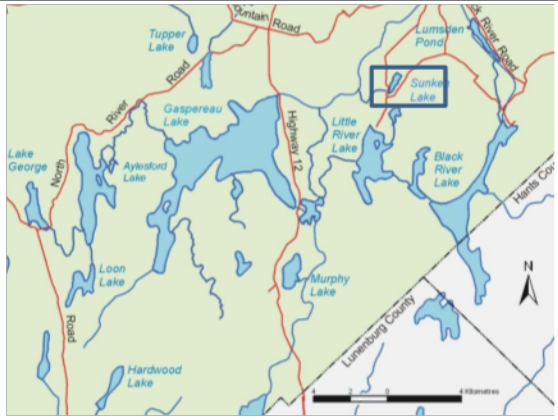
In Sunken Lake, the Water Quality index (WQI) for 2018 reached the value of 100 (Excellent). The WQI has been increasing in the lake for the last 4 years, ranging from poor (in 2015) to excellent (in 2018). This value reflects the low nutrient levels and low chl.a concentrations measured during the sampling season. There were no exceedances in parameters used to calculate the WQI.



Summary report card:

In 2018, the WQI in Lake Sunken was the highest among all lakes sampled in this study. No exceedances were recorded for any of the parameters entered to calculate the index. Nutrients levels, and in particular TP concentrations, remain very low, typical of oligotrophic lakes.

SUNKEN LAKE



100

Drainage Order = n/a

Elevation = ~209 m

Lake Area = ~22.2 ha

Max Depth = 6.9 m

2006-2018 Trends:

WQI change (1Y and 5Y): 21 and 45%

	Parameter							
	TP (µg/L)	Chl A (mg/m^3)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	13.5	2,5	2.2-3.4	7.1-7.3	2.8-3.6	7.3-14.5	350	1,3
2018 average	5,50	1,70	3,00	7,20	3,60	5,30	215	0,75
2018 (min - max)	(4-7)	(1.1-2.2)	(2.9-3.1)	(7.1-7.2)	(**2.7-4.6**)	(5-6.6)	(170-290)	(0.5-0.95)
2006-2017 average	9,30	**3,30**	2,80	7,16	3,25	11,60	204	1,22

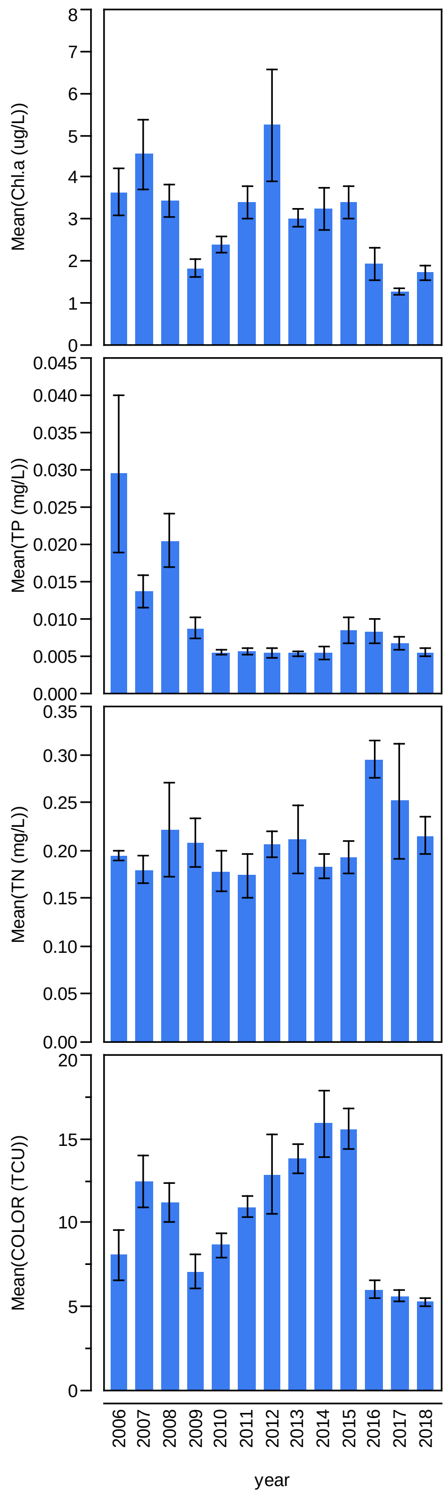
0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

Temporal trends for nutrient (TP and TN) as well as for chl.a a are not showing any statistical trends over time. The concentrations in chl.a were lower in 2017 and 2018 compared to the last 6 years (explaining the increase in WQI values). The mean concentration in chl.a measured in 2017 was the lowest in over a decade. The concentrations in TP remained low (below 10 mg/L) and constant over the last 8 years. These findings are consistent with oligotrophic conditions for Lake Sunken. The mean concentrations in TN have increased (from close to 200 to 300 µg/L) in 2016 and 2017; and to a lower extend in 2018. Further analyses would be needed to confirm if this trend is maintained over the longer-term.

Interestingly, water colour has declined to a mean value of 5.6 TCU over the last 3 years. This result is unclear because Secchi depth or DOC concentrations did not follow a similar trend.

Sunken Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour

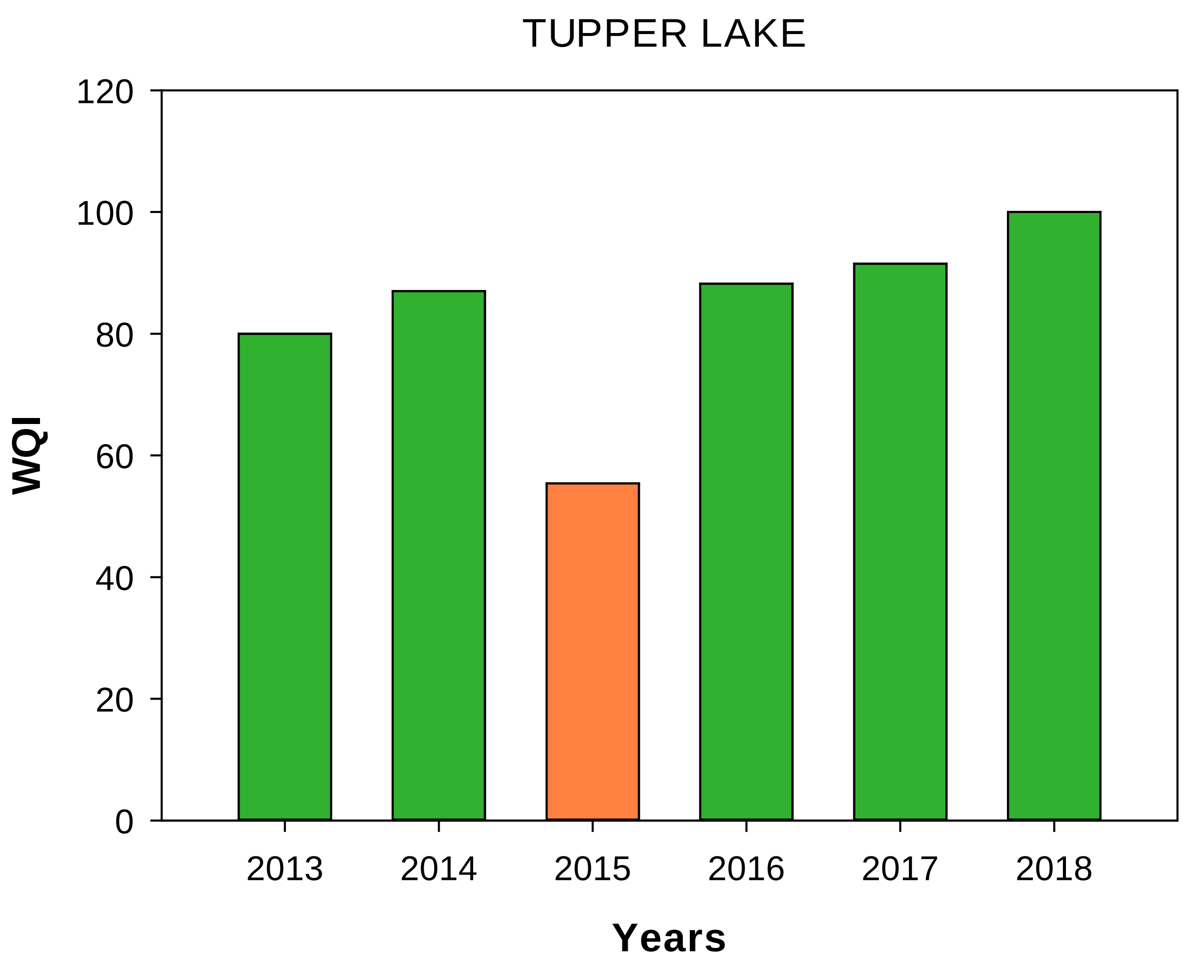


3.12 Tupper Lake

Lake Tupper is a small (36 ha), shallow (max depth: 3m) lake. This lake is not connected to other lakes in this study.

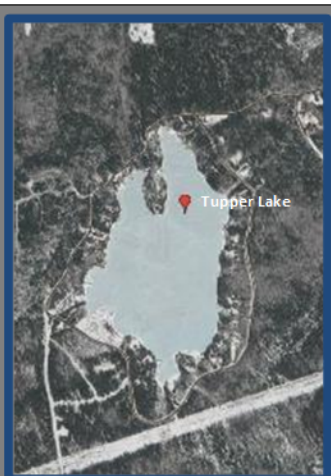
Water Quality Index (WQI):

In 2018, the Water Quality Index for Lake Tupper was 100, which indicates an excellent water quality rating. The value increased slightly over the last 3 years. This WQI rating has been consistent for this lake, with 5 'excellent' rating over the last 6 years.

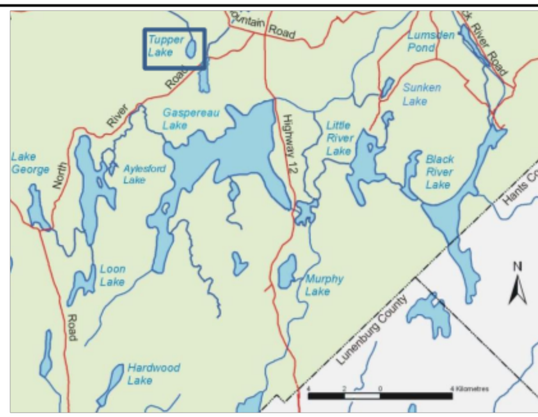


Summary report card:

The water quality parameters measured in Tupper Lake were consistanlty under guideline values in 2018. The nutrient concentrations (TP and TN) in the lake are very low and support little production. The mean concentration in Chl. a was 1.5 μg/L, a value that is typical of oligotrophic lakes. The lake has also low colour and DOC and turbidity levels compared to the other lakes in the region.



