2013 Kahshe Lake Steward Report

Kahshe Lake Ratepayers' Association

March 2014

2013 Kahshe Lake Steward Report

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2013 Executive Summary

Based on the findings from 30 years of water quality sampling and analysis carried out by The District Municipality of Muskoka (DMM) and the Ontario Ministry of the Environment (MOE) with sampling by the Kahshe Lake Steward, the following conclusions regarding the water quality and biological health of Kahshe and Bass Lakes can been drawn:

- Total phosphorus concentrations in both Kahshe and Bass Lakes, which are an indicator of the potential for algal blooms, are currently well below the level which would flag them as an Over Threshold lake by DMM.
- Although total phosphorus levels have not increased or decreased over the past 30 years, both Kahshe and Bass Lakes have been determined by DMM to be moderately sensitive to phosphorus inputs, meaning we need to continue our vigilance in trying to reduce phosphorous levels.
- The clarity of water also is measured as an early warning indicator of algal growth, and based on the DMM and MOE measurements over the years, the clarity levels range from 2.5-3.5 m for Kahshe and 1.5-2.5 m for Bass Lake. Clarity in both lakes is lower than the 3.0-4.9 m typical clarity for a tea coloured, Mesotrophic lake and more representative of clarity in a mildly Eutrophic lake.
- Based on the findings from the aquatic invertebrate sampling and identification program which has been operated by the DMM with assistance from the Kahshe Lake Steward and many KL volunteers over the period from 2004 to the present, the abundance and composition of benthic life on Kahshe Lake is similar to or better than the average results for reference sites from a selected database of Muskoka lakes.

In conclusion, based on the analysis of a large number of chemical and physical parameters by both the DMM and the MOE, it is apparent that water quality and benthic health in Kahshe Lake is in good condition and compares favourably with the results for other Muskoka lakes. Although there has been no MOE monitoring of Bass Lake and no benthic sampling either, the DMM results for water quality indicate that Bass Lake is in good condition, even though water clarity is lower than expected for a lake with naturally elevated DOC levels.

Given the potential for increasing water temperatures which have been documented in the entire Muskoka lake dataset, we need to remain vigilant in our sampling efforts and overall lake stewardship, as warmer waters are more prone to algal growth and may negate potential improvements in nutrient enrichment and other chemical indicators of lake health. It is also apparent that an additional monitoring location needs to be added to the south-western area of Kahshe Lake, where shallow waters are likely to be more sensitive to temperature increases. The bottom line is that each of us needs to do our part to maintain the quality of the water by:

- managing our septic systems properly and having tanks pumped out regularly,
- avoiding the use of products containing phosphorus (detergents and cleaners),
- disposing of toxic wastes (batteries, paint, oil, old gas, construction waste) at approved land fill sites
- minimizing near-shore removal or management of vegetation and soil and ensuring that any shoreline disturbance is conducted in compliance with permitted uses,
- avoiding the use of any chemical fertilizers and pesticides in areas close to the shore, and,
- taking precautions to minimize the potential for introducing invasive species into the lake.

1.0 Kahshe Lake Stewardship Mandate

In 2013, the Kahshe Lake Steward Committee was dissolved, with the role of the Lake Steward being assigned to a newly created Conservation Committee which reports directly to the Kahshe Lake Ratepayers' Association (KLRA). The Lake Steward has been made a permanent sitting member of this new committee. This change in reporting structure has not altered the roles and responsibilities of the Lake Steward, and these remain as:

- Educating the residents and other users of the lake on how to **preserve** and **improve** the quality of the lake and its shoreline.
- Monitoring the environmental quality of the lake and keeping the association members up to date on the results of the testing programs.

As this is the second Annual Lake Steward Report, much of the historical and background information presented in the 2012 Lake Steward Report has not changed, and as such this 2013 report will only briefly summarize the history of environmental monitoring on Kahshe and Bass Lakes and focus more on the chemical testing and biological monitoring that has taken place in 2013. The 2013 report also will place more emphasis on the results of testing on Bass Lake, and will not repeat the comparisons which were made in 2012 of water quality on two other up-gradient lakes (Ryde and Sunny Lakes).

Another important water quality parameter that is not being routinely monitored in either lake or at the public beaches by any organization is coliform contamination. If you are drinking water from the lake – **which is strongly not recommended** - and want to ensure that your filtering system is functioning properly, you can submit a sample of water to the Simcoe Muskoka Health Unit for coliform analysis. The contact info is:

- 2-5 Pineridge Gate, Gravenhurst, ON, P1P 1Z3. PHONE: 705-684-9090, FAX: 705-684-9887.

Anyone who suspects that a neighbouring septic system is in need of pumping or improved management can also take a sample from the lake and submit it to the Simcoe Muskoka Health Unit.

Given the importance of maintaining fully functional septic systems, the following information has been extracted from a Good Neighbour Resource Hand book article by Rob Abbott which is in the process of being updated for 2014 by the Conservation Committee.

> Your septic system is a sewage treatment facility that requires careful attention to design, construction, operation and maintenance. **As a property owner, this is your responsibility.** In Ontario, the specifications for construction and maintenance of sewage systems with a flow of less than 10,000 litres per day are regulated under the *Ontario Building Code*, and municipalities are responsible for the inspection and approval of all septic installations. In the case of Kahshe Lake, the Building Department of the Town of Gravenhurst is the department with this responsibility. In addition to permitting the installation of septic systems, the Town of Gravenhurst also operates a septic re-inspection program which is briefly summarized below:

- the re-inspection on Kahshe Lake is carried out every 5 years (2008… 2013….);
- it consists of a trained student visiting most (but not always all) properties and carrying out a visual inspection of the tank and bed;
- if the visual inspection finds the tank and bed in good condition, they leave a note to inform the property owner and send a follow-up letter;
- if there are visual signs of failure of the leaching bed, they leave a notice and the Building Department follows up with a letter requiring a pump-out and system inspection with a receipt from a licenced pumper to confirm that it has been carried out;
- if the visual signs point to a serious failure, the Building Department issues a stop order until evidence is provided that the problem has been corrected.

Unfortunately, there is no systematic process for re-inspections based on permits or on re-inspection findings. However, cottage owners are encouraged to report any suspected problems to the Building Department so they can follow up with an inspection of the system. Another way neighbouring property owners can support a concern regarding possible septic system failure is to submit a sample of lake water from a location close to the suspect property. The sample should go to the Simcoe Muskoka Health Unit for coliform analysis at the address noted on the previous page.

2.0 History of Environmental Monitoring on Kahshe and Other Muskoka Lakes

Kahshe Lake is being monitored for water quality and biological functioning parameters under two main initiatives as outlined below:

Lake Partner Program (LPP)

This program is operated by the Ontario Ministry of the Environment (MOE) through the Dorset Environmental Science Centre. Under this program, water sampling and measurement of water clarity is conducted by the Kahshe Lake Steward <u>every year</u>.

The program consists of the following activities:

- Water clarity measurements
  - Clarity of the water is measured every two weeks during the ice-free period at three locations using a Secchi disc, and these findings are forwarded to the MOE for compilation and comparison with other lakes in Ontario.
- Water quality testing
  - Water is sampled from three locations in May each year and sent to the MOE where it is analyzed for total phosphorous.

Lake System Health Program (DMM)

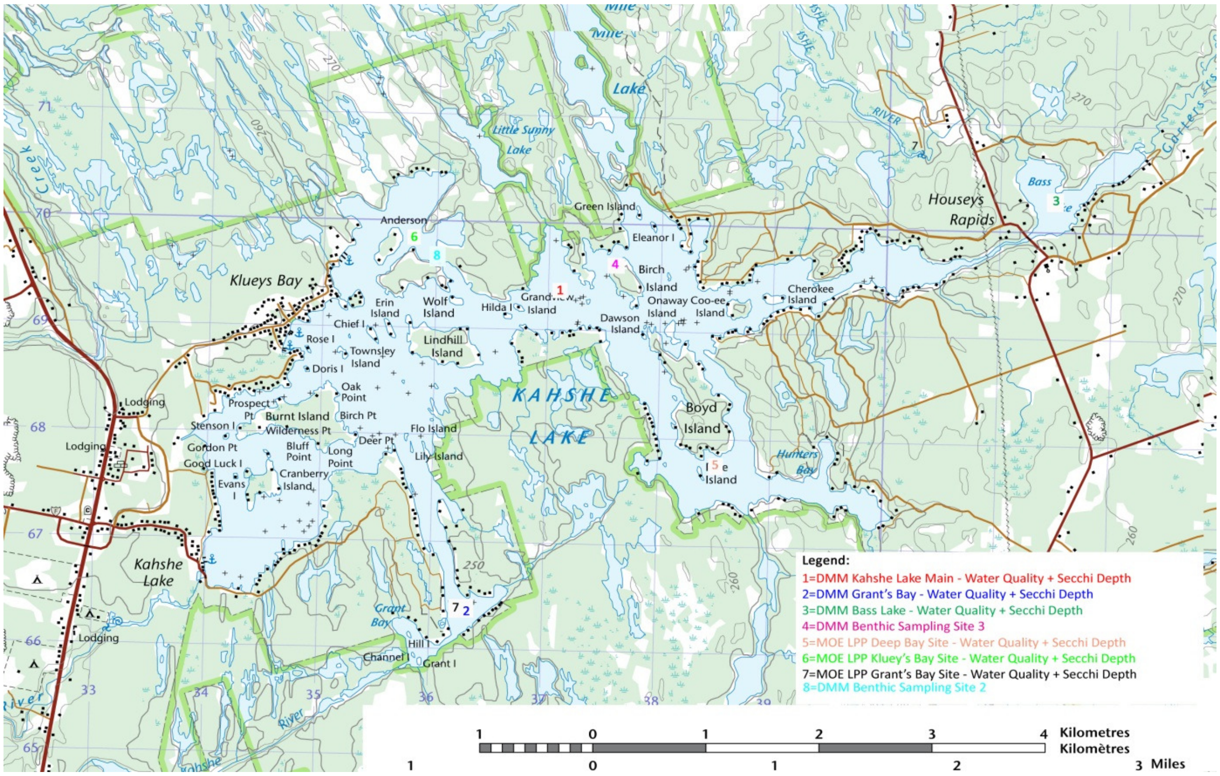
This program is one of several components of a larger **Muskoka Water Strategy** which is operated by The District Municipality of Muskoka (DMM), with support from the Muskoka Watershed Council (MWC), the MOE and several other participating agencies.

The monitoring program consists of 193 sampling sites on 164 lakes on a rotational basis. The program was designed to deliver a monitoring program which would establish a long-term record of key water quality parameters so that trends in water quality and lake system health could be identified and appropriate management decisions taken to protect lake water quality.

For Kahshe and Bass Lakes, the DMM program consists of the following activities which are conducted every other year (i.e. Bass L was sampled in 2012 and Kahshe Lake in 2013):

- Spring phosphorus sampling conducted in May (2 sites in KL and 1 in Bass L);
- Water sample collection for a suite of physical and chemical parameters in May (2 sites in KL and 1 in Bass L);
- Secchi depth measurements collected in May and August (2 sites in KL and one in Bass L);
- Temperature and dissolved oxygen at increasing water depths taken in May and August (2 sites in KL and 1 in Bass L);
- Benthic invertebrate sampling in August (1 of 2 established sites in Kahshe Lake only).

To give a better perspective on where the sampling for both the MOE Lake Partner Program and the DMM Lake System Health Program is conducted on Kahshe and Bass Lakes, the locations of water sampling and measurement have been shown on a map below.



3.0 Reported Findings of Monitoring on Kahshe and Bass Lakes

While the MOE, MWC and DMM have web sites where the sampling and analysis data are presented, there is only a limited amount of trend analysis and interpretative information available that is specific to data collected for Kahshe or Bass Lakes. Presented below is a brief summary of what each agency has published, and the conclusions which can be drawn from the data.

3.1 MWC Watershed Reports

The MWC's Watershed Report Cards are published every four years, and to date, three report cards have been released (2004, 2007 and 2010), with the next one to be released in 2014. The Report Cards focus *on Indicators of Watershed Health* which were developed in 2002 through a Water Strategy public consultation process.

Based on information provided in the MWC's Report Cards, the Kahshe Lake sub-watershed is 24,533 hectares (ha) in size, and is located within the Severn River Watershed. Kahshe Lake itself is 8.2 km^2 in area, while Bass Lake has an area of 0.4 km^2. In total there are 20 lakes over 8 hectares in size in the sub-watershed.

Approximately 5% the sub-watershed is developed with 76% of the land in the sub-watershed being Crown land. There are no major urban areas within the sub-watershed and rural and shoreline residential development comprises most of the land use. About 11% of the sub-watershed is protected through provincial parks, crown nature reserves, or local land trusts.

In the most recent 2010 Report Card, the MWC grades assigned to the Kahshe Lake Sub-Watershed were:

Land: B

Water: A

Wetland: —

While this gives a general perspective on the health of the Kahshe Lake Sub-Watershed, it doesn't provide any specific information on Kahshe Lake itself. For those interested in more detail regarding the scoring system used by the MWC, the Kahshe Lake Sub-Watershed Report showing the scoring system and the results for each category (land, water and wetland) have been attached.

3.2 MOE Lake Partner Program

The MOE does not generate a year-end report on their Lake Partner Program. Instead, they provide a web-based link to all of the data generated via this program for use by Lake Stewards and other interested parties.

3.3 DMM Lake System Health Monitoring

The DMM publish a Year End Lake System Health Monitoring Program report and for each lake that is monitored, a Lake Data Sheet is posted on the DMM web site. The analysis of the DMM water quality monitoring program has been broken into the following two main components:

- **Evaluation of DMM Year-End Findings – 2013 Kahshe Lake Water Quality and 2012 Bass Lake Water Quality**
- **Additional Analysis of Kahshe and Bass Lake Water Quality Data to Answer Three Questions:**

  Question 1: Do the DMM results for total phosphorus and Secchi depth signal a need for concern regarding water quality and clarity in Kahshe and Bass Lakes?

  Question 2: How do DMM results for Kahshe and Bass Lake compare to results from MOE's LPP Sampling Program?