TUPPER LAKE



100

Drainage Order = n/a

Elevation = 201 m

Lake Area = 36 ha

Max Depth = 3.0 m

2003-2018 Trends:

WQI change (1Y and 5Y): 9 and 24%

	Parameter							
	TP (μg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (μg/L)**	**Turbidity (NTU)**
Guideline	16.9	2.5	3.6-5.4	6.6-7	2.6-3	14-22	350	1,3
2018 average	9,80	1,50	4,60	7,00	-	13,70	224	0,85
2018 (min - max)	(5-16)	(0.8-1.9)	(4.4-5.1)	(6.9-7.1)	-	(8.8-22.6)	(180-260)	(0.6-1.2)
2003-2017 average	11,40	2,60	4,50	6,80	2,60	19,15	227	0,94

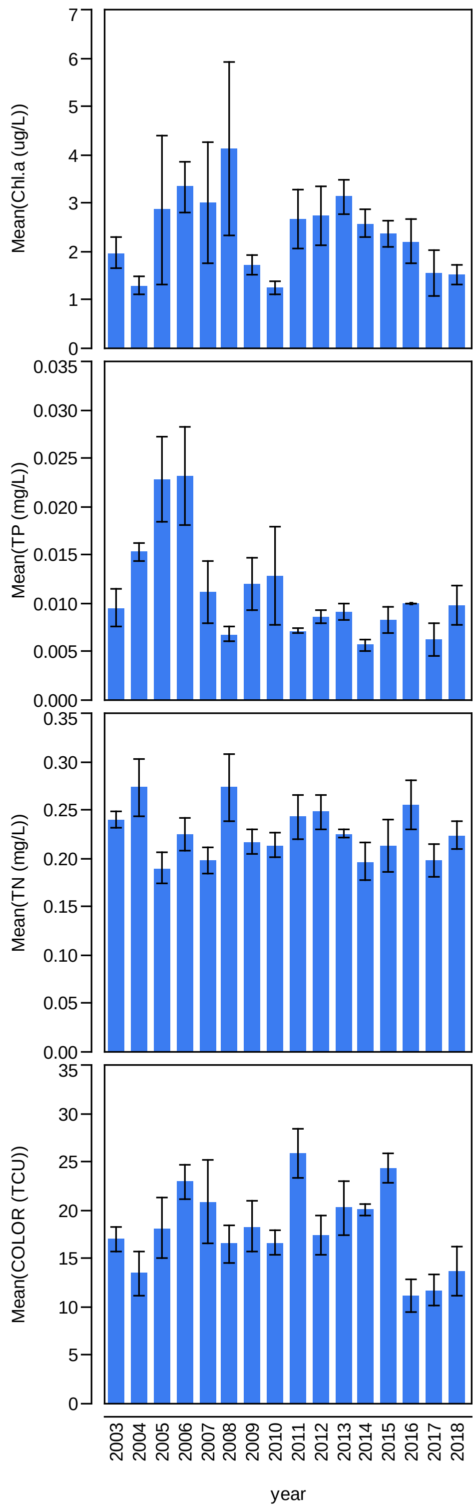
0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

The 2018 data for Lake Tupper did not lead to significant long-term trends in Chl. a and in total nitrogen. The concentration in chl.a has declined over the last 6 years to reach a mean value close to 1.5 µg/L in 2018. There is a modest decline in TP (-0.7 µg/L/Yr) over the last 15 years but the concentration has been fairly constant over the last 8 years, with values at less than 10 mg/L. The mean concentration in total nitrogen has remained fairly constant over the years.

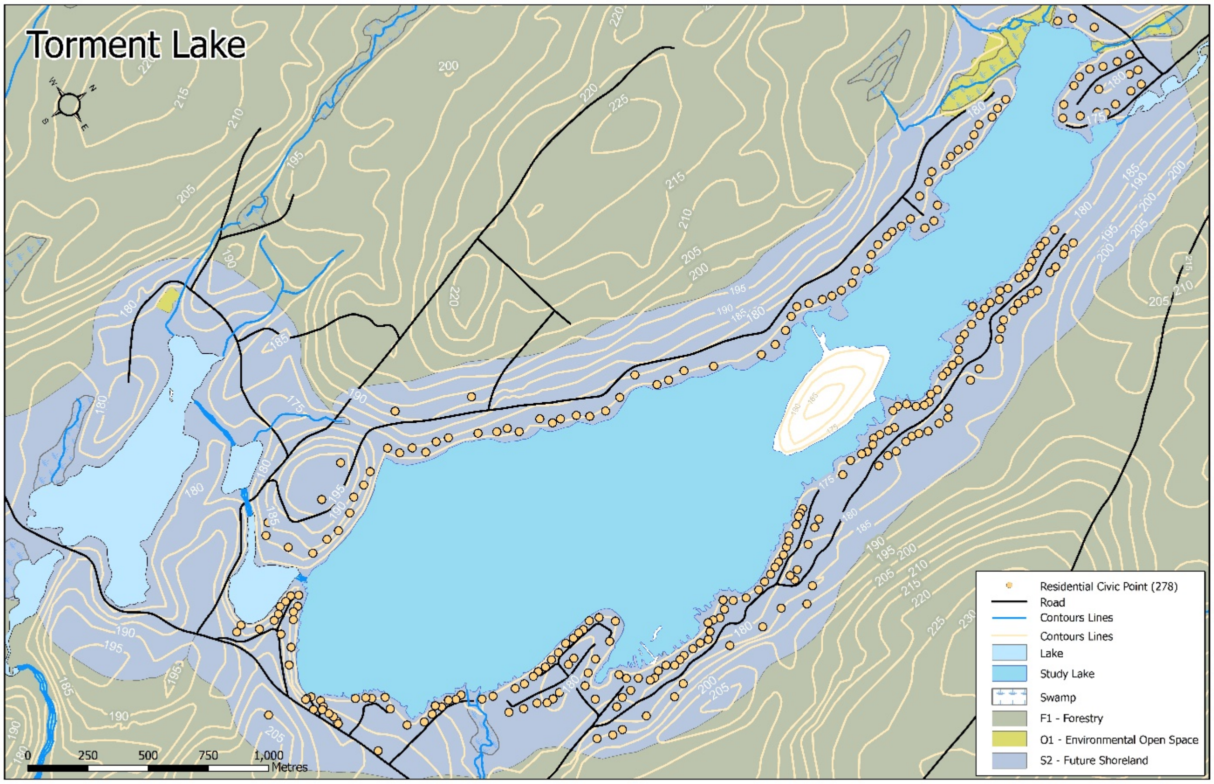
Interestingly, the colour of the lake has significantly declined over the last 3 years, with a reduction of almost 50 % compared to 2003-2015.

Tupper Lake: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



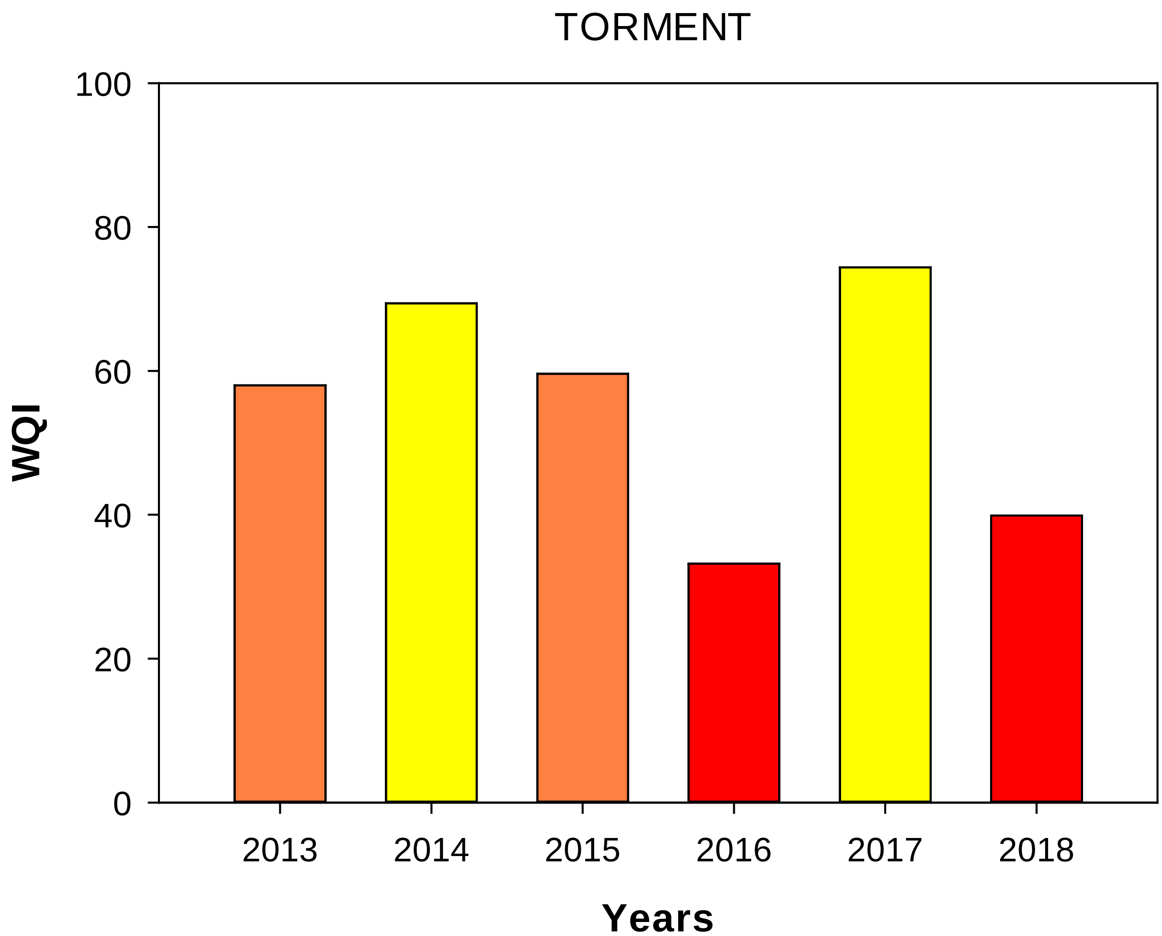
3.13 Lake Torment

Lake Torment is a medium size (261 ha), shallow (max depth: 3.4m). Lake Torment is connected to Lake Armstrong. Based on satellite imagery, the lake is surrounded by a forested area. It has a significant residential development in the nearshore area.



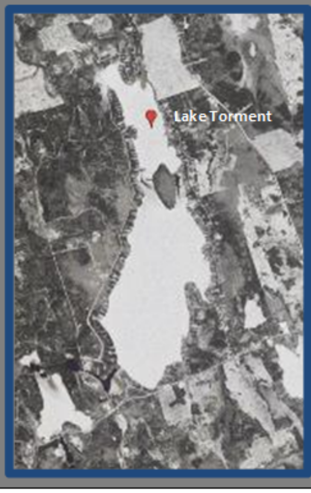
Water Quality Index (WQI):

In 2017, the Water Quality Index for Lake Torment was 39.9, with a poor rating. This value is similar to that observed in 2016 and is a significant decrease (by 46%) compared to 2017.



Summary report card:

The 2018 WQI value for Lake Torment reflects exceedances in almost all variables but secchi depth. The mean value in chl.a for 2018 has significantly increased (mean: 4.6 µg/L) compared to 2017 (2.3 µg/L). This lake is the least healthy lake in this study.



Lake Torment

39.9

Drainage Order = n/a

Elevation = 174 m

Lake Area = 261 ha

Max Depth = 3.4 m

2011-2018 Trends:

WQI change (1Y and 5Y):

-46 and -32%

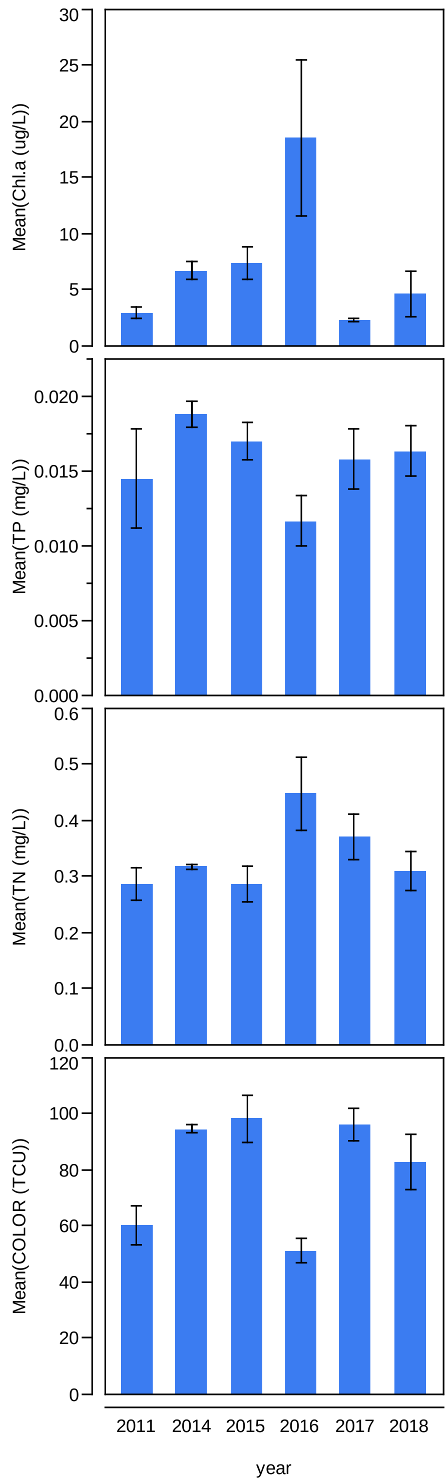
	Parameter							
	TP (µg/L)	**Chl A (mg/m^3)**	**DOC (mg/L)**	**pH**	**Secchi Depth (m)**	**Colour (TCU)**	**TN (µg/L)**	**Turbidity (NTU)**
Guideline	20	2,5	7.6-11.4	6.3-6.5	1.1-1.6	58-98	350	1,3
2018 average	16,30	4,60	10,70	6,30	1,30	82,80	310	1,40
2018 (min - max)	(12-**23**)	(1.4-**14.9**)	(8.5-**16.9**)	(**6.0** - 6.5)	(1.2-1.4)	(69.6-**131**)	(230-**420**)	(0.7-**3.6**)
2011-2017 average	15,4	**9,04**	9,2	6,4	1,53	76,9	340	**2**

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

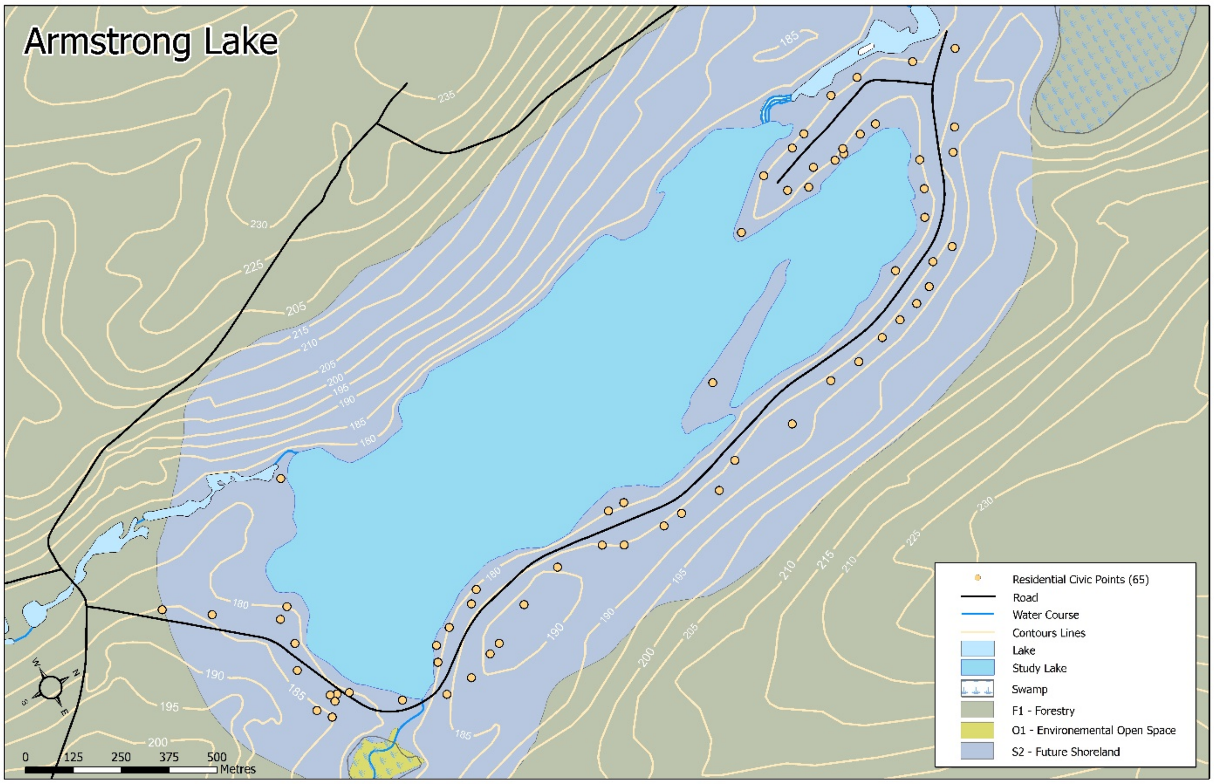
The reason of the decline in WQI values in 2018 compared to 2017 are related to exceedances in nutrients and chl.a that are significantly above guideline. The concentration in chl.a peaked at 14.9 µg/L (that is 6 times the guideline). This lake has not been sampled for as many years as others in this study and further study on the sources of nutrients would be required. The survey developed in 2018 could help better understand the limnology of this lake.

Lake Torment: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



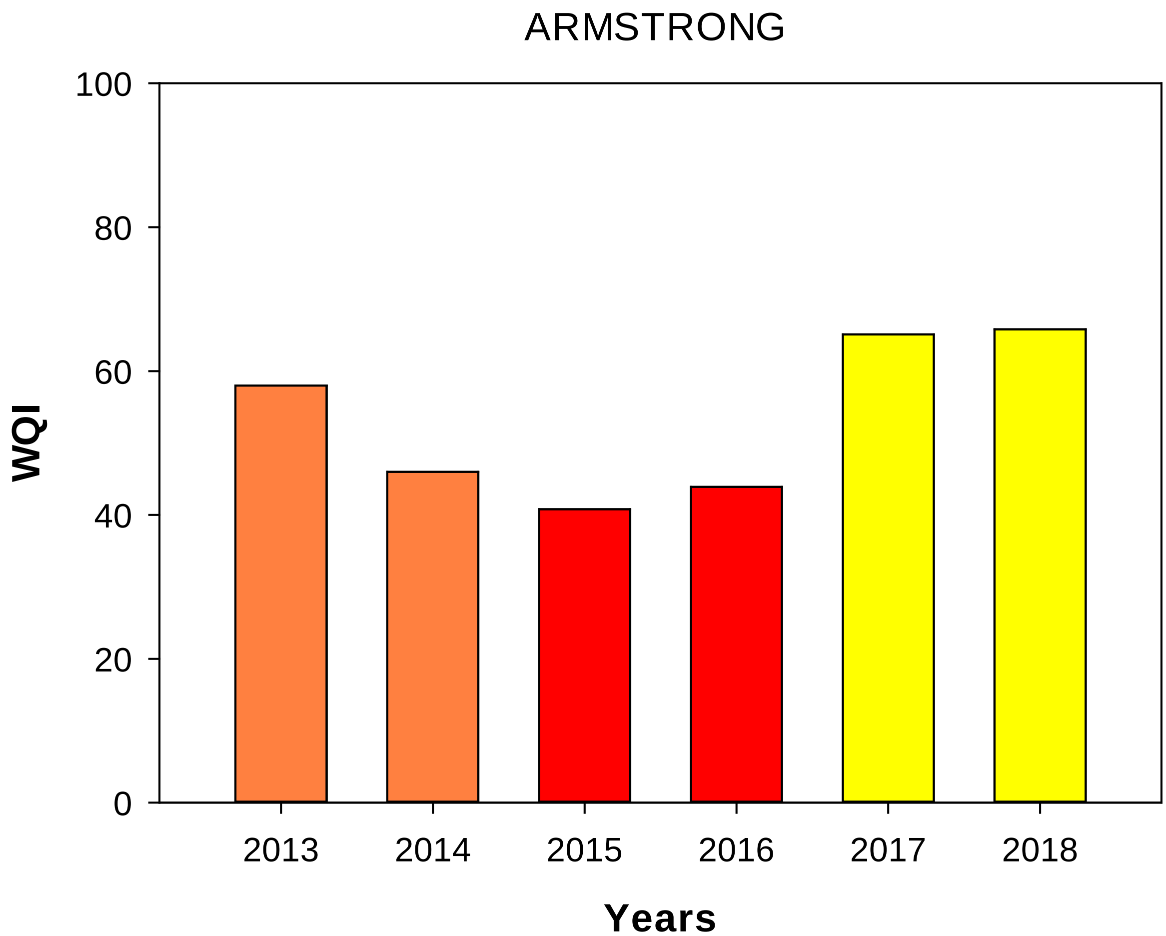
3.14 Armstrong Lake

Lake Armstrong is a small (89 ha), deep (max depth: 21m) lake. It is connected to Lake Torment. Based on satellite imagery, the lake has low to moderate residential development on the east side. It is located in close proximity to large forested areas that have been clear-cut.



Water Quality Index (WQI):

In 2018 and similar to 2017, the Water Quality Index for Armstrong Lake was 65.8, corresponding to a rating of Fair water quality. This value has increased from 44 in 2016 to 65.1 in 2017. This value is also the highest value obtained since 2013.



Summary report card:

The WQI value observed for Lake Armstrong is explained by exceedances in 3 variables: Chl.a; total nitrogen and turbidity. Chl.a concentration was on average higher than the guideline for 2018 (mean: 2.7 µg/L, guideline: 2.5 µg/L). There was no significant trends (increase or decrease) in Chl. a; TP and TN since the lake was first sampled.