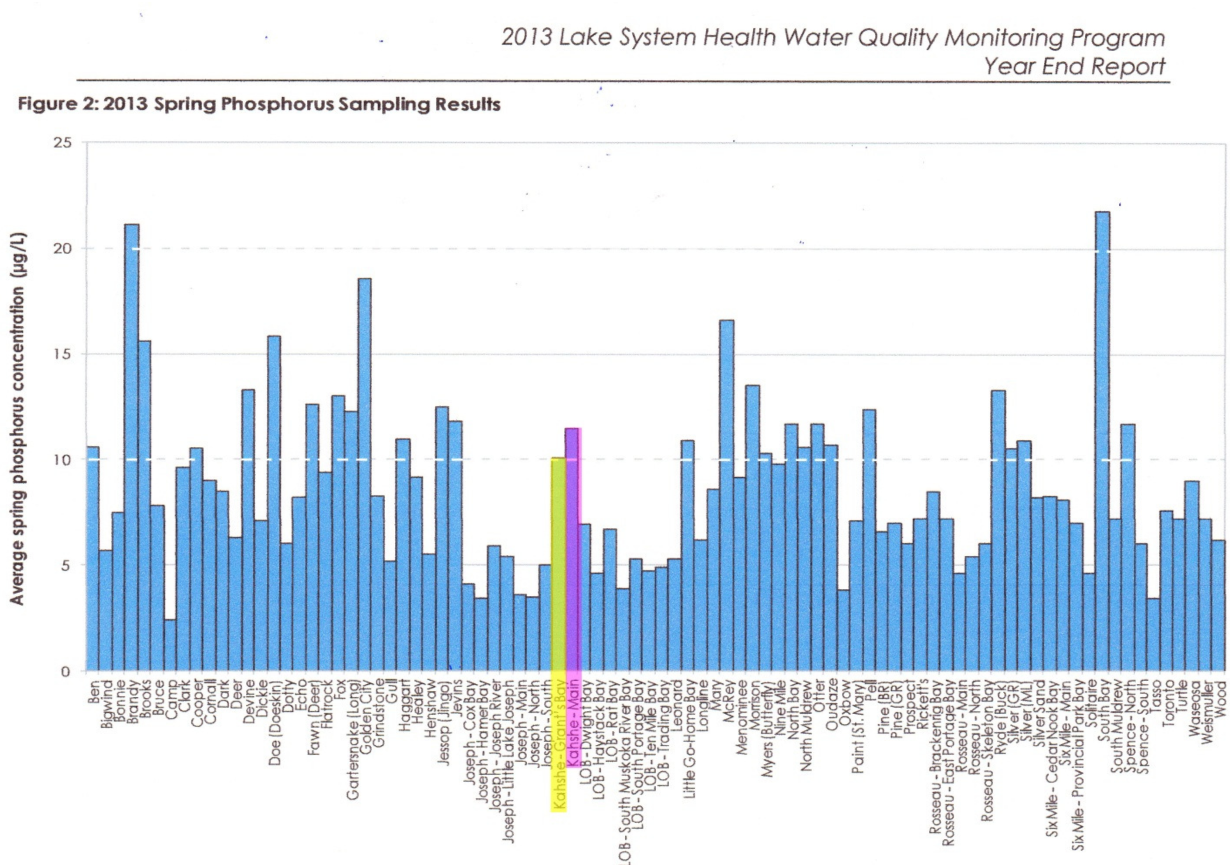
  Question 3: Can any conclusions be drawn based on the results of a large suite of physical and chemical parameters that have been analyzed by DMM but not all included in the Year-End report?

3.3.1 Evaluation of DMM Year-End Findings

The DMM year-end summary report and data sheets provide interpretative information on trends in water quality and the biological basis for analyzing the tested parameters and interpreting the outcome of the changes that are being seen across Muskoka. The 2013 year-end data sheets for Kahshe Main and Grant’s Bay sampling sites show current (2013) and historical sampling results for total phosphorus and Secchi depth as well as current water temperature and dissolved oxygen concentrations with increasing sampling depth. There is also a data sheet which shows the results of the benthic sampling over the years it has been undertaken and a data table showing most (but not all) of the other chemical parameters which were analyzed. In the case of Bass Lake, similar data sheets are provided for the most recent sampling in 2012. However, there has been no benthic monitoring on Bass Lake.

The charts on water quality as presented in the 2013 DMM year-end report are shown below for the Kahshe Lake Main and Grant’s Bay locations.

2013 - Total Phosphorus Results – Kahshe Lake

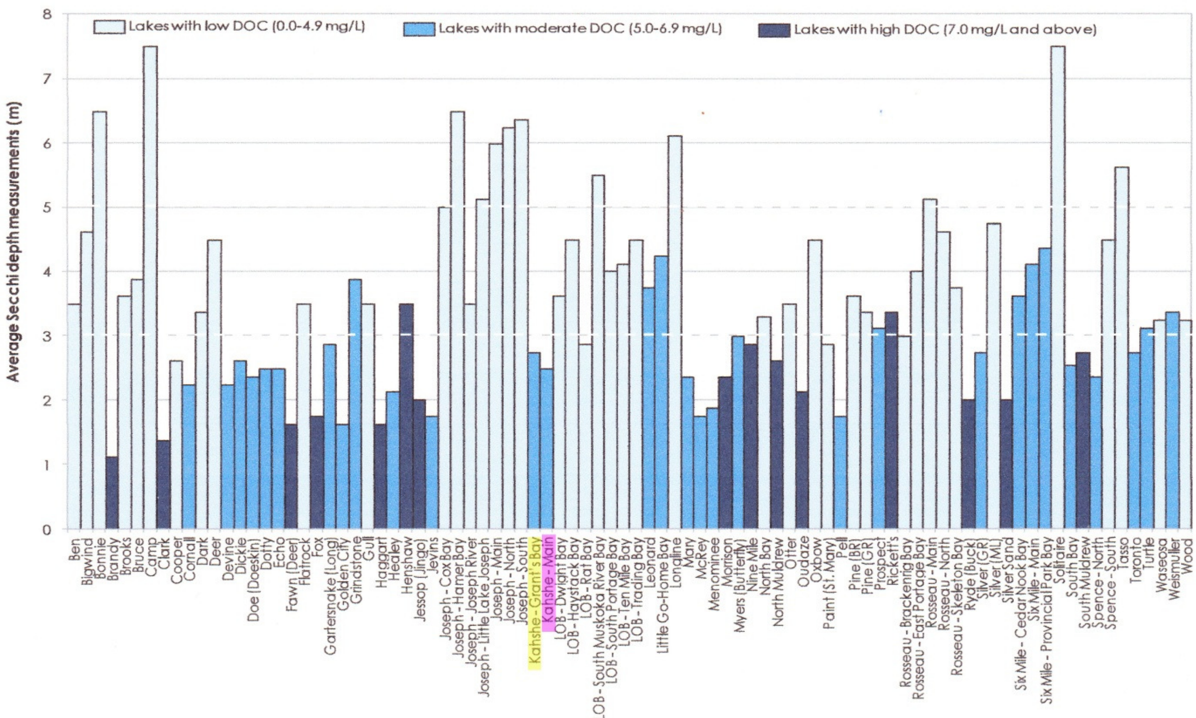


What does this tell us?

- This chart plots the total phosphorus concentrations of all Muskoka lakes that were sampled in 2013.
- Based on these findings, Kahshe Lake’s total phosphorus concentrations (11.4 and 10.1 µg/L for the Main and Grant’s Bay sites, respectively) are within the range of 11 - 20 µg/L which classifies Kahshe Lake as a M**esotrophic lake.**

2013 – Secchi Depth Measurements – Kahshe Lake

Figure 3: 2013 Secchi Depth Measurements



What does this tell us?

- This chart plots the Secchi depth measurements for all Muskoka lakes that were measured in 2013.
- To understand this chart, it's important to consider that water clarity in Muskoka lakes is determined by two factors:
  - The first is dissolved organic carbon (DOC) which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations are reflective of the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.
  - The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.
- Because of the effect DOC has on the clarity of lake water, the results have been colour coded into three DOC ranges. Kahshe Lake is classed as having a moderate amount of DOC, and the clarity measurements for the two sites are close to the median (50^{th} percentile) of the 30 lakes in this category.
- However, for a lake classed as Mesotrophic, the water clarity results in 2013 are below the expected range in Secchi depth of 3-4.9 m as noted in the DMM year-end report.

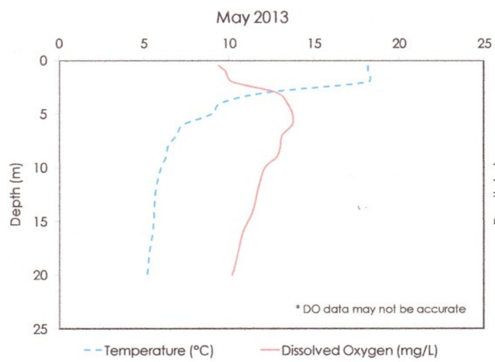
2013 – Historical Trends in Total Phosphorus and Secchi Depth – Kahshe Lake

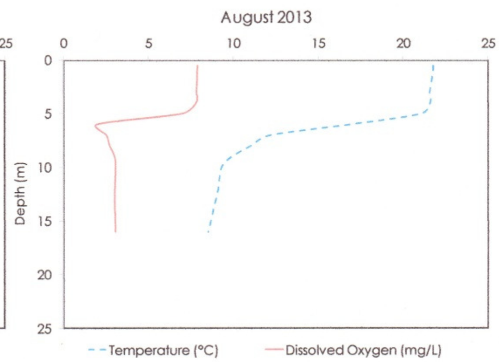
THE DISTRICT MUNICIPALITY OF MUSKOKA

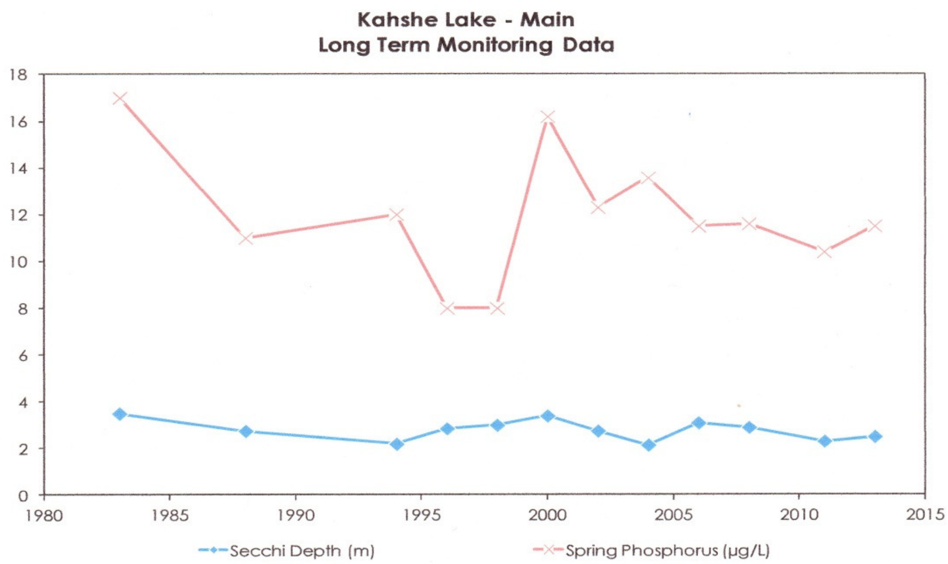
Lake Data Sheet 2013

Kahshe Lake – Main

Municipality:	**Gravenhurst**	Quaternary Watershed:	**Kahshe River**
Surface Area:	**8.21 km²**	Watershed Area (excluding lake):	**32.53 km²**
Maximum Depth:	**20 m**	Lake Trout Lake?	**No**
Wetland Area:	**14 %**	Secchi Depth (10-year average):	**2.6 m**
Phosphorus (10-year average):	**11.7 µg/L**	Sensitivity:	**Moderate**







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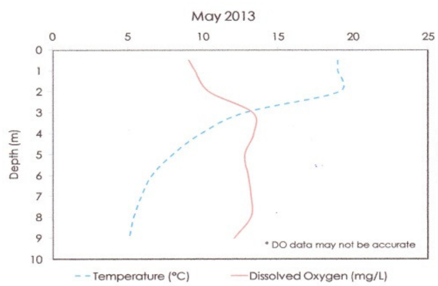
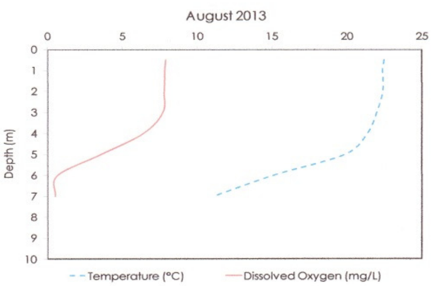
Lake Data Sheet
2013

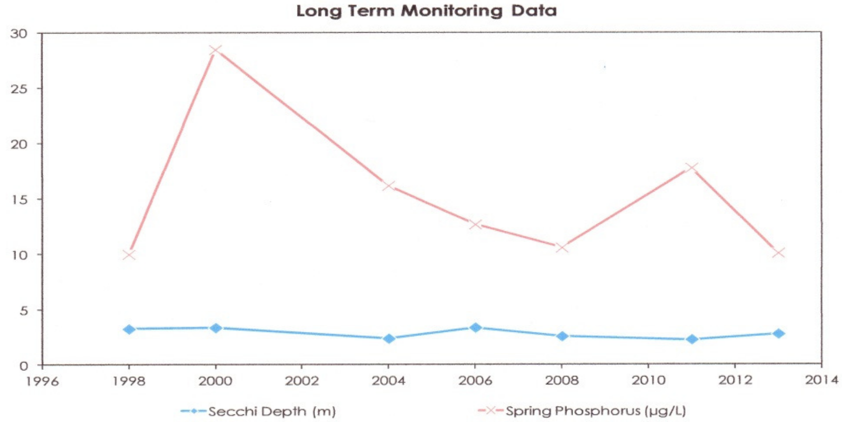
Kahshe Lake – Grant's Bay

Municipality:	Gravenhurst	Quaternary Watershed:	Kahshe River
Surface Area:	8.21 km²	Watershed Area (excluding lake):	32.53 km²
Maximum Depth:	20 m	Lake Trout Lake?	No
Wetland Area:	14 %	Secchi Depth (10-year average):	2.7 m
Phosphorus (10-year average):	13.5 µg/L	Sensitivity:	Moderate





Kahshe Lake - Grant's Bay
Long Term Monitoring Data



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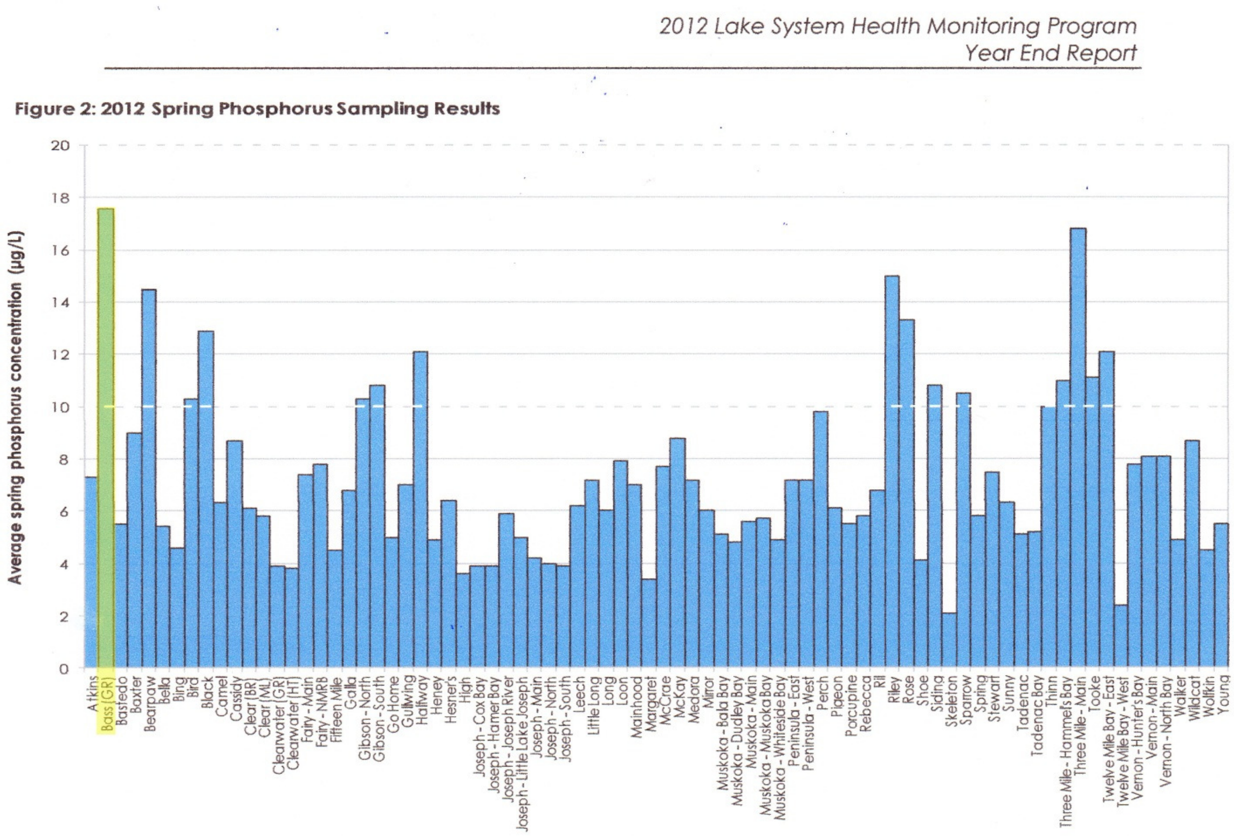
What do these charts tell us?