Armstrong Lake

65,8

Drainage Order = n/a

Elevation = 178 m

Lake Area = 89 ha

Max Depth = 21 m

2011-2018 Trends:

WQI change (1Y and 5Y):
1 and 30%

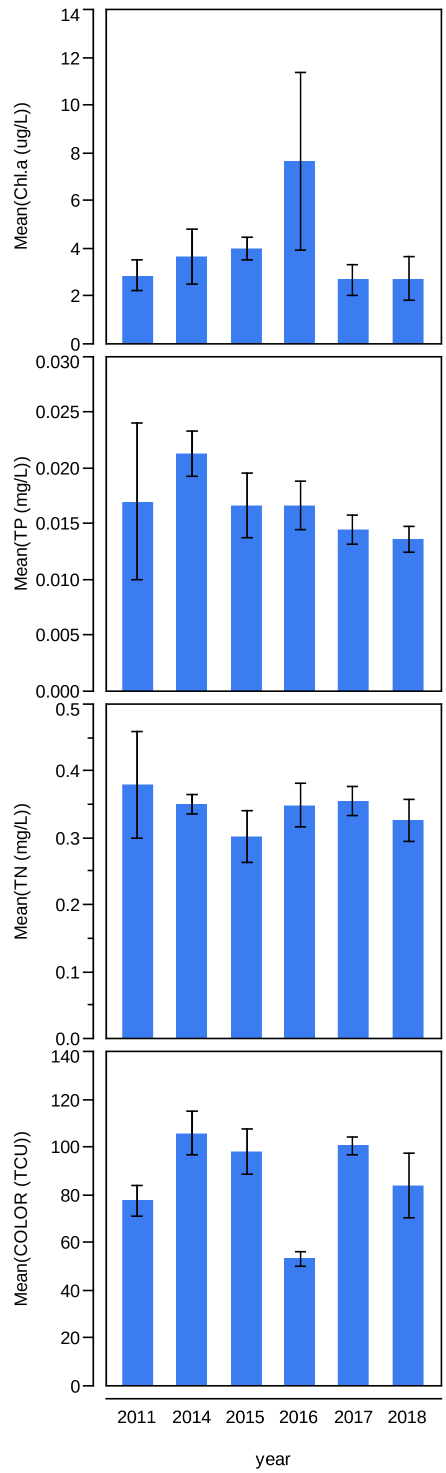
	Parameter							
	TP (µg/L)	Chl A (mg/m^3)	DOC (mg/L)	pH	Secchi Depth (m)	Colour (TCU)	TN (µg/L)	Turbidity (NTU)
Guideline	20	2,5	7.6-11.4	6.3-6.5	1.1-1.7	59-103	350	1,3
2018 average	13,6	**2,7**	10,6	6,4	1,1	83,7	326	1
2018 (min - max)	(11 - 16)	(0.9-**5.1**)	(8.4-**17.1**)	(5.8-6.6)	(**1**-1.3)	(60-**136**)	(260-**430**)	(0.7-**1.8**)
2011-2017 average	17,5	**5,1**	9,2	6,4	**1,63**	81,2	335	1,2

0-44	45-64	65-79	80-94	95-100
Poor	Marginal	Fair	Good	Excellent

Long-term trends:

The long-term trends for Lake Armstrong are similar to those reported for Lake Torment. The concentration in chl.a declined from close to 8 µg/L in 2016 to less than 3 µg/L in 2018. The concentrations in both TP and TN remained fairly similar since 2011. The value for colour increased in both 2017 and 2018, back to values comparable to 2014 and 2015.

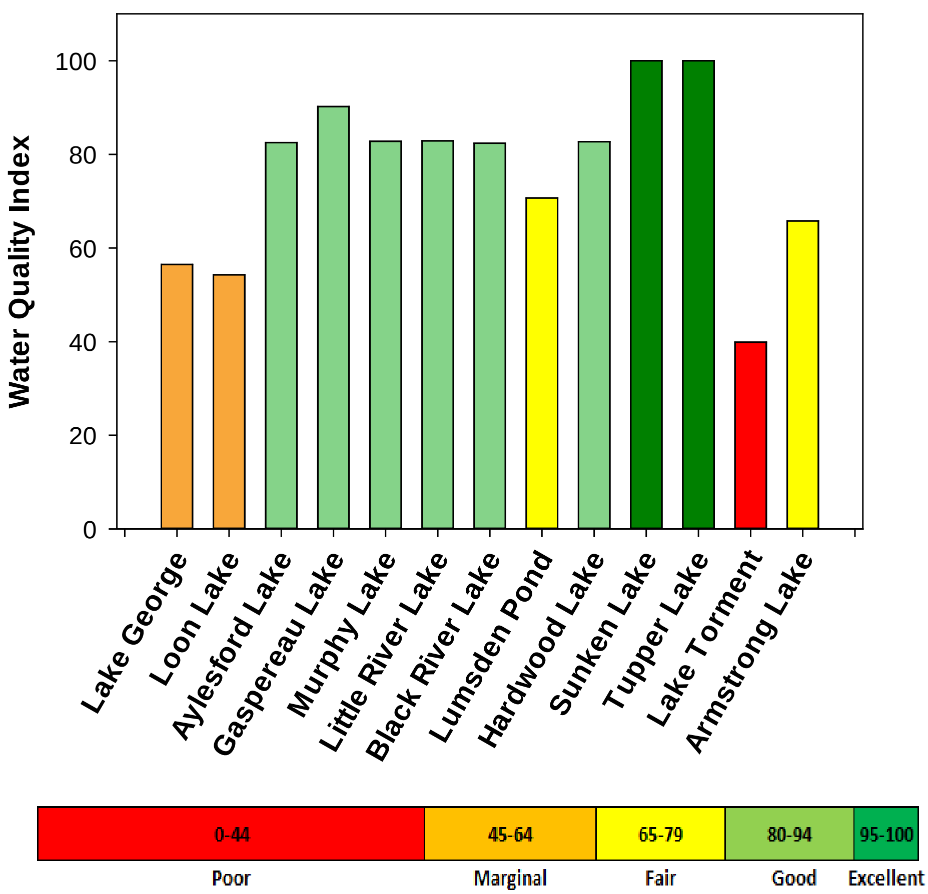
Lake Armstrong: Histograms of the long-term values in chl.a, TP, total nitrogen concentrations and colour



4 Conclusions and Recommendations

The following recommendations are suggested for the Kings County Lake Monitoring Program and have been carried forward from previous reports with changes based on the 2018 data:

In 2018, water quality in the Kings County lakes varied from poor (lake Torment) to excellent (Sunken and Tupper lakes). Among the 13 sampled lakes, 6 had a good water quality rating. As such, with only 3 lakes with a poor/marginal rating, the health of the Kings county lake is generally good.



The ratings are strongly related to the concentration in nutrients as TP and TN. In most lakes, it is below guideline values; and when a lower rating is observed, it is often due to exceedances in chl.a concentrations (and not necessarily in TP and TN). In the recent years (2015 and 2016), an increase in productivity was observed in most lakes, reaching values never observed during the course of this time series. This increase was not observed in the last 2 years (2017 and 2018): instead the concentration in chl.a declined significantly. This decline was not related to changes in nutrients, nor in the amount of precipitations. To help understand these variations, a survey was developed to retrieve information on the timing of the ice-free period and other parameters that could stimulate algal production.

The colour values and dissolved organic carbon (DOC) concentrations in the KCVLMP lakes are naturally very high with the exception of Sunken and Tupper lakes where the water is clear. These 2 lakes are showing the best water quality rating (Excellent) in 2018. It is important to note however that high values in colour and DOC does not impact the water quality rating and that these values are not a sign of poor water quality. These values reflect the input of terrestrial organic matter that enters the lakes via run-off. The low nutrient levels recorded in the lakes indicate that the organic matter loading is nutrient poor, as observed in most boreal shield lakes. As noted by members of TAC, in the Atlantic regions, high DOC and colour in lake water are associated to the presence of *Sphagnum* bogs in the watershed. Because of the strong connection between the land and the water, this report would benefit from a better understanding of the importance of wetlands in the watershed of each lakes, coupled with an assessment of annual and seasonal precipitations.

Although nutrient levels are low in most of the KCVLMP lakes, the influence of the watershed on colour or DOC indicates that local residents should continue and maintain programs aiming at reducing nutrient loading to the lakes. Although most of the WQI rating was good in 2018, it does not mean that the lakes will remain in good health if nutrient loading was to increase in the future or climate change effects to lake biological, physical and chemical processes.

The following recommendations are based on the combined results of this year and previous recent years:

1) Continue with volunteer monitoring programming for all lakes. Ensure consistency of monthly data collection events to allow detection of seasonal trends. Two new lakes were added in 2014 and additional data would be required to understand their characteristics (and year to year variations). Most of the lake WQI increased for the last two years: although this is good news, it also indicates that the value varies greatly from year to year. Some lakes were rated with a poor WQI in previous years are showing improvement this year, which calls for continued monitoring. Although the cause of such variability is not well understood, the analysis would benefit from considering weather related variables, as well as potential long-term changes in the climate.

2) As per the recommendation from TAC in 2016, the report card includes a temporal trend of colour that was not part of previous report. In 2016, colour declined in most lakes and this finding could explain why more algal biomass was observed in the lakes, as they become clearer (allowing for additional algal production). Since 2017,

the trends in colour was not as clear: in some lakes, colour came back to levels comparable to before 2016. It is recommended that variables such as colour, turbidity and Secchi depth continue to be monitored as part of this study to better understand their effects on other variables (such as chl.a).

3) As noted in previous years, with this long-term data set, the opportunity to relate long-term changes to watershed characteristics is evident. This year, maps of each lakes were added to the report and an analysis was performed to asses relationships between local development and sampled variables. Such analysis yielded no significant results. Addition work could be invested to define the limits of the watershed for each lake. This would allow to calculate the amount of precipitation in the drainage area, and then better estimate the influence of precipitations on sampled variables. Other variables are now part of the survey that will help determine the following:

    a. Number of residences on septic systems living in the watershed;

    b. The presence of beaver dams;

    c. The presence of invasive species (plants, mussels, etc.);

    d. The assessment of the effect of water flow regulation in some of the lakes affected by a hydroelectric dam. Water levels from the operator would be useful to this study.

    e. The use of additional parameters to chl.a as a proxy of algal biomass and speciation to understand what group of algae has an increasing growth.

f. The understanding of water quality variables would benefit from evaluating the impact of seasonal and annual precipitation and run-off amounts. Depending on how much precipitation each watershed receives, an increase in nutrient and contaminants in lake water may be observed during wet periods. Dry periods may cause an increase in biological activity within the lake water column. Characterizing wet and dry years could help refine the findings for each lake.

4) Although not observed in 2017and 2018, chl.a concentration, and for some of the lakes, to a lesser extend TN concentration are the main variable showing a significant increase in recent years, causing lower values of the WQI. We recommend investigating the type of algae that may support this increase. In particular, it would be useful to know if there is a relative increase in green algae versus cyanobacteria. This question could be answered by using tools and methods that allow for the distinction between various algal groups. For example, a fluoroprobe is able to evaluate the contribution of different algal groups due to differences in algal pigments. Another alternative would be to apply a taxonomic approach to identify the algal species. A field approach (using a probe) would likely be the most cost-effective measure.

   An alternative approach would consist in recording algal observations which is now part of the survey distributed in 2019.

5) We suggest continuing the application of a modified WQI to assess water quality. DOC, colour and Secchi depth should not be included in the calculation, as indicated in this report. As suggested by TAC, the report may benefit from less emphasis on WQI rating and more effort could be invested in evaluating the effect of climate and watershed characteristics on observed water quality.

6) The frequency of sampling events could be increased to capture a minimum of 10 samples per season (biweekly collections) for each monitored lake for improved analysis of sampled parameters if feasible, and pending suitable budgetary support. The rational for such frequency is supported by the high turn-over of the algal community, which is typically completely renewed every 10 to 15 days in boreal lakes. Additionally, averages would be more indicative of the state of the lakes and less skewed by outliers. At a minimum, samples could be taken when volunteers report something unusual in the survey.

7) Despite a weak relationship between nutrients and chl.a reported in this study, , significant increase in lake productivity and chl.a levels would be expected if additional nutrients were added to the watershed. Therefore, nutrient control and reduction strategies are recommended to maintain good water quality and protection of desired water uses. Communities in the watersheds of study lakes are encouraged to continue to use best practices and reduce/ limit nutrient releases from all sources to protect lake water quality.

8) The Municipality is encouraged to continue to link this lake monitoring program with land use planning activities and to consider supporting watershed management approaches to help maintaining and promote the health of the lakes.

5 References

Brylinsky, M. 2008. Results from the 1997-2008 Kings County Volunteer Water Quality Program. Acadia University, Wolfville, Nova Scotia. Prepared for Kings County Water Quality Monitoring Volunteers and Kings County Department of Community Development Services.

Canadian Council of Ministers of the Environment. 2001. Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index

Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg. http://www.ccme.ca/assets/pdf/wqi_techrprtfctsht_e.pdf.

Carignan, R.; D'Arcy, P. and Lamontagne, S. 2000. Comparative impacts of fire and forest harvesting on water quality in Boreal Shield lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, 2000, 57:105-117,https://doi.org/10.1139/f00-125

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Centre for Water Resources Studies and Stantec. 2009. Kings County Lakeshore Capacity Model Review, Final Report.

Chambers, P.A., Culp, J.M, Brua, R., Benoy, G. April 2011.Defining Nutrient Concentrations to Prevent Eutrophication of Canadian Agricultural Streams. Retrieved June 2, 2011, from http://nitrogen.ceh.ac.uk/nitrogen2011/_poster_presentations/S3_Chambers.pdf.

Clean Annapolis River Project. 2010. Kings County Lake Monitoring Program Report: 2009 Season.

Clean Annapolis River Project. 2011. Kings County Lake Monitoring Program Report: 2010 Season.

Clean Annapolis River Project. 2012. Kings County Lake Monitoring Program Report: 2011 Season.

Clean Annapolis River Project. 2013. Kings County Lake Monitoring Program Report: 2012 Season.

Cole, G. 1983. Textbook of Limnology. 3rd edition. Arizona State University. The C. V. Mosby Company, St. Louis. Government of British Columbia.

1981. Ambient Water Quality Guidelines for Organic Carbon. Last updated August 7, 2001. Water Management Branch, Ministry of Water, Land and Air Protection, British Columbia.

Government of British Columbia. 1981. Water Quality Criteria for Nutrient and Algae. Last updated August 7, 2001. Water Management Branch, Ministry of Water, Land and Air Protection, British Columbia.

Kerekes, J. 1981. Atlantic Region. Chapter I. Pp. I 1-13. In: Janus, L.L and R.A. Vollenveider (Eds.). Summary report. The OECD Cooperative Programme on Eutrophication. Canadian Contribution. (Scientific Series # 131, Pp. 1-13). National Water Res. Inst., Inland Waters Directorate, Canadian Centre for Inland Waters, Burlington, Ont.

Kerekes, J. and B. Freedman. 1989. Characteristics of Three Acidic Lakes in Kejimkujik National Park, Nova Scotia, Canada. Archives of Environmental Contamination and Toxicology, (18), 183-200.

Municipality of the County of Kings. 2009. http://www.county.kings.ns.ca/comdev/lakemon/overview.htm. Access Date: February 9, 2010.

Kevern, N., D. King, and R. Ring. 1996. Lake Classification Systems. The Michigan Riparian, February 1996. http://www.mlswa.org/lkclassif1.htm

Mackie, G. 2004. Applied Aquatic Ecosystem Concepts. 2nd Edition, Kendall/Hunt Publishing Company, Dubuque, Iowa.

MacMillan, J. L., D. Cassie, J. E. LeBlanc and T. J. Crandlemere. 2005. Characterization of water temperature for 312 selected sites for Nova Scotia. Canadian Technical Report of Fisheries and Aquatic Sciences 2582.

Parks Canada. 2008. Water Quality Index Monitoring Protocol, Quebec-Atlantic Bioregion. Draft report. Parks Canada Agency.

Parks Canada. Technical compendium to the 2010 State of Park Report, Kejimkujik National Park and National Historic Site. Parks Canada Agency.

Roy V., Amyot M., Carignan R. 2009. Beaver ponds increase methylmercury concentrations in Canadian Shield streams along vegetation and pond-age gradients. Environmental Science & Technology. 43 (15): 5605-5611. doi : 10.1021/es901193x

Sharpe A. and D. Sullivan. 2006. CARP Quality Assurance/Quality Control Project Plan. – Currently in draft form.

Thienpont, J.R., et al. 2008. An Assessment of Environmental Changes in Three Lakes from King's County (Nova Scotia, Canada) Using Diatom-Based Paleolimnological Techniques. Water Quality Research Journal of Canada Volume 43, No.2/3, 85-98.

US Geological Survey. 2005. Seasonal Kendall Test for Trend.

Vollenweider, R.A. and J. Kerekes 1982. (OECD 1982). Eutrophication of waters, monitoring, assessment and control. Final Report. OECD Cooperative programme on monitoring of inland waters (Eutrophication control), Environment Directorate, OECD, Paris. 154p.

Water Quality Survey of Fourteen Lakes in the Carleton River Watershed Area**,** 2016. Report accessed on March 20, 2019, at: https://www.district.yarmouth.ns.ca/index.php/community/community-organizations-programs/224-carleton-river-watershed

WSP Canada Inc. 2014. Kings County Lake Monitoring Report: 2013 Season.

WSP Canada Inc. 2015. Kings Lake Monitoring Final Report: 2014 Season.

Appendix 1: Zoning Bylaws, provided by the Municipality of Kings County

12.2 RURAL COMMERCIAL (C9) ZONE

12.2.1 Purpose

The purpose of the Rural Commercial (C9) Zone is to provide for the development of a limited range of commercial uses serving the local convenience needs of the surrounding forestry, country residential and shoreland districts.

12.2.2 Permitted Uses

No Development Permit shall be issued in a Rural Commercial (C9) Zone except for one or more of the following uses and subject to the following requirements:

Convenience Stores
Farm Markets
Gas Bars
General Merchandise Stores
Residential Units in Commercial Buildings
Service Stations
Single Detached Dwellings

12.2.3 General Provisions

12.2.3.1 Part 3 of this Bylaw contains provisions which apply to all zones in the Municipality and includes regulations for parking for disabled, loading spaces and signs.

12.2.3.2 Section 10.1 of this Bylaw contains provisions which apply to rural zones including regulations for bulk fuel and hazardous materials.

12.2.4 Access

12.2.4.1 A maximum of 2 accesses to any commercial lot from any public road shall be permitted.

12.2.4.2 A minimum 25 foot separation distance consisting of a curb, barrier, or ditch designed to prevent vehicular access shall be maintained between accesses.

12.2.4.3 Accesses shall have a maximum width of 36 feet.

12.2.4.4 Accesses shall be located at least 50 feet from the nearest intersection of street lines.

12.2.4.5 Access shall be to a Rural Collector Road where possible.

12.2.5 **Outdoor Commercial Display**

12.2.5.1 Outdoor commercial display shall be located a minimum of 20 feet from any lot line.

12.2.5.2 Outdoor commercial display is not permitted in any yard which abuts a R6 or R7 Zone.

12.2.6 **Outdoor Storage**

12.2.6.1 Outdoor storage is not permitted within any front yard of a lot.

12.2.6.2 Outdoor storage is not permitted in any yard which abuts a R6 or R7 Zone or a P1 Zone.

12.2.7 **Special Requirements: Residential Units in Commercial Buildings**

Residential units are permitted in commercial buildings provided:

12.2.7.1 The residential units are contained in the main building constituting the commercial use, except for a detached dwelling on the lot.

12.2.7.2 For each residential unit, 1.5 parking spaces shall be provided on site.

12.2.7.3 The residential units are located above, behind, beside or below the permitted commercial uses.

12.2.8 Zone Requirements

Any permitted use in any Rural Commercial (C9) Zone must comply with the following regulations:

RURAL COMMERCIAL (C9) ZONE	Permitted C9 Zone Uses
Minimum Lot Area	50,000 sq ft
Minimum Lot Frontage	200 ft
Minimum Front or Flankage Yard	45 ft
Minimum Rear Yard	40 ft
Minimum Side Yard (Main Building)	
a) General	20 ft
b) Pump Island Included	80 ft
Maximum Height of Main Building	35 ft
Maximum Height of Accessory Building	20 ft
Minimum Clear Distance between Main Buildings	20 ft
Maximum Commercial Floor Area	2,000 sq ft

11.2 FORESTRY (F1) ZONE

11.2.1 Purpose

The purpose of the Forestry (F1) Zone is to provide for forestry, forest industries and related land uses. In addition, the Forestry (F1) Zone provides for agricultural and residential uses.

11.2.2 Permitted Uses

No Development Permit shall be issued in a Forestry (F1) Zone except for one or more of the following uses and subject to the following requirements:

Agricultural Uses as part of the farm operation excluding livestock operations
Bunkhouses
Double Wide Mobile Homes
Duplexes
Existing Community Facilities
Existing Gun Ranges
Fish Farm
Fishing Uses
Forestry Uses
Greenhouses
Kennels
Mini Homes
Mobile Homes
Multi-sectional Modular Homes
Nonprofit Camps
Nurseries
Radio Controlled Aircraft Fields
Residential Care Facilities
Seasonal Dwellings
Semi-Detached Dwellings
Single Detached Dwellings
Small-Scale Wind Turbines
Wildlife Rescue and Rehabilitation Centre

11.2.3 Uses Subject to Conditions

Bed and Breakfast Operations
Commercial Livestock Operations
Farm Market Outlets
Farm Tenement Buildings

Home Day Care
Homes for Special Care
Recycling Depots
Rural Home Occupations
Tourist Commercial Facilities for Lodging, Food Services and Ancillary Uses
Wind Monitoring (Meteorological) Towers

11.2.4 **General Provisions**

11.2.4.1 Part 3 of this Bylaw contains provisions which apply to all zones in the Municipality and includes regulations for parking, loading spaces and signs.

11.2.4.2 Regulations for home day care, bed and breakfast operations and home occupations and storage of petroleum and dangerous goods are contained in the Rural General Provisions, Section 10.1, of this Bylaw.

11.2.4.3 Regulations for tourist commercial facilities for lodging, food services, and ancillary uses are set out in Section 10.1.5 of this Bylaw.

11.2.5 **Special Requirements: Commercial Livestock Operations**

Commercial Livestock Operations must comply with the following conditions:

11.2.5.1 New livestock buildings shall not be located within one thousand (1,000) feet of a hamlet (excepting Grand Pré) or a growth centre where abutting lands are zoned for residential or institutional use.

11.2.5.2 New buildings, including manure storage facilities, shall be located a minimum distance of three hundred (300) feet from a well, watercourse or a dwelling on an adjacent property.