- These data sheets for Kahshe Lake show how both total phosphorus and Secchi depth measurements have varied over the 30 year period for which DMM data are available for the Kahshe Lake Main site and the Grant's Bay site which has been monitored over a 15 year period.
- In both cases, the data confirm a fairly normal amount of variability from year to year, with no apparent upward or downward trend.
- In the case of water temperature and Dissolved Oxygen, the 2013 results show fairly typical thermal stratification effects, and these 2013 findings will be more thoroughly evaluated later in this report.

2012-Total Phosphorus Results for Bass Lake

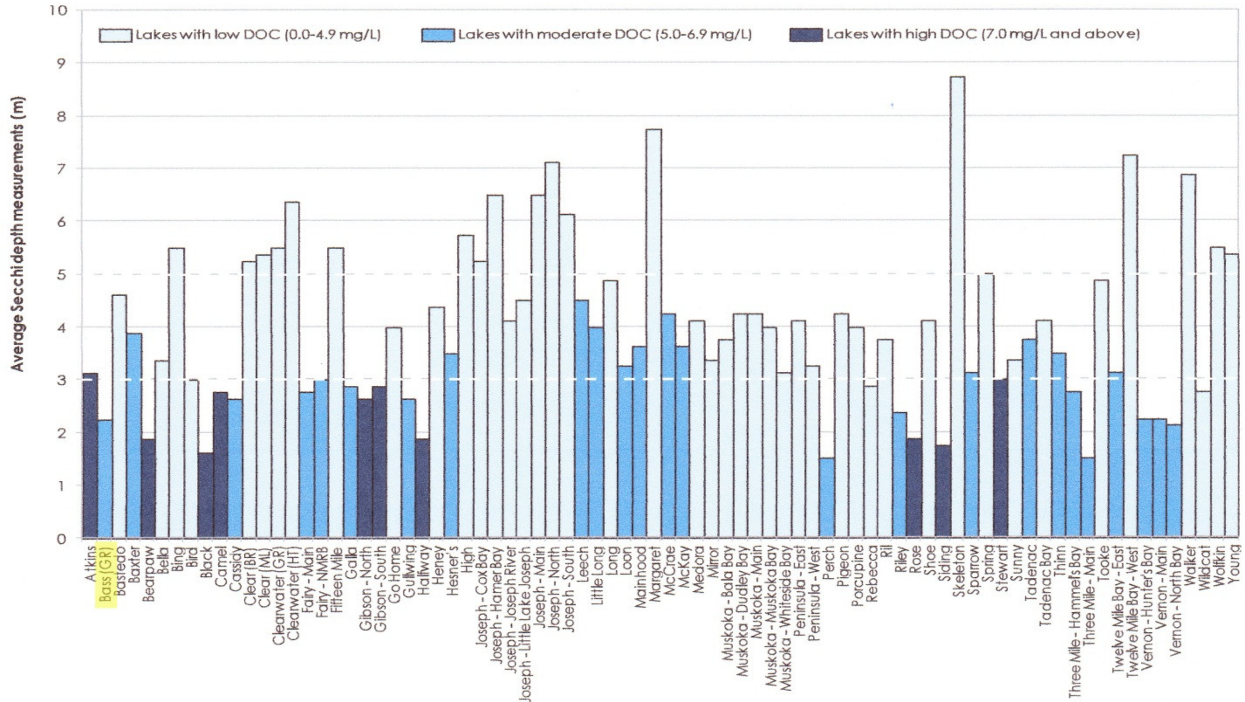


What does this tell us?

- This chart plots the total phosphorus concentrations of all Muskoka lakes that were sampled in 2012.
- Based on these findings, Bass Lake's total phosphorus concentration of 17.6 µg/L was the highest of all Muskoka Lakes sampled in 2012.
- However, this concentration of total phosphorus is within the range of 11 - 20 µg/L which classifies Bass Lake as a M**esotrophic lake.**

2012-Secchi Depth Results for Bass Lake

Figure 3: 2012 Secchi Depth Measurements



What does this tell us?

- This chart plots the Secchi depth measurements for all Muskoka lakes that were measured in 2012.
- To understand this chart, it's important to consider that water clarity in Muskoka lakes is determined by two factors:
    - The first is dissolved organic carbon (DOC) which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.
    - The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.
- Because of the effect DOC has on the clarity of lake water, the results have been colour coded into three DOC ranges.
- While Bass Lake is classed as having a moderate amount of DOC, the clarity measurements are at the low end of the range for the 25 lakes in the moderate DOC category – i.e. for a lake with moderate DOC, water clarity is lower than expected.
- Also, for a lake classed as Mesotrophic, the water clarity result (2.2 m) in 2012 was below the expected range in Secchi depth of 3-4.9 m as noted in the DMM year-end report.

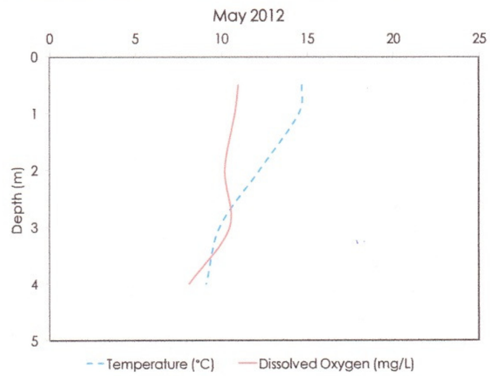
2012 – Historical Trends in Total Phosphorus and Secchi Depth – Bass Lake

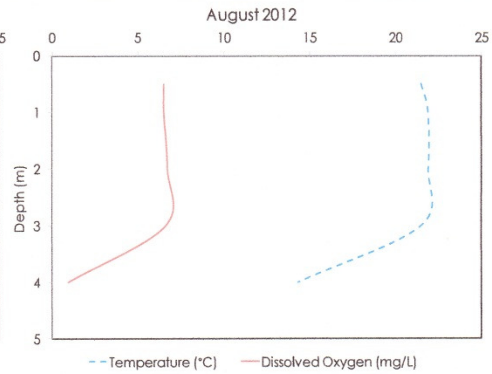
THE DISTRICT MUNICIPALITY OF MUSKOKA

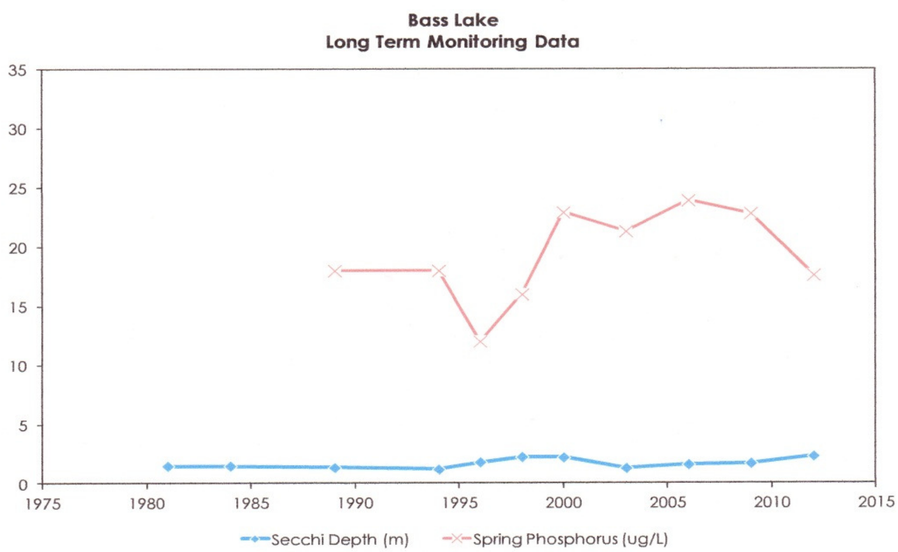
Lake Data Sheet 2012

Bass Lake

Municipality:	**Gravenhurst**	Quaternary Watershed:	**Kahshe River**
Surface Area:	**0.40 km²**	Watershed Area (excluding lake):	**17.00 km²**
Maximum Depth:	**8 m**	Lake Trout Lake?	**No**
Wetland Area:	**10 %**	Secchi Depth (10-year average):	**1.7 m**
Phosphorus (10-year average):	**21.4 µg/L**	Sensitivity:	**Moderate**







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What does this chart tell us?

- This chart shows how both total phosphorus and Secchi depth measurements in Bass Lake have varied over the 20 year period for which DMM data are available.
- In both cases, the data confirm a fairly normal amount of variability from year to year, with no apparent upward or downward trend.
- In the case of water temperature and Dissolved Oxygen, the 2012 results show fairly minimal thermal stratification effects which is expected in a fairly shallow lake. It is also interesting that the DMM summary shows the depth of Bass Lake at the monitoring site as 8 m; however, in looking back over the water temperature and DOC depth sampling results, there are only a few times when sampling extended down to 5 m, with most stratified sampling extending only to a depth of 2-3 m.

3.3.2 Additional Analysis of Kahshe and Bass Lake Water Quality Data

As the DMM year-end reports do not provide a detailed discussion or analysis of the findings for individual lakes, this section of the report will look more closely at the Kahshe and Bass Lake results.

To carry out a more detailed analysis of the DMM and MOE data with greater emphasis on Kahshe and Bass Lakes, all of the DMM data for Kahshe plus Bass Lake were requested from DMM. Once the entire dataset was obtained, it was merged and aligned to match sampling dates across the years that sampling was carried out. This full set of data is attached as Appendix Table A.

During the course of this investigation, four other water quality analysis reports or presentations were obtained and have proven very beneficial in understanding how water quality on Kahshe and Bass Lakes compares to other lakes in Muskoka. These are all available on-line and are listed in order from most recent to oldest below:

Palmer, M. Ontario Ministry of the Environment. *Our Lakes: How Have they Changed Over the Last 25 Years?* Environmental Lecture Series, Muskoka Watershed Council. July 26, 2012. Port Carling, Ontario.

Somers, K., Willison, R. Brouse, J. and Yan, N. 2009. *Muskoka's Water Quality: An Analysis of the Data from Your Lake.* Environmental Lecture Series. November 2009.

Gartner Lee Limited. 2008. *Review of Long Term Water Quality Data for the Lake System Health Program*. Prepared for the District Municipality of Muskoka.

Gartner Lee Limited. 2005. *Recreational Water Quality Management in Muskoka*. Prepared for the District Municipality of Muskoka. June 2005.

Because of the complexity of the analyses that have been completed in each of the above references, the material here will show very briefly how the findings from Kahshe and Bass Lakes compare to the results and conclusions reached in each of the above reference papers/presentations.

This analysis was undertaken to answer the following three key questions:

Question 1:	Do the DMM results for total phosphorus and Secchi depth signal a need for concern regarding water quality and clarity in Kahshe and Bass Lakes?
Question 2:	How do DMM results for Kahshe and Bass Lake compare to results from MOE's LPP Sampling Program?
Question 3:	Can any conclusions be drawn based on the results of a large suite of physical and chemical parameters that have been analyzed by DMM but not all included in the Year-End report?

Question 1: Do the DMM Results Signal the Need for Concern About Nutrient Enrichment?

In order to answer this question, it is important to understand the reason for the primary focus both the DMM and MOE have on total phosphorus and water clarity.

- Phosphorus is a natural substance required by all living organisms. It enters a lake naturally through sediment and precipitation, and via human activities such as:
  - Nutrient loading from septic systems;
  - Use of phosphorus-based cleaning supplies; and
  - Loss of native shoreline vegetation, especially the diverse forest environment. As lawns replace trees, fertilizer runoff, storm water and soil erosion wash higher loads of phosphorus into our lakes.

- Phosphorus samples are collected in the spring during a period called "spring turnover", as studies have shown that total phosphorus concentrations at this stage of thermal mixing of water bodies is representative of the average of phosphorus concentrations throughout the whole ice-free period.

- After spring turnover, the lake will stratify thermally such that the upper, epilimnetic layers do not mix with the deep hypolimnetic waters. Precipitation and runoff from the watershed of a lake add phosphorus to the epilimnetic waters and the growth of algae is confined to the upper waters of the lake which are illuminated by sunlight. Upon death at year end, algal cells sink to the hypolimnetic waters, where they are decomposed and phosphorus is re-mineralized. Over the course of a year, therefore, phosphorus concentrations will vary with depth and with time.

- The reason for focusing on total phosphorus is that it is typically the best chemical indicator of lake eutrophication or enrichment and has been found to be the best chemical signal as a warning sign for potential algal blooms which detract from recreational water quality, have the potential to release organic toxins, and can affect the habitat of coldwater fish species such as Lake trout.

What does this mean in terms of the potential for algal blooms and concern regarding more intensified development?

- Based on a review of the science, the DMM has opted to conservatively preserve the levels of total phosphorus equated with eutrophication and algal bloom problems based on their predicted background or undeveloped concentrations. The threshold level for total phosphorus in each lake in Muskoka is determined by adding 50% of the background concentration to a background base which was developed through a water quality model.

- The setting of the background base is currently under review and is a complex process whereby relevant parameters which can influence background concentrations are used in a mathematical water quality model that has been developed and refined over several years.

- In the case of Kahshe Lake, the background was set at 9.5 µg/L, resulting in a total phosphorus threshold of 14.2 µg/L – i.e. 9.5 + [0.5*9.5]= 14.2 µg/L. The threshold for Bass Lake is 30.9 µg/L.

What happens when a total phosphorus threshold is exceeded?

- There are two criteria that must be examined to determine if a lake has exceeded its acceptable threshold for phosphorus. If a lake meets both of these criteria, then it is considered to be Over Threshold:
    - Total phosphorus concentration, as estimated by the Muskoka Water Quality Model, exceeds the “Background + 50%” threshold; and,
    - The long-term (10-year) measured total phosphorus concentration, as determined by the DMM Program, also exceeds the “Background + 50%” threshold value.

- If a lake is considered to be over threshold, restrictive planning policy will be implemented, and a Remedial Action Program will be developed in consultation with lake ratepayer’s associations and any other interested parties.

- A lake that is Over Threshold will be de-listed only after the 10-year long-term average of total phosphorus is less than the threshold established for the lake and there have been three consecutive phosphorus measurements below its threshold value.

- However, in the event that a 10-year review of the Water Quality Model is underway (which it is), lakes will not be listed as being Over Threshold nor delisted as no longer being Over Threshold until the model review is complete.