11.2.5.3 Livestock operations located within the separation distance specified in Section 11.1.9.1 shall be conforming provided they were in existence prior to May 2, 1988. Such operations shall be permitted to expand or rebuild. Permitted expansions of existing livestock operations shall include barn or other facility additions, new barn construction, and changes from one form of livestock operation to another. In no case shall the livestock operation expansion encroach more than twenty (20%) of the existing distance between the nearest wall of the livestock operation and the affected growth centre, hamlet or non-farm dwelling.

11.2.5.4 Any new livestock operation or expansion to an existing livestock operation after January 1, 2003 must have a manure disposal plan approved by the Province of Nova Scotia.

11.2.6 **Special Requirements: Farm Market Outlets**

Farm market outlets must comply with the following conditions:

Parking must be provided on the site at the ratio of one (1) parking space for each sixty (60) square feet of floor area.

11.2.7 **Special Requirements: Recycling Depots**

11.2.7.1 Outdoor storage shall not exceed 25% of the lot area.

11.2.7.2 Outdoor storage is not permitted in any minimum required yard.

11.2.7.3 The outdoor storage area shall be visually screened from the travelling public and surrounding residential uses, year-round, by the retention of existing coniferous trees or planting of additional trees. Newly planted trees must have an initial minimum height of 10 feet, or a lesser height if augmented by an earth berm providing equivalent vertical screening height.

11.2.7.4 A minimum 5 foot high fence shall be required and maintained along the abutting property line to ensure the security, safety, and containment of the use, where the recycling depot abuts an existing residential use.

11.2.8 **Uses Not Requiring a Permit**

Agricultural, forestry, and fishing uses may occur without a development permit but any structure required with the use shall not be erected without the issuance of a development permit.

11.2.9 Minimum Rear Yards

The minimum rear yard regulation shall be waived for boathouses and fish sheds.

11.2.10 Public Street Frontage

A development permit may be issued for an agricultural or forestry use to be located on a lot which does not front on a public street provided such use does not include a dwelling.

11.2.11 Redesignated Lands

Notwithstanding Section 11.2.12, the erection of a dwelling is permitted on any lot created prior to January 5, 1988 and rezoned from A1, Agricultural to Forestry provided the minimum requirements of Section 11.1.19 and all other relevant provisions of this Bylaw are met.

11.2.12 Homes for Special Care

11.2.12.1 A building originally built and designed as a single detached dwelling may be converted for use as a home for special care; or

11.2.12.2 A building originally built and designed as a church or for a similar denominational use may be converted for use as a home for special care.

11.2.13 Zone Requirements

Any permitted use in any Forestry (F1) Zone must comply with the following regulations:

FORESTRY (F1) ZONE	Dwellings Seasonal Dwellings Non-Farm Buildings Recycling Depots Homes for Special Care and Residential Care Facilities	Farm Buildings (except Commercial Livestock Buildings), Kennels, Greenhouses, Nurseries, Wildlife Rescue and Rehabilitation Centre	Commercial Livestock Buildings
Minimum Lot Area:			
a) General	50,000 sq ft	50,000 sq ft	200,000 sq ft
b) Semi-detached dwellings	25,000 sq ft/unit		
Minimum Lot Frontage:			
a) General	200 ft	No Regulation	No Regulation
b) Semi-detached dwellings	100 ft/unit		
Minimum Front or Flankage Yard	45 ft	120 ft	150 ft
Minimum Rear Yard:			
a) General	40 ft	40 ft	200 ft
b) Accessory Building	20 ft	40 ft	200 ft
Minimum Side Yard:			
a) General	20 ft	40 ft	200 ft
b) Semi-detached dwellings - common side lot line - other side	 0 ft 20 ft		
c) Accessory Buildings	10 ft	40 ft	200 ft
Maximum Height of Main Building	35 ft	55 ft	55 ft
Maximum Height of Accessory Building	20 ft	55 ft	20 ft
Minimum Side Yard Abutting Residential Use - Recycling Depot	40 ft		

PART 11	AMENDED DATE	SECTION
	October 6, 1992	11.2.13
	December 7, 1993	11.2.2
	September 6, 1995	11.2.3 / 11.2.4.3
	January 22, 1996	11.2.2 / 11.2.3 / 11.2.5 / 11.2.13
	September 4, 2001	11.2.3 / 11.2.5 / 11.2.13
	March 5, 2002	11.2.2 / 11.2.13
	July 5, 2005	11.3 Renumbered as 11.2 / 11.2.1 / 11.2.2 / 11.2.3 / 11.2.4 / 11.2.4.1 / 11.2.4.2 / 11.2.4.3 / 11.2.5 / 11.2.5.1 / 11.2.5.2 / 11.2.5.3 / 11.2.5.4 / 11.2.6 / 11.2.7 / 11.2.7.1 / 11.2.7.2 / 11.2.7.3 / 11.2.7.4 / 11.2.8 / 11.2.9 / 11.2.10 / 11.2.11 / 11.2.12 / 11.2.13
	August 31, 2006	11.2.2
	May 21, 2009	11.2.10 / 11.2.13
	June 2, 2011	11.2.3 (Large-scale Wind Turbines and Wind Monitoring (Meteorological) Towers inserted)
	August 30, 2012	11.2.3 Large-scale Wind Turbines deleted (File P12-01)
	October 25, 2013	11.2.12 Homes for Special Care / 11.2.13 Homes for Special Care and Residential Care Facilities (File 12-24)

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.

18.3 ENVIRONMENTAL OPEN SPACE (O1) ZONE

18.3.1 Purpose

The purpose of the Environmental Open Space (O1) Zone is to prevent development from occurring on lands subject to flooding or otherwise posing a hazard and to protect environmental sensitive areas from development.

18.3.2 Permitted Uses

No Development Permit shall be issued in an Environmental Open Space (O1) Zone except for one or more of the following uses and subject to the following requirements:

Agricultural Uses
Flood Control Facilities
Fishing Uses
Forestry Uses
Radio Controlled Aircraft Fields

18.3.3 Special Requirements: O1 Zone

Any permitted use in any O1 Zone must comply with the following special requirements.

18.3.3.1 No permanent building or structure may be erected in an O1 Zone except for buildings or structures related to sewage treatment, flood control, or water supply facilities.

18.3.3.2 Temporary or seasonal structures accessory to all other permitted uses are permitted and new accessory structures for uses existing as of March 2, 2006 no greater than 150 square feet in size are permitted, subject to the conditions of Section 18.3.4.

18.3.3.3 Permitted permanent or temporary structures shall not be located closer than fifty (50) feet from any lot line or exceed a height of thirty-five (35) feet.

18.3.3.4 Agricultural, forestry and fishing uses may occur without a development permit but any structure required with the use shall not be erected without the issuance of a development permit.

18.3.4 **Existing Uses in the O1 Zone and New Accessory Structures**

New accessory structures no greater than 150 square feet in size for structures existing as of March 2, 2006 in the O1 Zone shall be permitted, subject to the following conditions:

a. the structure and the associated utilities shall be designed and constructed in accordance with the accepted flood proofing measures (as certified by a professional engineer) and entrances and exits from the building can be safely used without hindrance in the event of a flood

b. the proposed use of the facility and site will not involve any storage of potential pollutants such as fuels, chemicals, pesticides, manure, or any other substance with the potential to pollute surface or groundwater resources

c. the property owner submits a letter to Municipal Staff acknowledging they are aware they are developing in a floodplain

18.3.5 **Signs**

All signs shall be subject to the requirements of Section 3.7, General Provisions for signs in all zones.

18.3.6 **Floodplains**

Floodplains, or lands subject to periodic inundation which are included within the O1 Zone are delineated as determined by the March, 2004 Floodplain Review, as conducted by Municipal Staff and are derived from the best technical and historical data available.

18.3.7 **Alteration of Land Levels**

There shall be no alteration or change of the natural grade within the O1 Zone with the exception of minor recontouring related to cultivation of arable land, public park uses or development permitted by Subsection 18.3.4.

PART 18	AMENDED DATE	SECTION
	October 4, 1993	18.3.2
	September 7, 2004	18.3.5
	March 2, 2006	18.3.3.1 / 18.3.3.2 / 18.3.4 / 18.3.5 / 18.3.6 / 18.3.7

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.

18.4 WATER SUPPLY (O2) ZONE

18.4.1 Purpose

The purpose of the Water Supply (O2) Zone is to limit development within public water supply areas and thereby protect the surface water supply from contamination.

18.4.2 Permitted Uses

No Development Permit shall be issued in a Water Supply (O2) Zone except for one or more of the following uses and subject to the following requirements:

Agricultural Uses subject to requirements of the A1 Zone except for Intensive Livestock Operations and dwellings subject to requirements of the A1 Zone
Existing Land Uses
Forestry Uses
Single Detached Dwellings
Small-Scale Wind Turbines
Water Supply Facilities
Wind Monitoring (Meteorological) Towers (subject to conditions)

18.4.3 Special Requirements: O2 Zone

Any permitted use in any O2 Zone must comply with the following special requirements.

18.4.4 Permanent Buildings

No permanent building or structure shall be erected within 200 feet of a surface water supply or a watercourse draining into the water supply except flood control of water supply facilities.

18.4.5 Agricultural and Forestry Uses

No agricultural or forestry use which may contribute to excessive flooding, erosion, contamination or other detrimental consequences shall be permitted within 100 feet of a surface water supply or a watercourse draining into the water supply.

18.4.6 Signs

All signs shall be subject to the requirements of Section 3.7, General Provisions for signs in all zones.

18.4.7 **Small-Scale Wind Turbines**

All small-scale wind turbines shall be subject to an Environmental Impact Assessment satisfying the Nova Scotia Department of Health and Nova Scotia Environment.

18.4.8 Zone Requirements

Any permitted use in any Water Supply (O2) Zone must comply with the following regulations:

WATER SUPPLY (O2) ZONE	Permitted O2 Zone Uses
Minimum Lot Area	50,000 sq ft
Minimum Lot Frontage	200 ft
Minimum Front or Flankage Yard	45 ft
Minimum Rear Yard	40 ft
Minimum Side Yard	20 ft
Maximum Height of Main Building	35 ft
Maximum Height of Accessory Building	15 ft

PART 18	**AMENDED DATE**	**SECTION**
	October 6, 1992	18.4.7
	August 31, 2006	18.4.2 / 18.4.7 / 18.4.8
	May 21, 2009	18.4.7
	June 2, 2011	18.4.2 (Wind Monitoring (Meteorological) Towers (subject to conditions) inserted)

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.

PART 14 – RURAL RESIDENTIAL ZONES

14.1 COUNTRY RESIDENTIAL (R6) ZONE

14.1.1 Purpose

The purpose of the Country Residential (R6) Zone is to provide for a rural environment consisting of a mixture of residential development, agricultural uses and community facilities.