- As the DMM's water quality model review report (Gartner Lee, 2005), is a complicated technical presentation of the model parameters and their influence on total phosphorus concentrations, it is just too detailed to include in this summary. However, it did have an appendix where all of the Muskoka lakes were evaluated in terms of their compliance with the total phosphorus threshold and projected sensitivity to increasing phosphorus concentrations.

- The good news is that Kahshe Lake is listed as being at a level of background + 22.7% [well below the threshold of background + 50%] and is shown as being low in terms of total phosphorus responsiveness. However, because of limited soil attenuation potential, the mobility rating is high. The combination of these two factors results in a moderate sensitivity classification for Kahshe.

- Bass Lake is listed as being at a level of background + 3.2%, also well below the threshold of background + 50%. It too is shown as being low in terms of total phosphorus responsiveness and high for phosphorus mobility, resulting in an overall moderate sensitivity classification.

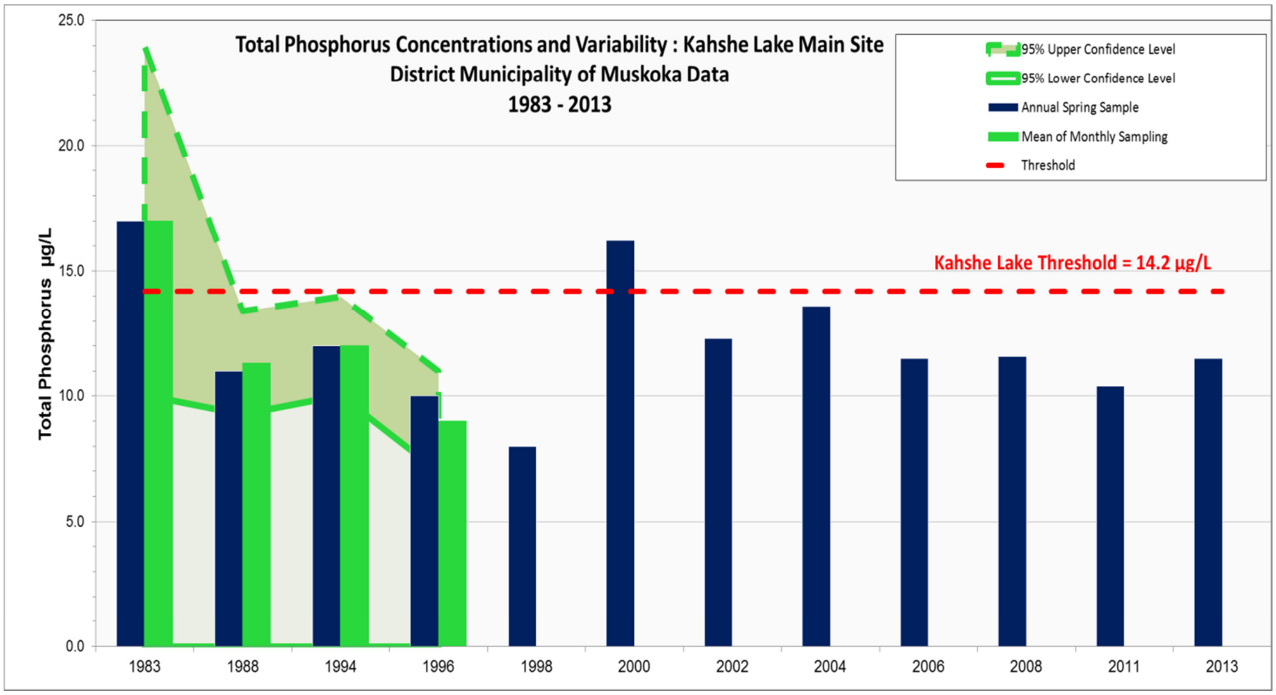
To better illustrate how these conclusions have been reached, the trends in total phosphorus and water clarity (Secchi depth) have been plotted using the DMM data.

The first chart examines the variability in the total phosphorus analytical results from the DMM sampling on Kahshe over the 30 year period from 1983 to 2013. It also shows the total phosphorus threshold level of 14.2 µg/L and provides an opportunity to evaluate whether there are any long term trends in total phosphorus concentrations. When comparing older data to newer data, DMM staff caution that the following factors must be kept in mind:

- Prior to 2001 samples were analyzed by the MOE's main laboratory in Rexdale.
- In 2002, samples started to be analyzed in the MOE's Dorset laboratory and the analysis is 10x more precise. Duplicates also started to be taken.
- In 2003, water samples started to be filtered before they were analyzed to remove any sediment or other material that could influence the results.

As a result of these changes to the laboratory analysis program, the more current data has less variability than the older data. Some of this is likely due to better analytical methods and quality control. When DMM looks at historical data for a lake, they usually look at 2001 to present and before 2001.

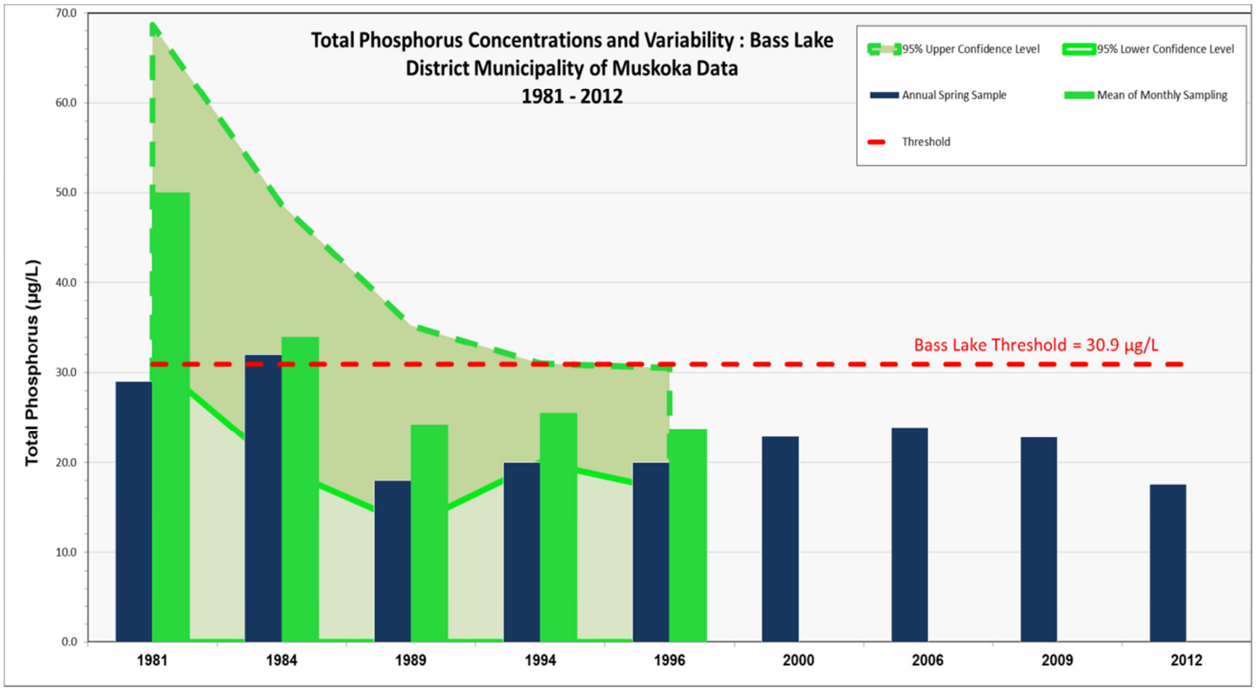
A tabular summary of the data used to prepare this chart can be found in Appendix Table B.



What does this tell us?

- To examine the variability in the total phosphorus data, the spring turnover results were plotted in blue. The green bars represent the average of monthly sampling results for the period up until 1996 when the DMM reduced their analysis to only the spring turnover time.
- The next step was to calculate the variability in the monthly data by via use of the 95% Upper and Lower Confidence Levels of the Confidence Interval.
- Statistically, there is a 95% level of probability (i.e. 95 times out of 100) that the mean of the population would fall between the upper and lower confidence limits.
- The upper and lower limits in total phosphorus values are shown in the green-shaded area.
- Although the statistical analysis could only be performed on the monthly data, these findings appear to be in line with the conclusions reached by the DMM using all total phosphorus sampling data (GLL, 2005a), where it was shown that there is approximately 40% variability in total phosphorus concentrations. This variability needs to be kept in mind in making any comparisons of data from Kahshe Lake with other lakes in our watershed.
- Although the results from Kahshe Lake have too much variability to confirm a significant reduction in total phosphorus concentrations as is being reported for Muskoka lakes in general, this is not unexpected, as the larger data sets available to evaluate long term changes would have a much higher power of analysis.
- However, based on the results for Kahshe Lake, it is apparent that total phosphorus concentrations are not increasing, and with continued analysis it may be possible to confirm that total phosphorus concentrations are decreasing as in other Muskoka lakes.

The same type of analysis was then run on the total phosphorus data for Bass Lake (data in Appendix Table B) and the results are shown below:

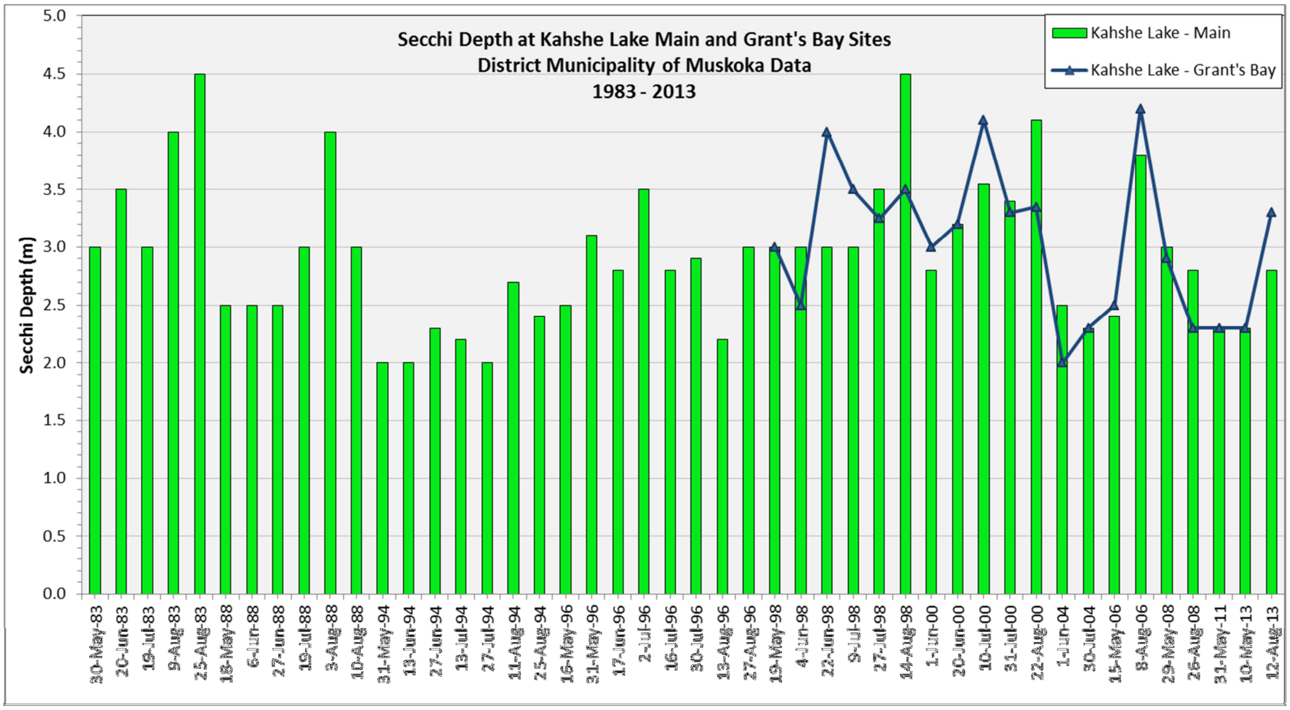


What does this tell us?

- As was the case for Kahshe Lake, there is a significant degree of variability in the Bass Lake data which also needs to be considered in making any comparisons with the total phosphorus concentrations from other lakes and over the sampling time period.
- Irrespective of this variability, it is apparent that that total phosphorus concentrations in Bass Lake are considerably higher than those in Kahshe Lake, and so too is the total phosphorus threshold (30.9 v. 14.2 µg/L).
- This is reflective of the fact that Bass Lake has a larger wetland area, and therefore, it has naturally higher levels of total phosphorus.
- However, as is the case for Kahshe Lake, the DMM analysis results over this 30 year period have demonstrated that there has been no significant deterioration in total phosphorus concentrations.

The next comparison involves water clarity as measured by Secchi depth.

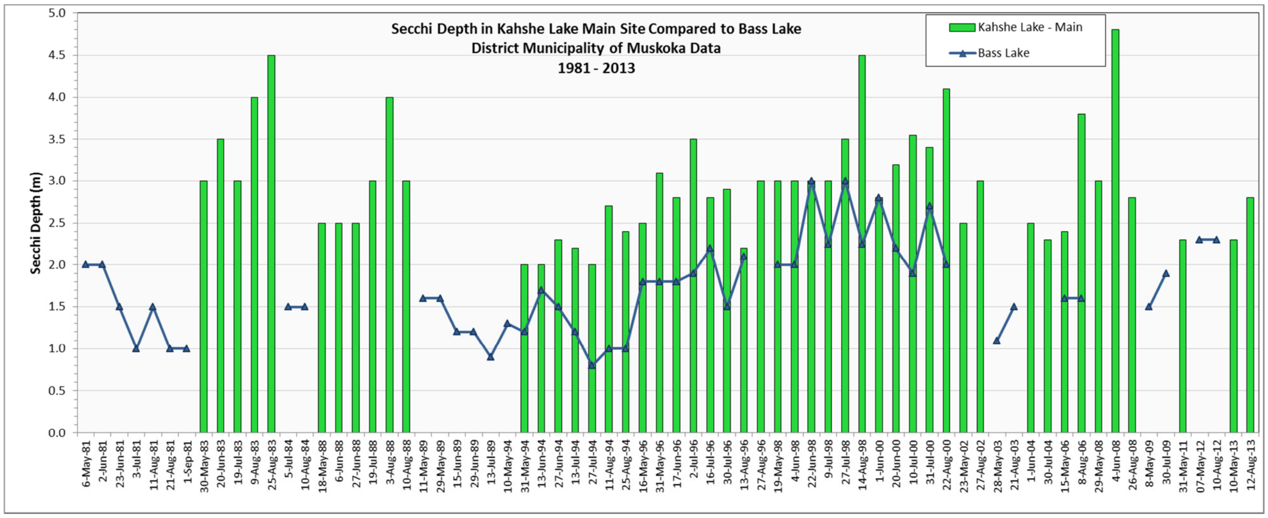
In the first chart, (data in Appendix Table C) the DMM data for the two sites on Kahshe Lake (Main and Grant's Bay) have been plotted over the period from 1983 to 2011. These are the same results as those found in the two DMM Kahshe Lake Data Sheets which were shown earlier, but they show how the two locations compare.



What does this tell us?

- Although Secchi depth measurements were not started in Grant's Bay until 1998, the results show that there is little difference in the Secchi depth over the period when both locations were measured.
- The results also show a fair amount of variability within each year and from year to year over this 30 year measurement history.

The next chart shows how Secchi depth in Kahshe Lake (main site) compared to Bass Lake. The full data set used in this chart can be found in Appendix Table D.



What does this tell us?

- This chart shows that water clarity, as measured by Secchi depth in Kahshe Lake is noticeably better than in Bass Lake.
- These findings are in general agreement with the total phosphorus results, in that Kahshe Lake had the lower total phosphorus concentrations than those in Bass Lake.
- However, it is also noted that DOC (tea colour) concentrations in Bass Lake are always higher than those in Kahshe Lake, so this is also a possible confounding factor.
- Another factor is the more shallow depth of Bass Lake v. Kahshe, which would limit the cycling of phosphorus and other nutrients due to limited thermal stratification.

As indicated in the earlier findings, one of the major factors involved in the formation of algal blooms and impacts on water clarity is the total phosphorus concentration as measured in the spring after turnover in the fall and before temperature-based stratification takes place.

If this hypothesis is true, then there should be a relationship between total phosphorus and chlorophyll "a", the main pigment associated with algal growth.

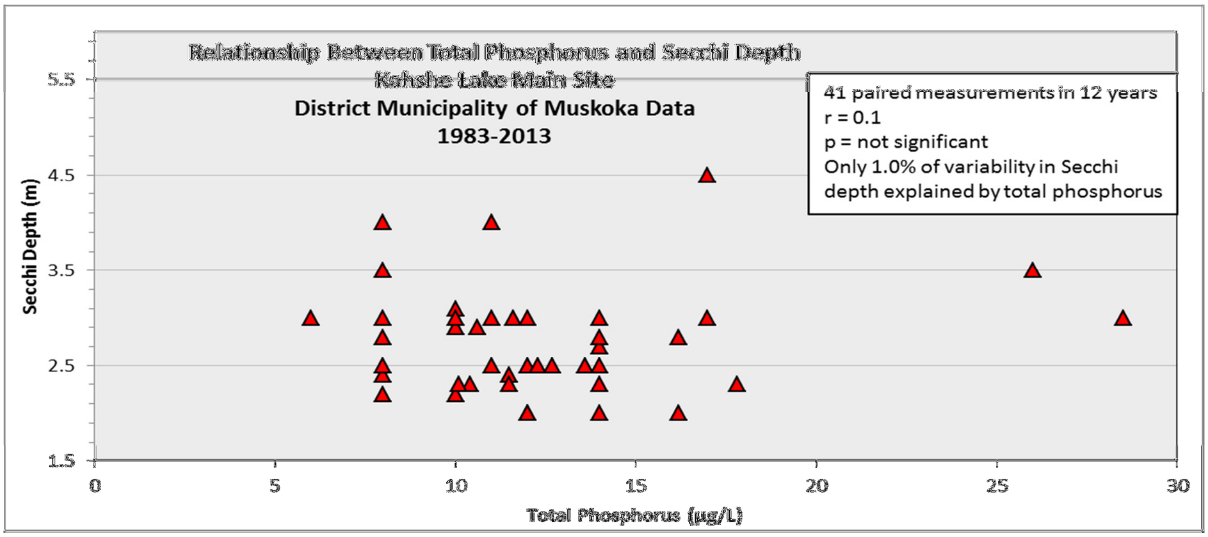
If both of these hypotheses are true, then water clarity as measured via the Secchi depth readings also should be correlated with both total phosphorus and chlorophyll "a" measurements. In other words, as total phosphorus concentrations increase, there should be an increase in chlorophyll "a" (green pigmentation) and a decrease in Secchi depth reflecting a reduction in water clarity.

These relationships were explored by the DMM (GLL, 2005) during the most recent evaluation of the water quality model parameters and indeed, using the DMM data up to 2005 the authors did find statistically significant relationships between all of these parameters when the data were expressed as long term means for all lakes. Based on these relationships, the regression charts developed via use of the entire Muskoka lakes database as published in GLL, 2005 were presented in the 2012 Lake Steward

Report, and will not be repeated here. The main conclusions were that by using lake means for total phosphorus and comparing with means for chlorophyll "a" and Secchi depth, some low level of causality was found. The predictive power of these relationships was improved by incorporating the degree of DOC as another variable. This resulted in a correlation value (r) of 0.81 with a much improved 65% of the variability in Secchi depth being explained by total phosphorous.

Based on these findings, the Kahshe Lake data that was available from DMM was selected to run similar correlation and regression analyses to see if any of these statistical relationships using data from all Muskoka lakes were being seen in Kahshe Lake data.

However, as there has been no further analysis of chlorophyll "a" since 1996, the charts involving a comparison of chlorophyll "a" and total phosphorus or Secchi depth have not changed since the 2012 Lake Steward Annual Report, and as such, they are not included here. However, since there was additional total phosphorus and Secchi depth data for 2013, the correlation and regression was re-run using this updated dataset for Kahshe Lake. The data and regression analysis are presented in Appendix Table E and the results of this analysis are shown in the chart that follows.



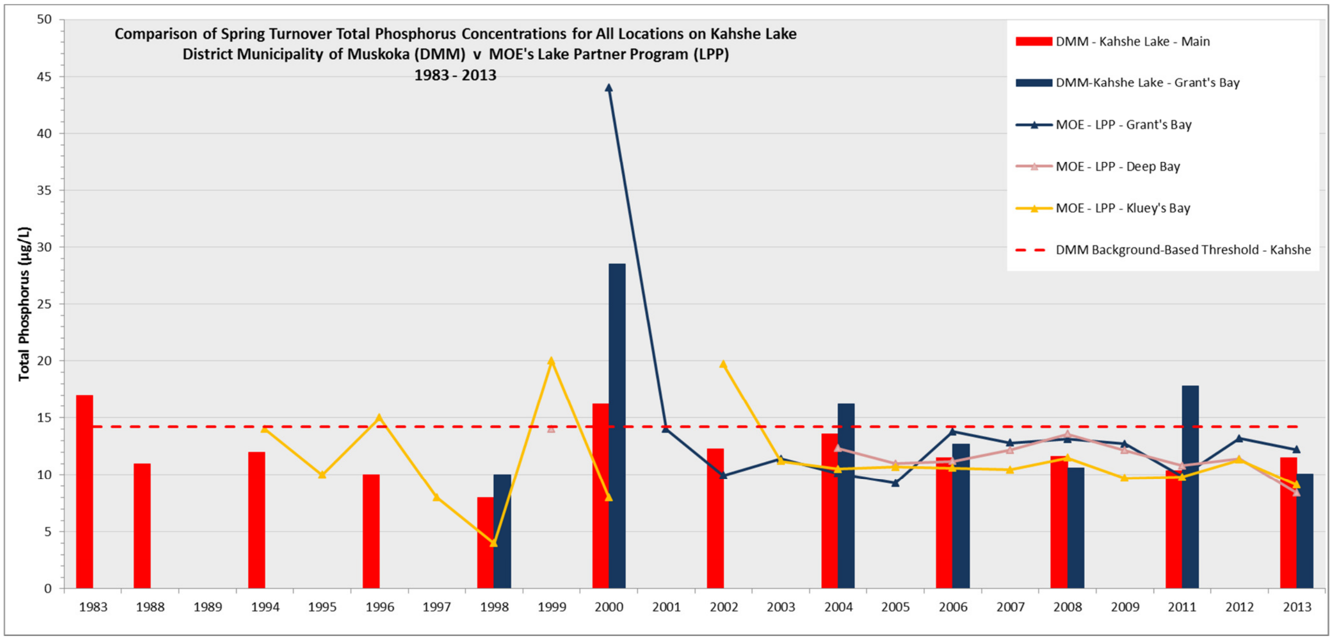
What does this tell us?

- Using paired total phosphorus and Secchi depth data for the 30 year period from 1983 to 2013, there was no significant relationship between these two parameters.
- In other words, based on this analysis, total phosphorus concentrations have had no detectable negative impact on Kahshe Lake water clarity.
- While this may be true, it should be noted that there are many factors which could be masking a relationship between these parameters. One factor could be timing, as there may be a lag period required before the algal growth stimulation effect of total phosphorus is manifested in water clarity degradation. If this was the case, Secchi depth measurements taken at the same time as spring phosphorus sampling may not capture potential increased growth of algae at a later date.

Question 2: How do DMM results for Kahshe and Bass Lake compare to results from MOE's LPP Sampling Program

Since there are no MOE results for Bass Lake, this comparison is limited to the findings from Kahshe Lake for total phosphorus and Secchi depth. As both the DMM and MOE carry out total phosphorus sampling and analysis on Kahshe Lake, the next comparison examines the results from both programs.

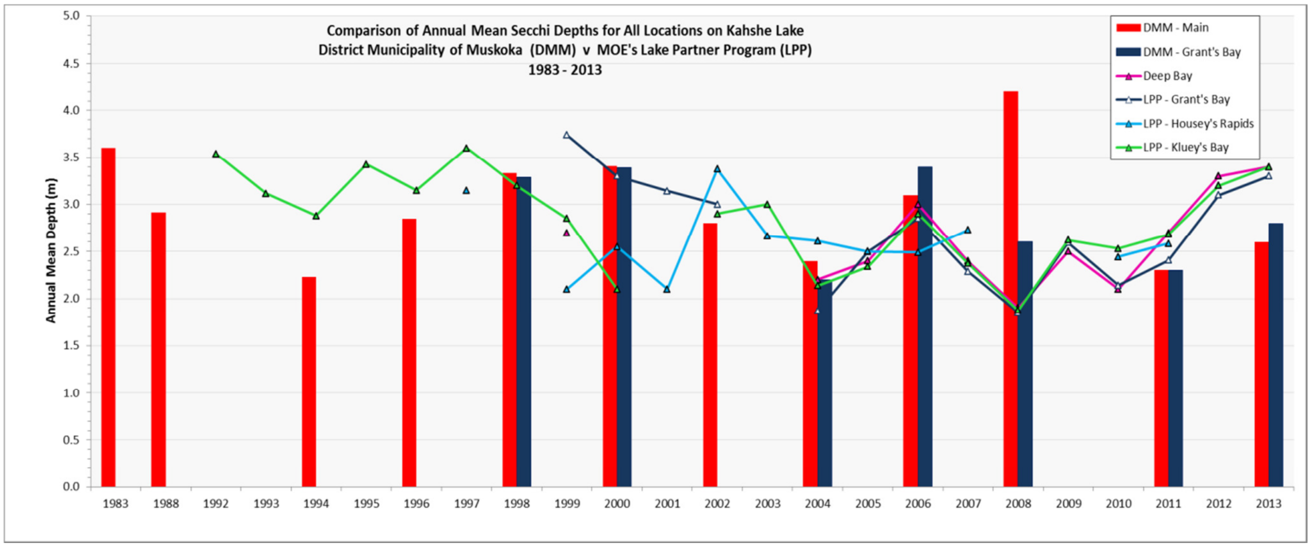
The data are presented in Appendix Table F and are charted below:



What does this tell us?

- In order to make this comparison of the results for the two sampling program, it was necessary to plot the findings from different types of data. In some cases, the MOE's LPP data represent annual ice-free average results, while in other cases, they represent concentrations for the spring sampling, as in those years, sampling was only conducted once a year.
- In the case of the DMM results, the values shown in the above chart are for the spring sampling period only. However, as shown in the two earlier charts for Kahshe Lake, the spring sampling results typically are representative of seasonal average concentrations.
- Keeping in mind the above differences in the data and the variability that exists within the total phosphorus database, it is apparent that when analysis results for similar sampling dates over the period from 1983 to 2013 are plotted, both programs appear to have generated similar results.

As was the case for total phosphorus, the next comparison was between the Secchi depth results of the DMM and MOE programs. The data are presented in Appendix Table G.



What does this tell us?

- As for total phosphorus, the results of the two sampling programs (DMM Secchi depth shown as columns and the MOE's LPP measurements shown as lines) show a considerable degree of variability over the period from 1983 to 2013, but are in general agreement in most years, and on average, are in the range of 2.5 to 3.5 m in depth.
- As was the case with total phosphorus, there has been no detectable upward or downward trend in water clarity over this 30 year period.

Question 3: Can any conclusions be drawn based on the results of a large suite of physical and chemical parameters that have been analyzed by DMM but not all included in the DMM's Year-End report?

In addition to the total phosphorus, Secchi depth measurements, the DMM program includes the analysis of a large suite of additional chemical and physical water quality parameters. This analysis has been conducted by breaking up the additional parameters into physical and chemical categories. Note that anyone considering the installation of a water treatment system to convert lake water for drinking purposes (which is not recommended), the findings from the testing of both physical and chemical parameters may eliminate the need to carry out these analyses during the installation program.

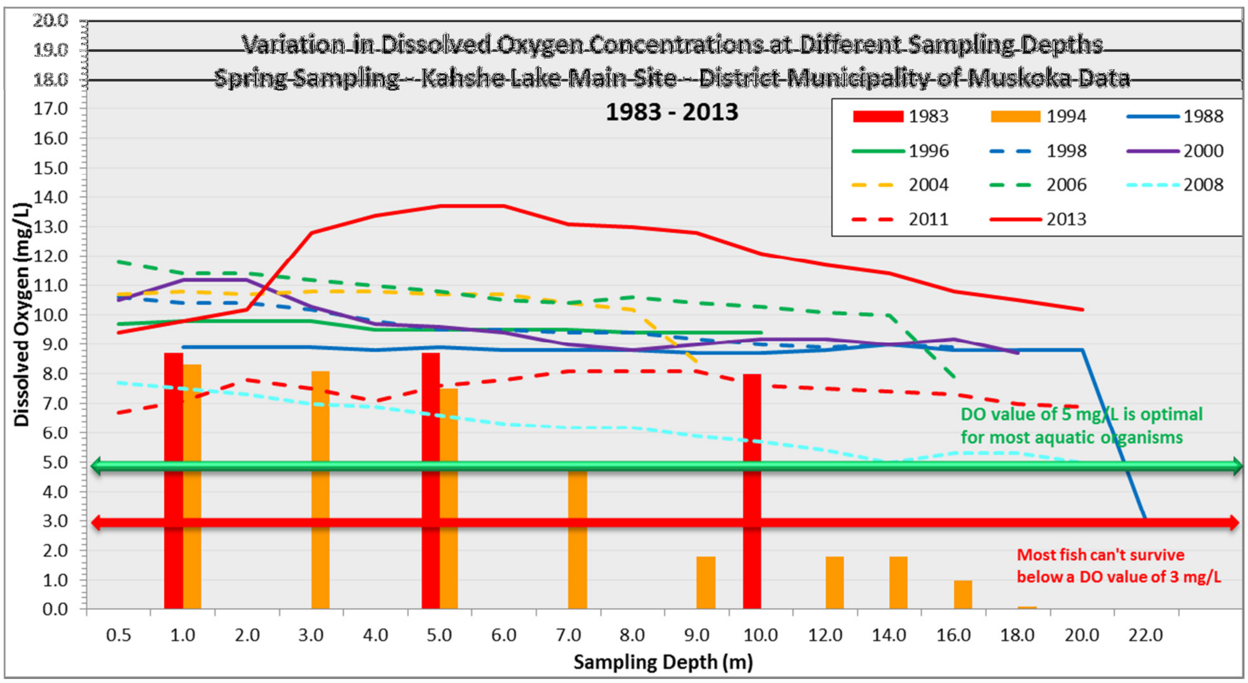
Physical Parameters

This group includes dissolved oxygen (DO), water temperature, dissolved organic carbon (DOC), electrical conductivity (EC) and pH.