14.1.2 Permitted Uses

No Development Permit shall be issued in a Country Residential (R6) Zone except for one or more of the following uses and subject to the following requirements:

Agricultural Uses
Commercial Livestock Operations subject to the requirements of the A1 Zone
Double Wide Mobile Homes
Duplexes
Existing Uses
Farm Market Outlets subject to the requirements of the A1 Zone
Farm Tenement Buildings and Bunkhouses subject to the requirements of the A1 Zone
Fish Farms
Fishing Uses
Forestry Uses
Kennels
Licensed Zoos
Mini Homes
Mobile Homes
Multi Sectional Modular Homes
Nonprofit Camps
Nurseries
Residential Care Facilities
Seasonal Dwellings
Semi-Detached Dwellings
Single Detached Dwellings
Small-Scale Wind Turbines

14.1.3 **Uses Subject to Conditions**

Bed and Breakfast Operations
Home Day Care
Rural Home Occupations
Tourist Commercial Facilities for Lodging, Food Services and Ancillary Uses
Wind Monitoring (Meteorological) Towers

14.1.4 **General Provisions**

14.1.4.1 Part 3 of this Bylaw contains additional requirements for swimming pools, signs, accessory buildings and parking.

14.1.4.2 Section 10.1 of this Bylaw contains general provisions which apply to Rural uses and includes regulations for rural home occupations, bed and breakfast operations, home day cares, cemeteries and parks.

14.1.4.3 Regulations for tourist commercial facilities for lodging, food services, and ancillary uses are set out in Section 10.1.5 of this Bylaw.

14.1.5 **Uses Not Requiring a Permit**

Agricultural, forestry, and fishing uses may occur without a development permit but any structure required with the use shall not be erected without the issuance of a development permit.

14.1.6 **Minimum Rear Yards**

The minimum rear yard regulation shall be waived for boat houses and fish sheds.

14.1.7 **Fronting on Public Street**

A development permit may be issued for an agricultural use, a forestry use, or a seasonal dwelling to be located on a lot which does not front on a public street provided such use does not include a dwelling.

14.1.8 **Reduced Lot Standards: Habitant**

Where a property fronts on the serviced portion of Highway 221 between Canning and Habitant, the minimum lot area shall be reduced to 20,000 square feet and the minimum frontage reduced to 100 feet.

14.1.9 **Zone Requirements**

Any permitted use in any Country Residential (R6) Zone must comply with the following regulations:

COUNTRY RESIDENTIAL (R6) ZONE	Mini Homes, Mobile Homes, Single Dwellings, Non-Farm Dwellings, Seasonal Dwellings, and Residential Care Facilities	Farm Buildings (except Commercial Livestock Buildings), Greenhouses, Nurseries	Commercial Livestock Buildings
Minimum Lot Area:		50,000 sq ft	200,000 sq ft
a) General	50,000 sq ft		
b) Habitant	20,000 sq ft		
c) Semi-detached dwellings	25,000 sq ft/unit		
Minimum Lot Frontage:		No Regulation	No Regulation
a) General	200 ft		
b) Habitant	100 ft		
c) Semi-detached dwellings	100 ft/unit		
Minimum Front or Flankage Yard	25 ft	120 ft	150 ft
Minimum Rear Yard:			
a) General	40 ft	40 ft	200 ft
b) Accessory Building	10 ft	40 ft	200 ft
Minimum Side Yard:			
a) General	20 ft	40 ft	200 ft
b) Semi-detached dwellings - common side lot line - other side	 No Regulation 20 ft		
c) Accessory Buildings	4 ft	40 ft	200 ft
Maximum Height of Main Building	35 ft	55 ft	55 ft

PART 14	**AMENDED DATE**	**SECTION**
	October 6, 1992	14.1.9
	January 5, 1993	14.1.2
	September 6, 1995	14.1.3 / 14.1.4.3
	January 22, 1996	14.1.2 / 14.1.9
	March 26, 1999	14.1
	September 4, 2001	14.1.2 / 14.1.9
	July 5, 2005	14.1.9
	August 31, 2006	14.1.2
	June 2, 2011	14.1.3 (Large-scale Wind Turbines and Wind Monitoring (Meteorological) Towers inserted)
	August 30, 2012	14.1.3 Large-scale Wind Turbines deleted (File P12-01)
	October 25, 2013	14.1.9 Residential Care Facilities (File 12-24)
	March 28, 2014	14.1.9 Minimum Front or Flankage Yard / Minimum Side Yard Accessory Buildings (File 13-19)

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.

14.4 SEASONAL RESIDENTIAL (S1) ZONE

14.4.1 Purpose

The purpose of the Seasonal Residential (S1) Zone is to provide for seasonal residential and recreational uses without negatively impacting water quality around the lakes on the South Mountain where Council has adopted official water quality objectives.

14.4.2 Permitted Uses

No Development Permit shall be issued in a Seasonal Residential (S1) Zone except for one or more of the following uses and subject to the following requirements:

Mini Homes
Parks and Recreation Uses
Seasonal Dwellings
Single Detached Dwellings
Small-Scale Wind Turbines conditional to same height and setback requirements as main building

14.4.3 Uses Subject to Conditions

Seasonal Dwellings, Single Detached Dwellings and Mini Homes on lakes that have reached their maximum carrying capacity
Wind Monitoring (Meteorological) Towers

14.4.4 General Provisions

14.4.4.1 Part 3 of this Bylaw contains provisions which apply to all zones in the Municipality and includes requirements for swimming pools, signs, and accessory buildings.

14.4.5 Special Requirements: Seasonal Dwellings, Single Detached Dwellings and Mini Homes

14.4.5.1 Development of seasonal dwellings, single detached dwellings and mini homes on lands within 350 feet of a lake or watercourse around lakes that have reached their maximum carrying capacity specified in section 14.4.13 of this Bylaw must obtain site plan approval in accordance with the criteria contained in section 14.4.11 of this Bylaw.

14.4.6 **Minimum Building Setback from Shoreline**

The minimum shoreline setback shall be modified for boathouses.

14.4.7 **Frontage on a Private Road**

A development permit may be issued for a mini home, seasonal dwelling or single detached dwelling to be located on a lot which does not front on a public road.

14.4.8 **Shoreline Setback**

Applicants for permits for seasonal and single detached dwellings on waterfront lots shall adhere to the following restrictions:

14.4.8.1 Vegetation within the shoreline setback would be disturbed as little as possible, consistent with passage, safety, and provision of views and ventilation.

14.4.8.2 Clear-cutting and removal of native plant species within the shoreline setback is prohibited with the exception of trees and underbrush necessary to permit a path to the shoreline and views of a lake.

14.4.8.3 The soil mantle within the setback should not be altered by cutting, filling, or recontouring of the natural grades or otherwise, to every extent possible.

14.4.9 **Maximum Building Footprint**

The maximum combined main and accessory building footprint is as follows:

	Waterfront Lots	Back Lots
Lots 0 to 25,000 sq ft in area	10 percent of lot area	20 percent of lot area
Lots 25,001 to 50,000 sq ft in area	2,500 sq ft	5,000 sq ft
Lots 50,001 to 75,000 sq ft in area	3,000 sq ft	5,500 sq ft
Lots 75,001 to 100,000 sq ft in area	3,500 sq ft	6,000 sq ft
Lots larger than 100,000 sq ft in area	4,000 sq ft	6,500 sq ft

14.4.10 **Development Requiring Site Plan Approval**

Development of Mini Homes, Seasonal Dwellings or Single Detached Dwellings on lands within 350 ft from a lake or watercourse in the Seasonal Residential (S1) Zone around lakes that have reached their maximum carrying capacity specified in section 14.4.13 of the Land Use Bylaw.

14.4.11 **Site Plan Content and Criteria**

14.4.11.1 No development permit shall be issued unless a clear and accurately scaled site plan showing the location and size of development on the property is provided. The site plan shall accurately show the following features:

a. Property Boundary and any shoreline

b. Any watercourses, steep slopes and wetlands

c. Driveway

d. Building Envelope

e. Any boathouse or fixed or floating dock

f. Area that may contain lawns, landscaping and accessory structures

g. Area to be maintained as natural vegetation

h. Area within the shoreline setback that may be partially cleared of some vegetation in order to provide for a path and view of the lake

i. Key measurements showing the location of the above features on the property

14.4.11.2 Proposed development shown in the site plan shall be in conformance with the following criteria.

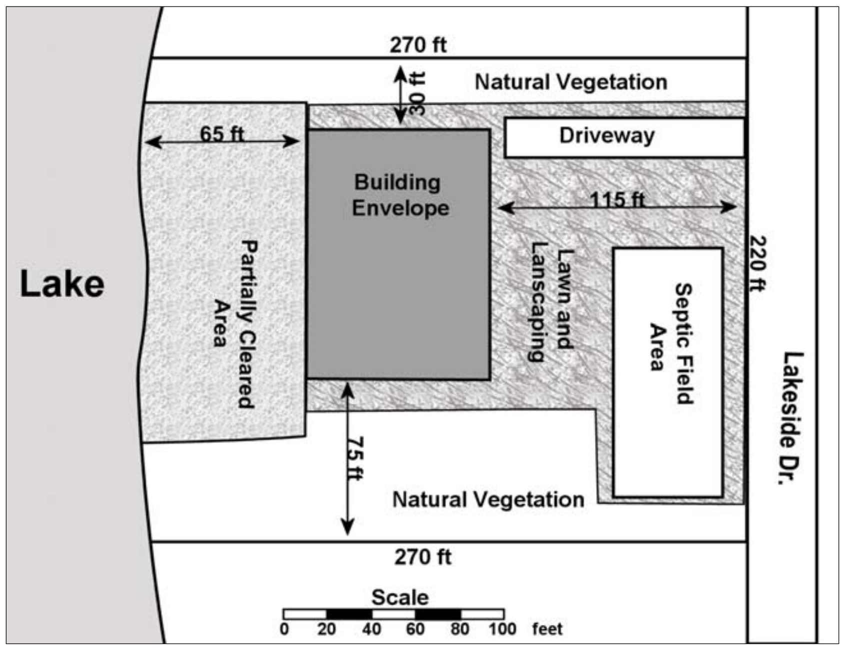
a. Lot requirements contained in section 14.4.12, below

b. Shoreline setback requirements contained in section 14.4.8, above

c. Any steep slopes or wetlands are maintained in a naturally vegetated state

d. Any accessory structures, excluding a boathouse, is located within the building envelope or area identified as lawn or landscaping. The main building must be located with the building envelope.