The combination of thermal stratification and biological activity causes characteristic patterns in water chemistry. In the summer, deep lakes stratify with warm water on top and cold water below. Because cold water is denser than warm water, these two layers do not mix and atmospheric oxygen cannot reach the bottom layer.

In general, the dissolved oxygen concentration in the epilimnion (top layer of water in a lake) remains high (but variable depending on the time of day and other factors) throughout the summer because of photosynthesis, which produces oxygen, and diffusion of oxygen from the atmosphere. Conditions in the hypolimnion (the bottom layer of water in a lake) vary with trophic status of the lake, but in general, dissolved oxygen declines during the summer because organisms continue to consume oxygen. In some lakes, the bottom layer may eventually become anoxic (almost totally devoid of oxygen).

To give some additional perspective on this parameter beyond the information that was presented earlier as part of the 2011 data sheet material from the DMM, an analysis was undertaken by examining the data over the period from 1983 through 2013 to see if there has been any noticeable change in DO concentrations, especially in the deeper horizons, where oxygen is critical to the survival of bottom dwelling organisms. The data for this chart are presented in Appendix Table H.



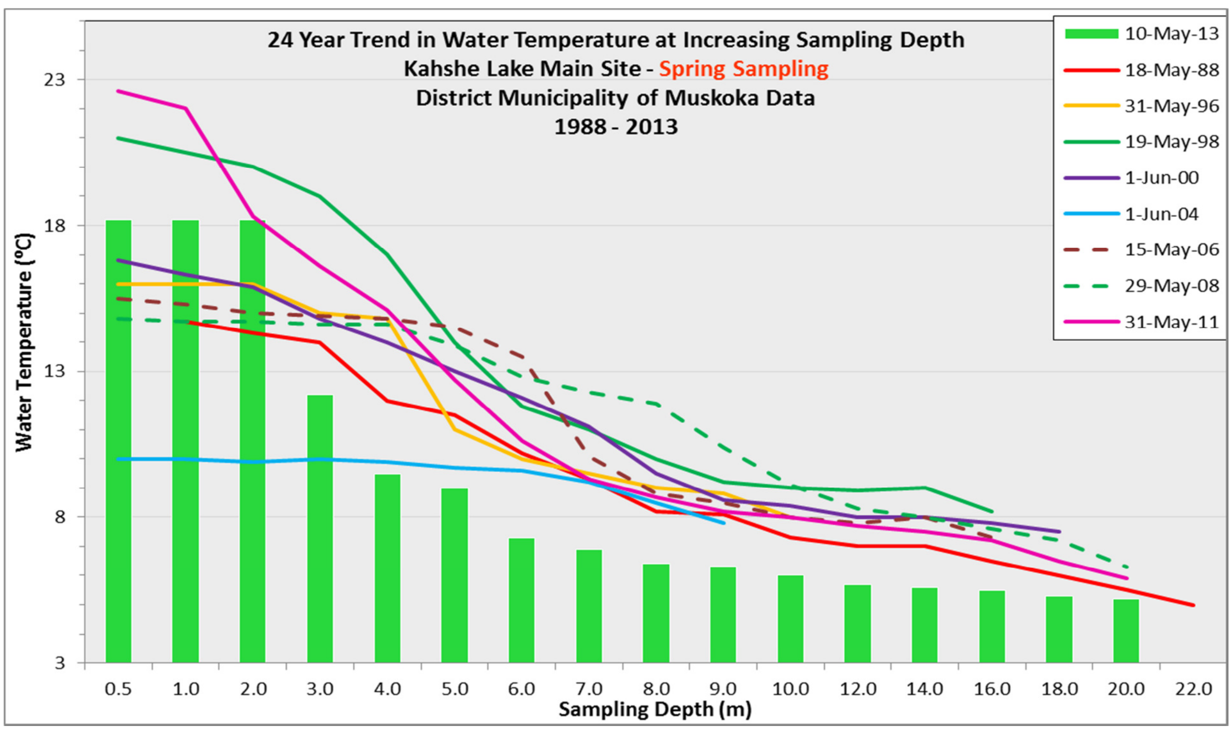
What does this tell us?

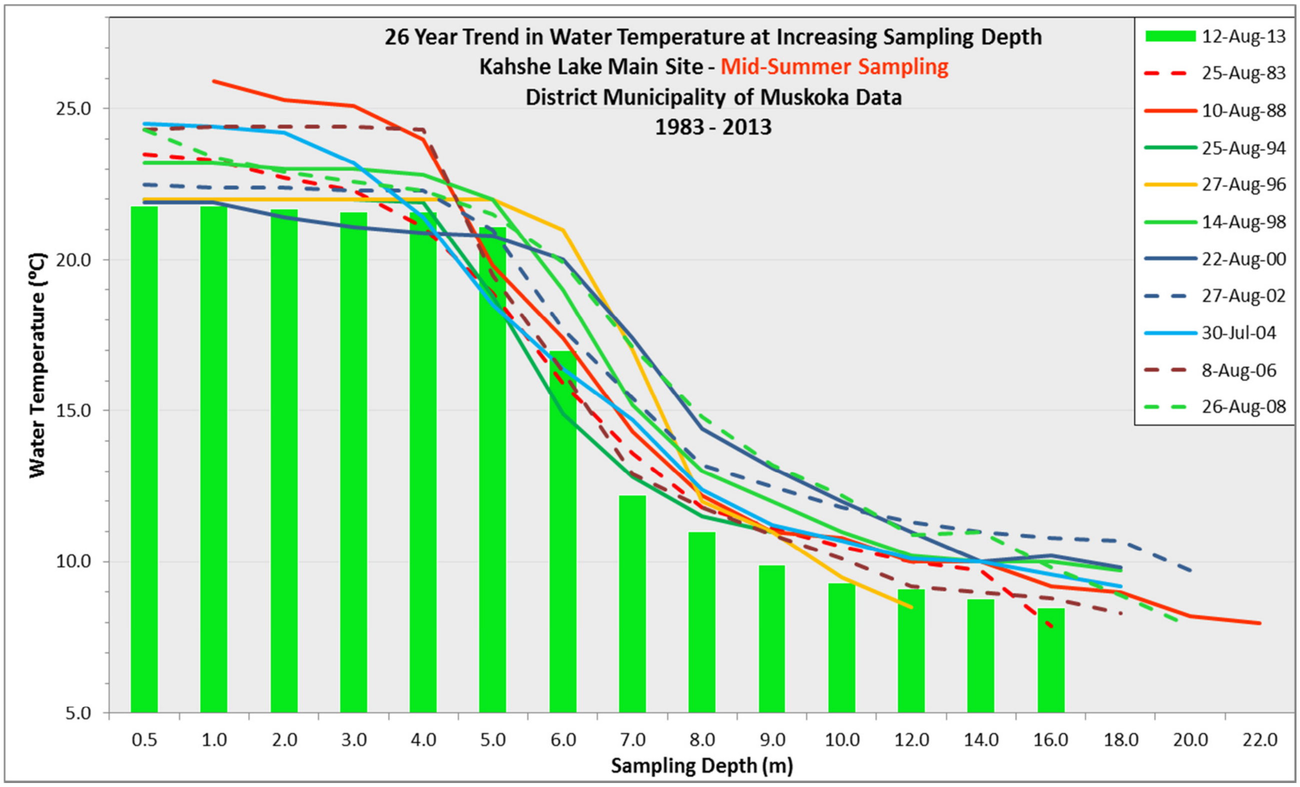
- It is apparent from the above chart that in almost all years for which DO has been analyzed, the spring turnover concentrations have been well above the optimal level for aquatic organisms.
- While the level considered optimal for most aquatic species is believed to be around 5 mg/L, concentrations of DO above this are not considered harmful, as many aquatic species thrive on DO levels above the Optimum value used in the chart.
- The only time DO levels fell below the Optimum level was in 1994, when optimal levels were not met at depths below 7 m (orange columns in chart).

Within-year variation in DO concentrations also was evaluated at increasing lake depths, to determine how low DO levels fall as the year progresses, and the lake starts to thermally stratify. The most recent year with sampling data was 2000, when sampling from depths of 0.5 down to 18 m was carried out from early June through August. These results were presented in the 2012 Lake Steward Annual Report and as there has been no recent sampling over the entire ice-free period since 2000, this chart will not be repeated here.

As for DO, water temperature at increasing depths has been monitored on both Kahshe and Bass Lakes by DMM since the 1980s. Up until 2008, these measurements were taken at least twice during the spring and summer season and in several cases, at monthly intervals.

The two charts below for Kahshe Lake show how water temperatures have varied over the 24-26 year period for the spring sampling event as well as the mid-summer sampling in August where data was available. The data for the spring and mid-summer readings are presented in Appendix Tables I and J, respectively. Given the shallow nature of Bass Lake, the water temperature results have not been charted. However, they have been included in Appendix Table A.

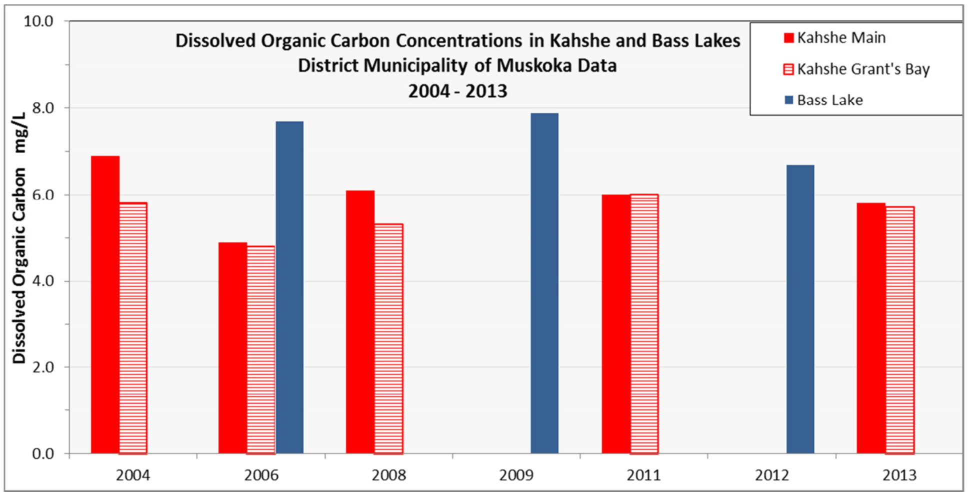


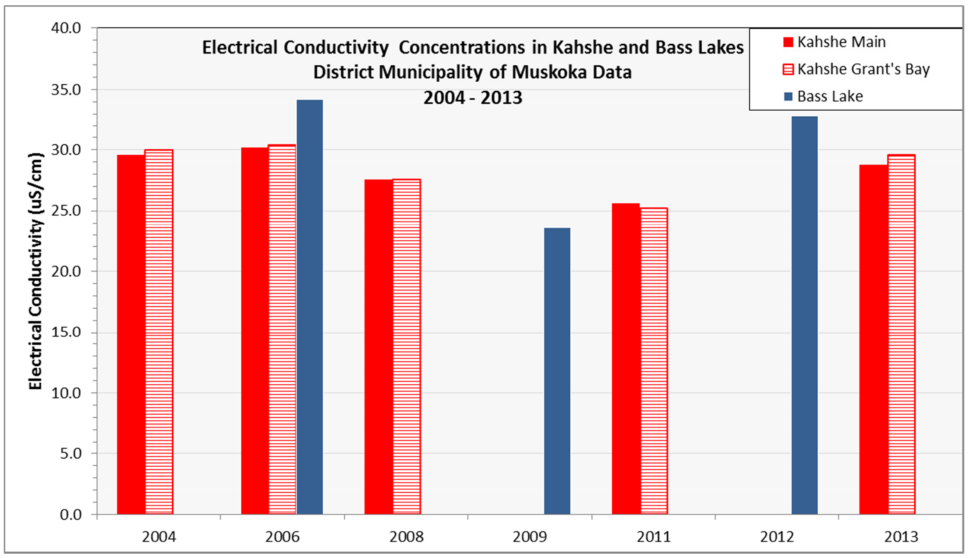


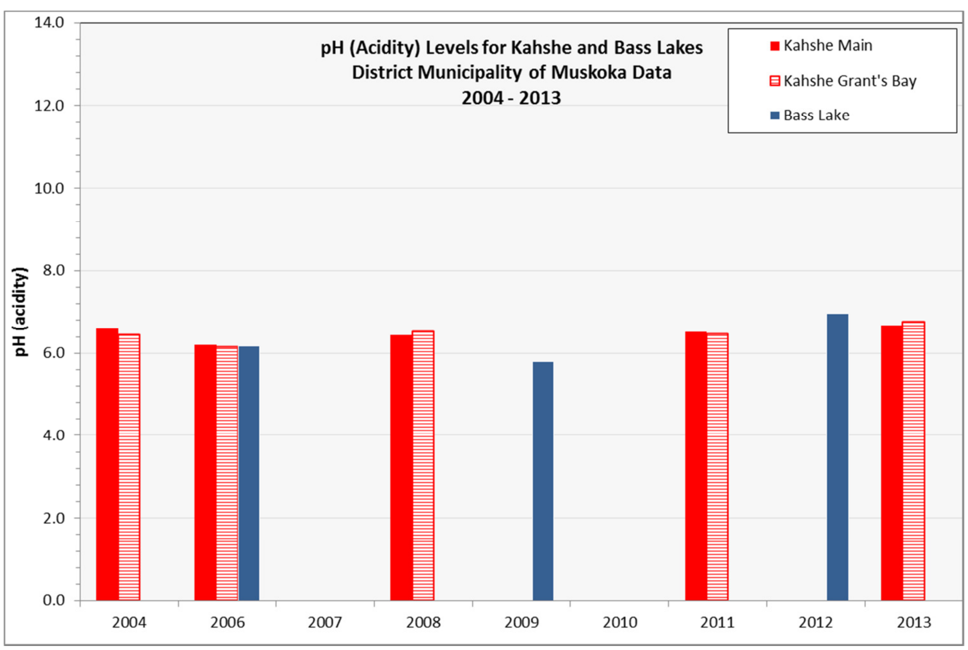
What does this tell us?

- In 2011, the data appeared to indicate a possible warming trend in the upper 4 m of the water column during the spring turnover sampling event. However, the 2013 data (shown as green coloured columns) demonstrate that this apparent trend was not evident based on the 2013 data.
- As shown in the second chart, by mid-summer, there is a little less variability in the temperature range from the surface down to the lower, cooler water levels.
- Based on these finding, the apparent warming effect in Muskoka lakes as reported by Dr. M. Palmer (Palmer, 2012) and by Somers et al. (2009) have not been detected in the waters of Kahshe Lake, as the variability is too great on this single lake.

The other three physical parameters evaluated in the DMM sampling program for Kahshe and Bass Lakes included DOC, EC and pH. The findings for these parameters are shown below. The data used to generate these charts can be found in Appendix K.


Dissolved Organic Carbon Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Dissolved Organic Carbon mg/L
10.0
8.0
6.0
4.0
2.0
0.0
2004
2006
2008
2009
2011
2012
2013


Electrical Conductivity Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Electrical Conductivity (uS/cm)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2004
2006
2008
2009
2011
2012
2013


pH (Acidity) Levels for Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
pH (acidity)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2004
2006
2007
2008
2009
2010
2011
2012
2013

What does this tell us?

- The charts for these three physical parameters demonstrate very little change or variability over the 8-9 year period during which the data have been collected.
- In the case of DOC, it is noted that the concentrations in Bass Lake are typically higher than those in Kahshe Lake. The aesthetic objective in drinking water is 5 mg/L, and values greater than 7 mg/L are considered high for recreational use. As such, even though DMM considers both lakes to fall in the moderate category, the DOC concentrations in Bass Lake exceed the aesthetic objective for recreational use.
- In the case of EC, which is a measure of dissolved salts (ions), both lakes fall within the normal range for natural waters of between 50-1,500 µS/cm.
- Finally, in the case of pH, the acidity of both lakes is just under the Provincial water quality objective of between 6.5 and 8.5; however, neither lake has pH below 5 or above 9, values that are known to be harmful to some aquatic organisms.

Chemical Parameters

The DMM has analyzed water samples for a much larger suite of chemical parameters than those that are routinely reported in their year-end and data sheet summaries each year. In a few cases, the substances analyzed in lake water samples from Kahshe and other Muskoka lakes were included in the long term analysis presentations by Palmer (2012) and Somers et al. (2009), so in those cases, the findings from this suite of non-nutrient analyses have been assessed for the combined Muskoka lakes dataset. However, this still left a large number of chemicals that have been analyzed but which have not been evaluated for long term trends or for their potential to impact lake quality. In 2012 and 2013, the DMM year-end report does include a summary table for each lake as well as some information on a few of the additional substances analyzed. This includes calcium, chloride, sodium, nitrate, total Kjeldahl nitrogen and sulphate.

As in 2011, the full suite of chemicals analyzed via the DMM sampling program included: chloride, nitrogen (ammonia + ammonium), nitrogen (nitrite+nitrate), total Kjeldahl nitrogen, sulphate, aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silicon, sodium, strontium, titanium, vanadium, zinc. In addition, the following new chemicals were added to the suite of chemicals in 2012 and 2013: antimony, arsenic, boron, selenium, silver, thallium and uranium.

As most of these chemicals have not been included in the DMM summary table of additional chemical parameters, this report attempts to do this by comparing the results for all years for which data exist to surface water benchmarks that are available from the MOE or other regulatory agencies. A brief description of the benchmarks which have been used and what they're designed to protect follows:

- For the anions and cations and other parameters included in the DMM dataset, the findings have been compared to currently available aquatic protection values (APVs) used by the Ontario MOE (MOE, 2011). These values represent the highest concentration of a contaminant in surface water to which an aquatic community can be exposed indefinitely without resulting in an adverse impact.

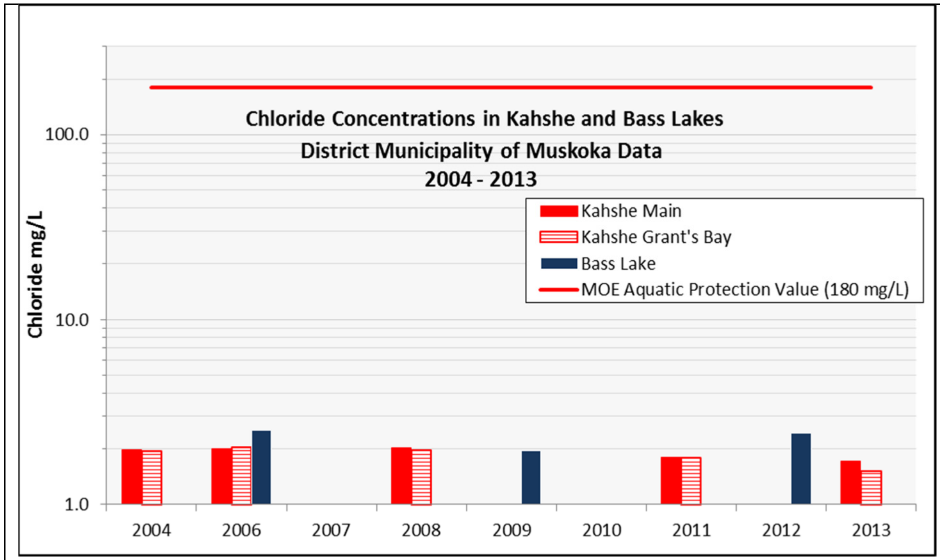
- In cases where an MOE APV was not available, a similar format to the one used by the MOE in protecting surface water from ground water discharges associated with contaminated sites (*O. Reg. 153/04* as amended) has been followed. This involved first checking for a U.S. EPA chronic ambient water quality criterion (based on a continuous chronic criterion, (U.S. EPA, 2012; U.S. EPA, 1986));

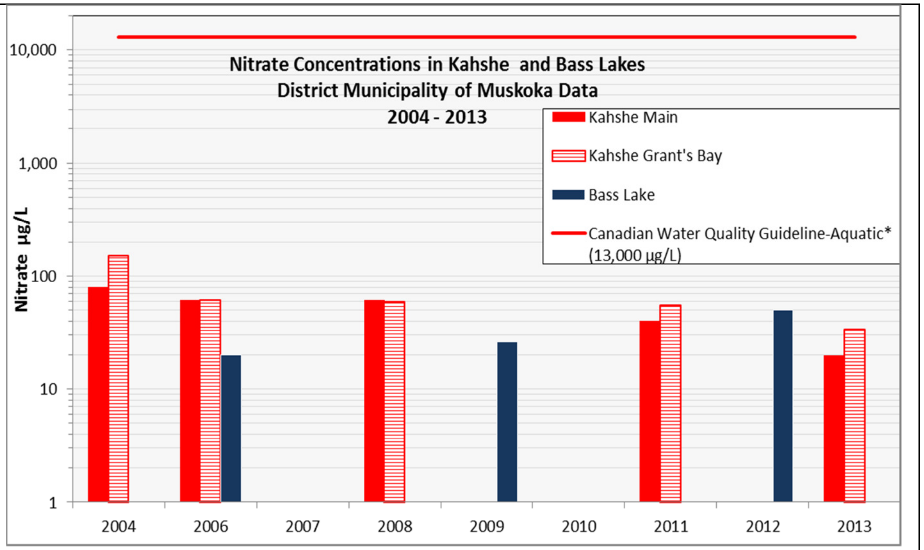
- If neither of these sources had a value, a Canadian Water Quality Guideline (CCME, 2012), a B.C. Ambient Water Quality Criterion (B.C. 2000; B.C. 2001) or a U.S. EPA Tier-II Secondary Chronic Value (Suter II and Tsao, 1996) has been used.

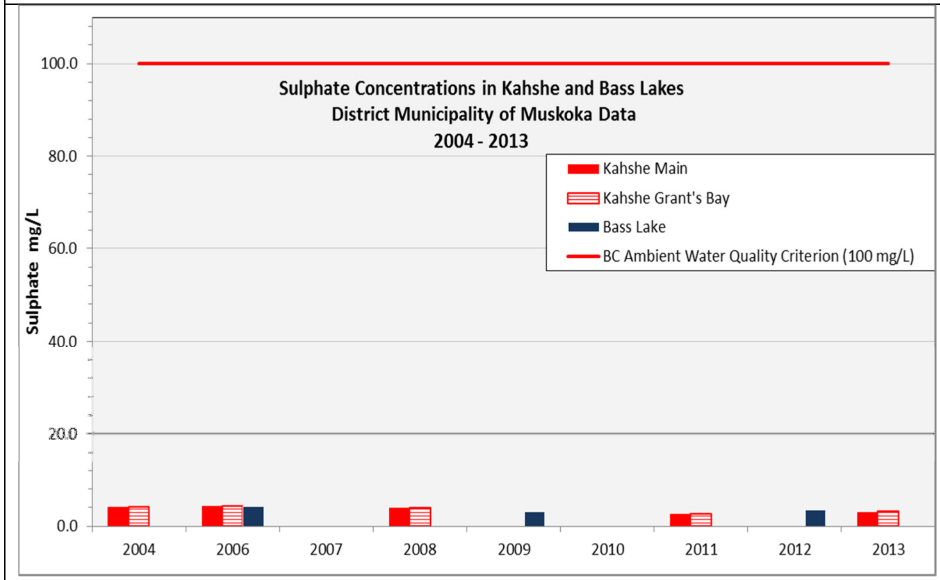
- In all cases, the surface water protection provided via these benchmarks is for long term exposure to concentrations that are considered chronic, as opposed to short-term protection against acute effects.

The charts for all chemicals with some type of water quality benchmark have been shown below, with the data for all of these charts being presented in Appendix Table L.

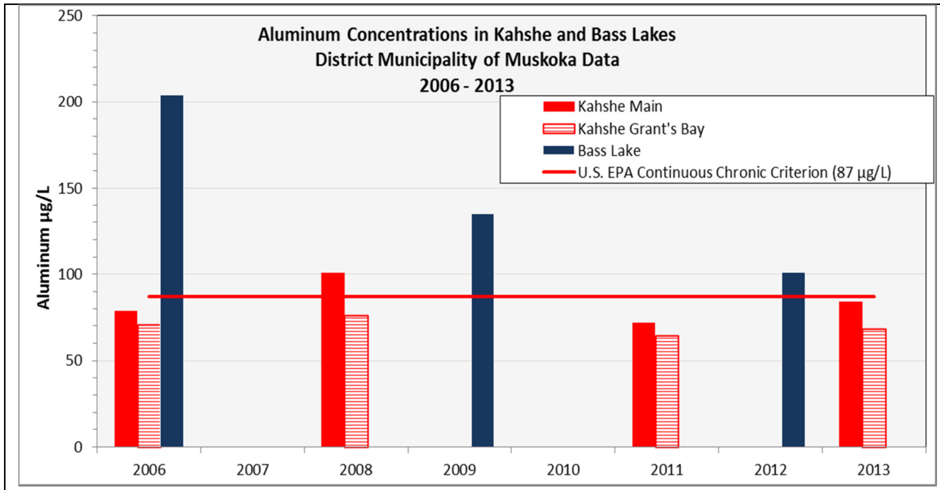
Anions

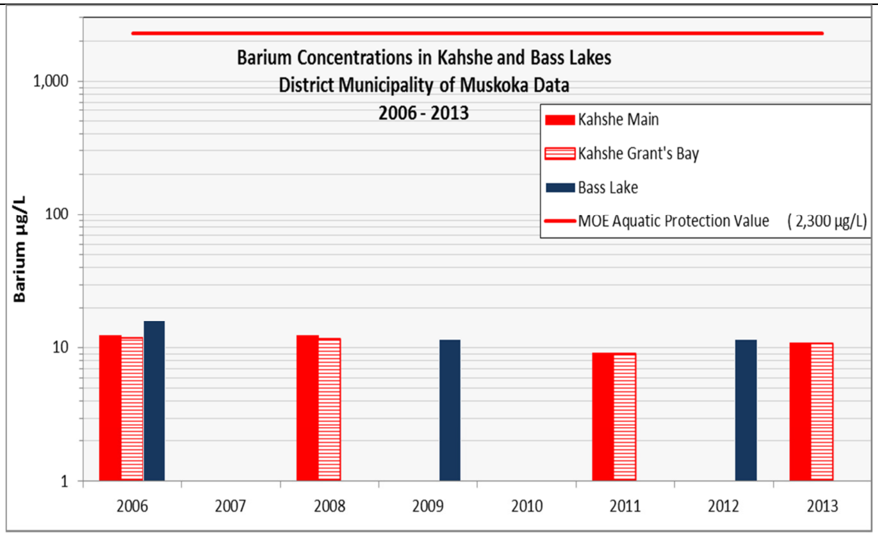

Chloride Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (180 mg/L)
Chloride mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013

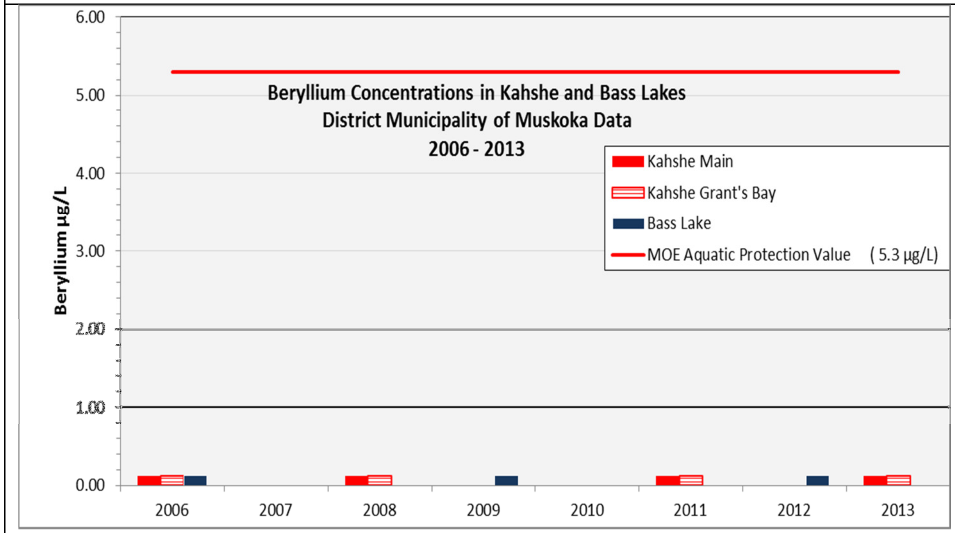

Nitrate Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Canadian Water Quality Guideline-Aquatic*
(13,000 µg/L)
Nitrate µg/L
10,000
1,000
100
10
1
2004
2006
2007
2008
2009
2010
2011
2012
2013

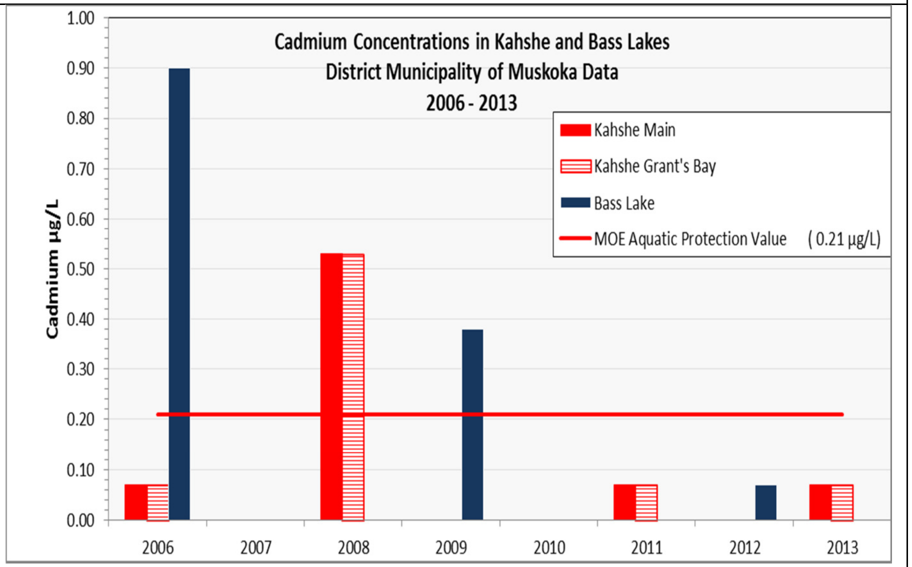

Sulphate Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (100 mg/L)
Sulphate mg/L
100.0
80.0
60.0
40.0
20.0
0.0
2004
2006
2007
2008
2009
2010
2011
2012
2013