14.4.11.3 Site plan example



14.4.12 **Zone Requirements**

Any permitted use in any Seasonal Residential (S1) Zone must comply with the following regulations:

SEASONAL RESIDENTIAL (S1) ZONE	Mini Homes Permitted S1 Zone Uses Seasonal Dwellings and Single Detached Dwellings Parks and Recreation Uses on Back-lots	Mini Homes Permitted S1 Zone Uses Seasonal Dwellings, Single Detached Dwellings, Parks and Recreation Uses on Waterfront Lots
Minimum Lot Area	50,000 sq ft	50,000 sq ft
Minimum Lot Frontage (road)	200 ft	200 ft
Minimum Water Frontage	-	200 ft
Minimum Front or Flankage Yard	45 ft	45 ft
Minimum Building Setback From:		
Road:	45 ft	45 ft
Shoreline:	-	65 ft
Minimum Boathouse Setback From Shoreline	-	4 ft
Minimum Rear Yard		
a) General	40 ft	see shoreline setback
b) Accessory Buildings	20 ft	see shoreline setback
Minimum Side Yard		
a) General	20 ft	20 ft
b) Accessory Buildings	10 ft	10 ft
Maximum Height of Main Building	35 ft	35 ft
Maximum lot area cleared for buildings, lawns or landscaping	50%	50%
Maximum Number of Seasonal or Permanent Dwellings Per Lot	1	1

14.4.13 Maximum Permitted Waterfront Lots

The following table lists the lakes in the Lake George to Lumsden Pond Watershed and the maximum permitted number of waterfront dwellings (dwellings which are located within 350 feet of the shoreline) which may be built as-of-right.[1]

Lake Name	Chlorophyll a Objectives (average ice free season) measured in micro grams/Litre	Maximum Permitted Number of Waterfront Seasonal Dwellings and Single Detached Dwellings as-of-right
1. Lake George	2.5[2]	110
2. Loon	2.5	60
3. Aylesford	2.5	336
4. Crooked	2.5	30
5. Four Mile	2.5	110
6. Two Mile	2.5	81
7. Blue Mountain	2.5	22
8. Gaspereau	2.0	600
9. Salmontail	1.7	25
10. Murphy	2.5[3]	85
11. Trout River Pond	2.2	75
12. Moosehorn	2.5	13
13. Little River	2.1	75
14. Methals	2.1	40
15. Dean Chapter	1.8	48
16. Black River	2.1	290
17. Lumsden Pond	2.4	55

[1] In keeping with Municipal background reports, "existing" water quality values and objectives reflect predicted Chlorophyll a concentrations with an assumption that one third of all waterfront dwellings will eventually be occupied or used on a permanent full time basis.

[2] Lake George 1997 predicted trophic status is 3.0 μg/l chlorophyll a average ice free concentration. It is Council's intention to work with residents to improve water quality and reduce trophic status to 2.5 μg/l

[3] Murphy Lake 1997 predicted trophic status is 2.7 μg/l chlorophyll a. Like Lake George, it is Council's intention to work with residents to improve water quality and reduce trophic status to 2.5 μg/l.

PART 14	AMENDED DATE	SECTION
	October 6, 1992	14.3.6
	September 6, 1995	14.3.3.3
	July 17, 1997	14.3 – Seasonal Residential (S1) Zone Replaced Permanent Residential Shoreland (S1) Zone
	July 5, 2005	14.3 Renumbered as 14.4 / 14.4.1 / 14.4.2 / 14.4.2.1 / 14.4.3 / 14.4.4 / 14.4.5 / 14.4.6 / 14.4.7 / 14.4.7A / 14.4.8
	August 31, 2006	14.4.1
	October 25, 2007	14.4
	August 29, 2008	14.4.1 / 14.4.6
	May 21, 2009	14.4.1 / 14.4.2 / 14.4.3 / 14.4.4 / 14.4.4.1 / 14.4.5 / 14.4.6 / 14.4.7 14.4.8 / 14.4.8.1 / 14.4.8.2 / 14.4.8.3 / 14.4.9 / 14.4.10 / 14.4.10.1 / 14.4.10.2 / 14.4.10.3 / 14.4.11 / 14.4.12
	June 2, 2011	14.4.3 (Large-scale Wind Turbines and Wind Monitoring (Meteorological) Towers inserted)
	August 30, 2012	14.4.3 Large-scale Wind Turbines deleted (File P12-01)
	August 1, 2014	14.4.9 / 14.4.12 (File 13-27)

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.

14.5 FUTURE SHORELAND (S2) ZONE

14.5.1 Purpose

The purpose of the Future Shoreland (S2) Zone is to provide for seasonal residential and recreational uses without negatively impacting water quality around lakes that Council has yet to determine the predicted capacity. This zone also recognizes special character areas that are found around the lakes in the Shoreland District.

14.5.2 Permitted Uses

No Development Permit shall be issued in a Future Shoreland (S2) Zone except for one or more of the following uses and subject to the following requirements:

Existing Agricultural Uses excluding livestock operations
Existing Seasonal Dwellings
Existing Single Detached Dwellings
Forestry Uses beyond 100 feet of a freshwater lake or tributary stream subject to the requirements of Section 11.2 Forestry Zone, of this Bylaw
Mini Homes on approved Lots and Back-lots
Parks and Recreation Uses
Single Detached Dwellings on approved Lots and Back-lots
Seasonal Dwellings on approved Lots and Back-lots
Small-Scale Wind Turbines conditional to same height and setback requirements as main building

14.5.3 Uses Subject to Conditions

Seasonal Dwellings, Single Detached Dwellings, or Mini Homes on waterfront lots created after October 25, 2007
Wind Monitoring (Meteorological) Towers

14.5.4 General Provisions

Part 3 of this Bylaw contains provisions which apply to all zones in the Municipality and includes requirements for swimming pools, signs, and accessory buildings.

14.5.5 Special Requirements: Seasonal Dwellings, Single Detached Dwellings and Mini Homes

14.5.5.1 Development of seasonal dwellings, single detached dwellings and mini homes on lots within 350 feet of a lake or watercourse that were created after October 25, 2007 must obtain site plan approval according to the criteria contained in section 14.5.8 of this Bylaw.

14.5.6 **Frontage on a Private Road**

A development permit may be issued for a mini home, seasonal dwelling or single detached dwelling to be located on a lot which does not front on a public road.

14.5.7 **Shoreline Setback**

Applicants who are eligible for permits for single detached dwellings on waterfront lots shall adhere to the following restrictions:

14.5.7.1 Vegetation within the shoreline setback would be disturbed as little as possible, consistent with passage, safety, and provision of views and ventilation.

14.5.7.2 Clear-cutting and removal of native plant species within the shoreline setback is prohibited with the exception of trees and underbrush necessary to permit a path to the shoreline and views of a lake.

14.5.7.3 The soil mantle within the shoreline setback should not be altered by cutting, filling or recontouring of the natural grades or otherwise to every extent possible.

14.5.8 **Development Requiring Site Plan Approval**

New seasonal or single detached dwellings or mini homes on lots with lake water frontage created after October 25, 2007.

14.5.9 **Site Plan Content and Criteria**

14.5.9.1 No development permit shall be issued unless a clear and accurately scaled site plan showing the location and size of development on the property is provided. The site plan shall accurately show the following features:

a. Property Boundary and any shoreline

b. Any watercourses, steep slopes and wetlands

c. Driveway

d. Building Envelope

e. Any boathouse or fixed or floating dock

f. Area that may contain lawns, landscaping and accessory structures

g. Area to be maintained as natural vegetation

h. Area within the shoreline setback that may be partially cleared of some vegetation in order to provide for a path and view of the lake

i. Key measurements showing the location of the above features on the property

14.5.9.2 Proposed development shown in the site plan shall be in conformance with the following criteria.

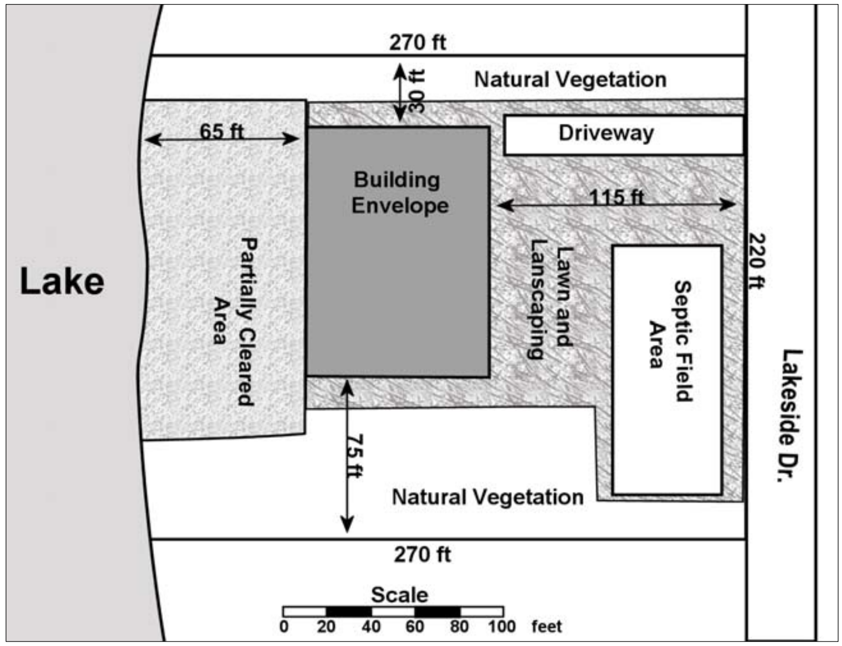
a. Lot requirements contained in section 14.5.7, below

b. Shoreline setback requirements contained in section 14.5.4, above

c. Any steep slopes or wetlands are maintained in a naturally vegetated state

d. Any accessory structures, excluding a boathouse, is located within the building envelope or area identified as lawn or landscaping. The main building must be located with the building envelope.

14.5.9.3 Site plan example



14.5.10 Zone Requirements

Any permitted use in any Future Shoreland (S2) Zone must comply with the following regulations:

FUTURE SHORELAND (S2) ZONE	Mini Homes Permitted S2 Zone Uses, Seasonal and Single Detached Dwellings on Back-lots, Parks, Recreation Uses and Forestry Uses	Mini Homes Permitted S2 Zone Uses, Seasonal and Single Detached Dwellings on Approved Waterfront Lots, Parks and Recreation Uses, Forestry Uses
Minimum Lot Area	50,000 sq ft	50,000 sq ft
Minimum Lot Frontage	200 ft	200 ft
Minimum Water Frontage	-	200 ft
Minimum Front or Flankage Yard	45 ft	45 ft
Minimum Building Setback From:		
Road:	45 ft	45 ft
Shoreline:	-	65 ft
Minimum Boathouse Setback From Shoreline	-	4 ft
Minimum Rear Yard		
a) General	40 ft	see shoreline setback
b) Accessory Buildings	-	see shoreline setback
Maximum Height of Main Building	35 ft	35 ft
Minimum Side Yard		
a) General	20 ft	20 ft
b) Accessory Buildings	10 ft	10 ft
Maximum Combined Main and Accessory Building Lot Coverage	20 percent up to 4,000 sq ft	10 percent up to 2,500 sq ft
Maximum lot area cleared for buildings, lawns or landscaping	50%	50%
Maximum Number of Seasonal or Permanent Dwellings Per Lot	1	1

PART 14	**AMENDED DATE**	**SECTION**
	October 6, 1992	14.4.7
	September 6, 1995	14.4.1 / 14.4.3.1 / 14.4.3.2.
	July 17, 1997	14.4 – Future Shoreland (S2) Zone Replaced Seasonal Residential (S2) Zone
	July 5, 2005	14.4 Renumbered as 14.5 / 14.5.1 / 14.5.2 / 14.5.3 / 14.5.4 / 14.5.5 / 14.5.6 / 14.5.6A
	August 31, 2006	14.5.1
	October 25, 2007	14.5
	August 29, 2008	14.5.1 / 14.5.5
	May 21, 2009	14.5.1 / 14.5.2 / 14.5.3 / 14.5.4 / 14.5.5 / 14.5.6 / 14.5.7 14.5.7.1 / 14.5.7.2 / 14.5.7.3 / 14.5.8 / 14.5.9 / 14.5.9.1 14.5.9.2 / 14.5.9.3 / 14.5.10
	June 2, 2011	14.5.3 (Wind Monitoring (Meteorological) Towers inserted)

Note: Numbering of Sections within this Bylaw may be different from the Amended Date.