Cations

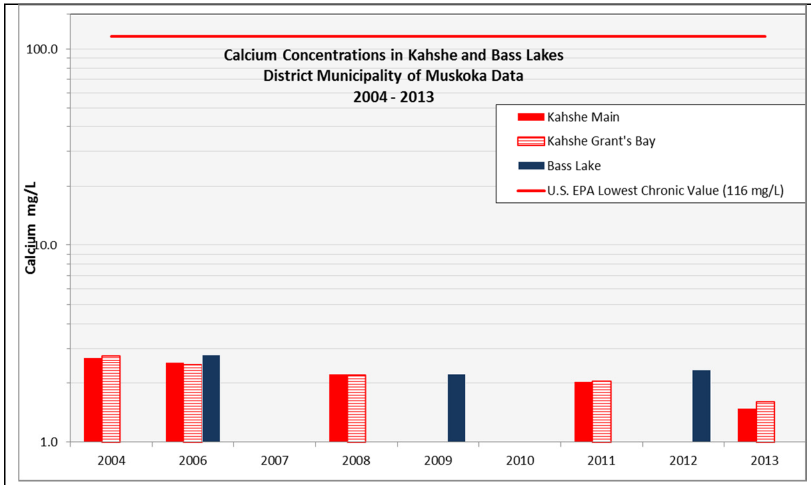

Aluminum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (87 µg/L)
Aluminum µg/L
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013

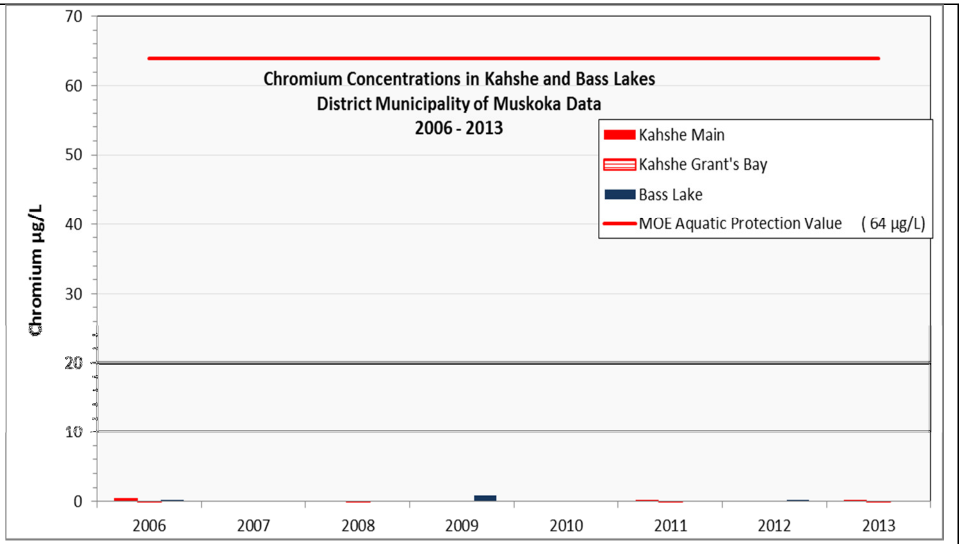

Barium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (2,300 µg/L)
Barium µg/L
1,000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013

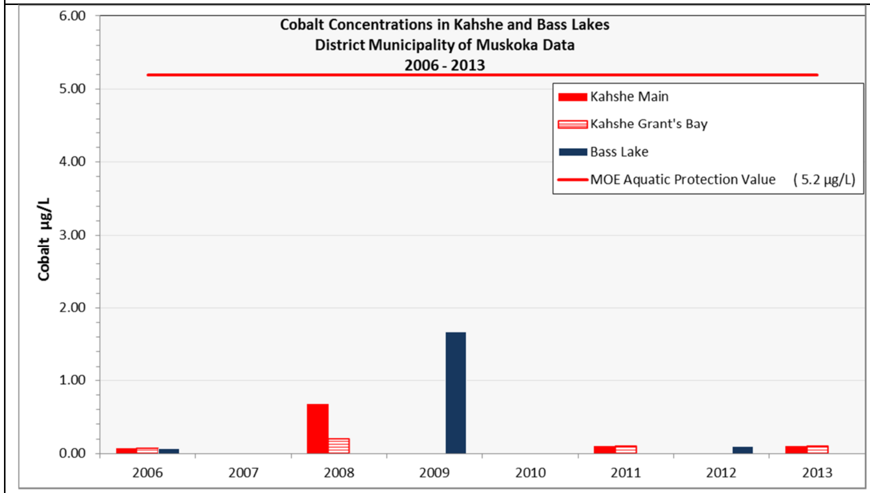

Beryllium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (5.3 µg/L)
Beryllium µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013

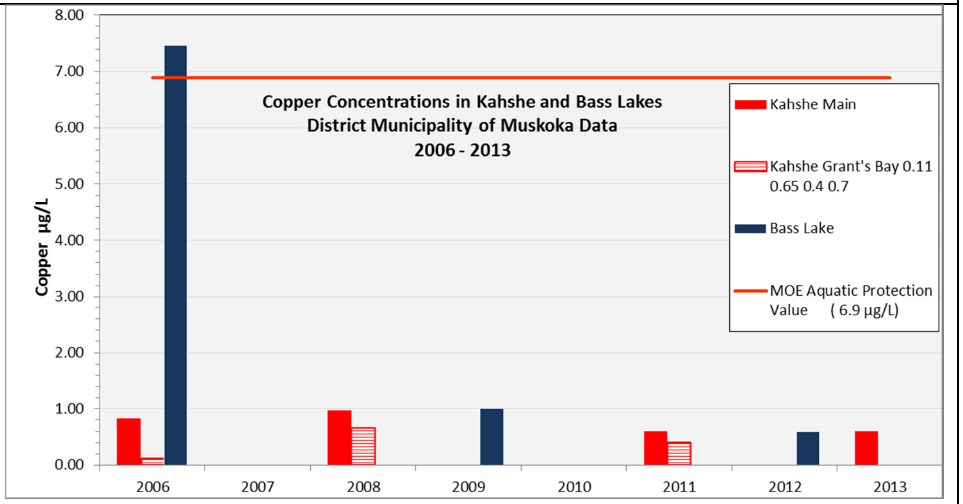

Cadmium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (0.21 µg/L)
Cadmium µg/L
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2006
2007
2008
2009
2010
2011
2012
2013

Cations

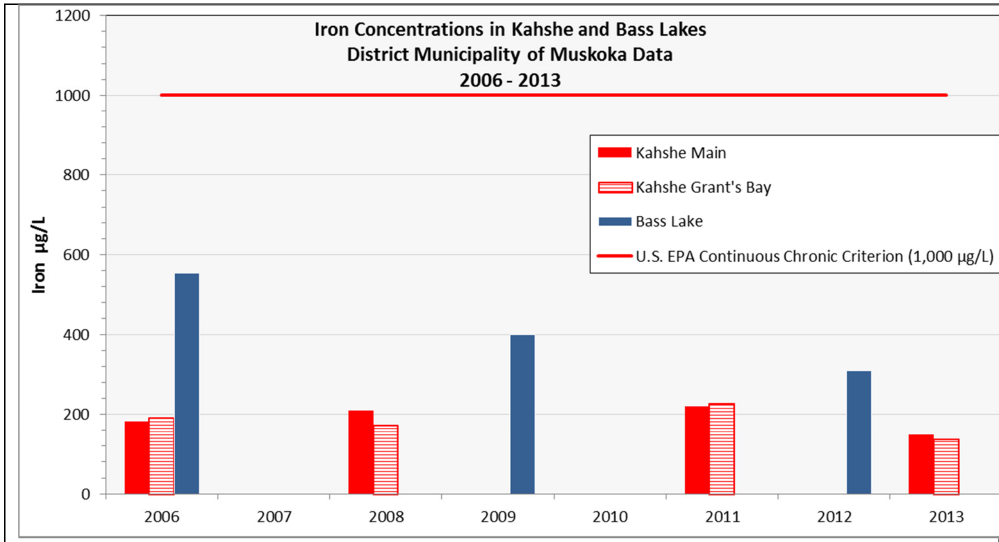

Calcium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (116 mg/L)
Calcium mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013


Chromium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (64 µg/L)
Chromium µg/L
70
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013

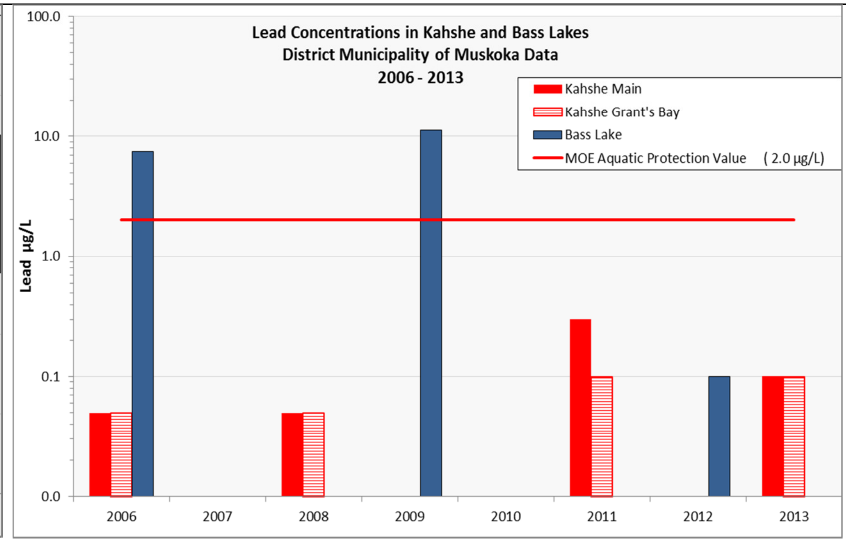

Cobalt Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (5.2 µg/L)
Cobalt µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013


Copper Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay 0.11 0.65 0.4 0.7
Bass Lake
MOE Aquatic Protection Value (6.9 µg/L)
Copper µg/L
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013

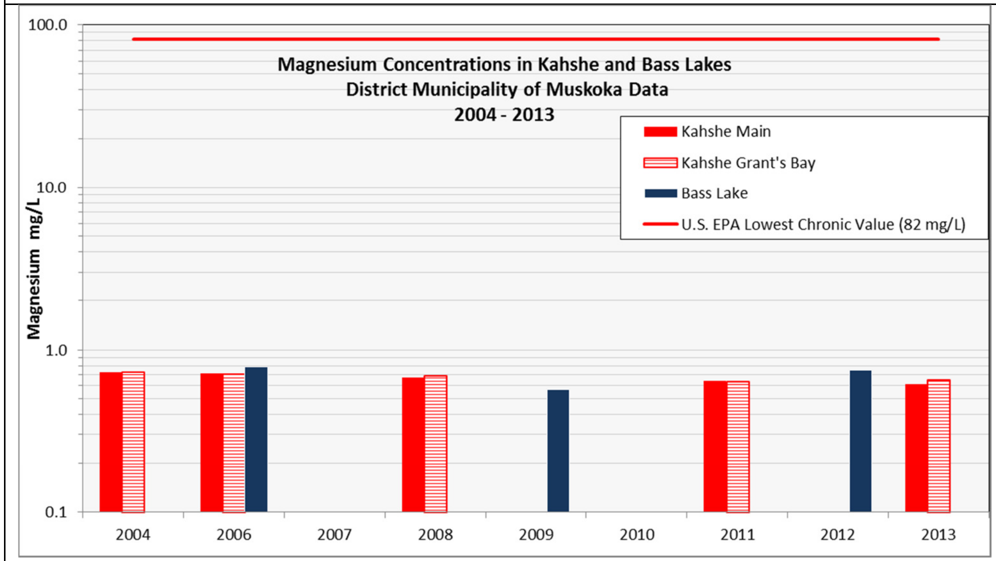
Cations



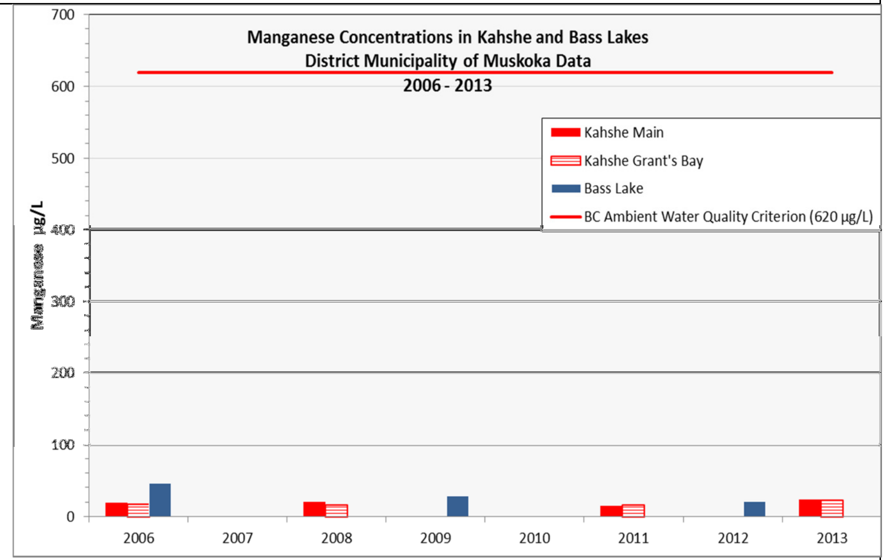
Iron Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Continuous Chronic Criterion (1,000 µg/L)
Iron µg/L
1200
1000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013



Lead Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (2.0 µg/L)
Lead µg/L
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013

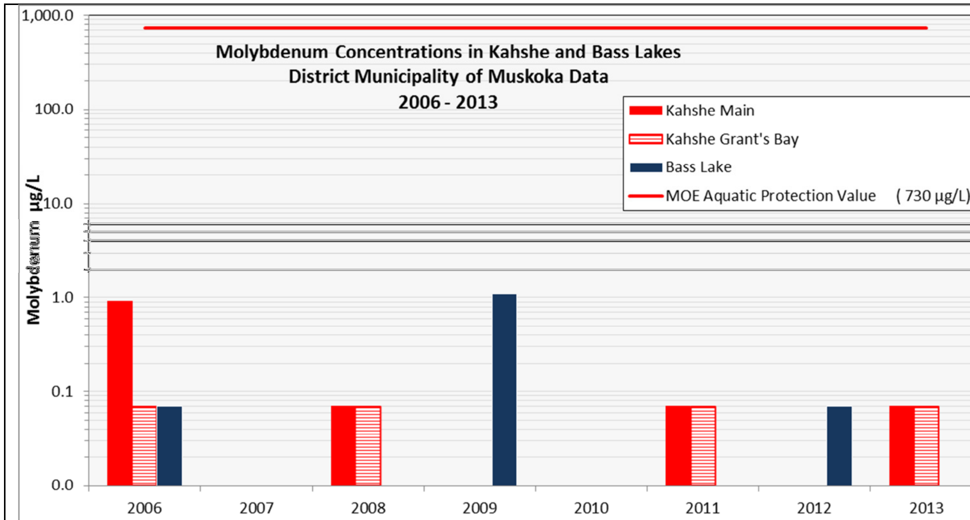


Magnesium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (82 mg/L)
Magnesium mg/L
100.0
10.0
1.0
0.1
2004
2006
2007
2008
2009
2010
2011
2012
2013

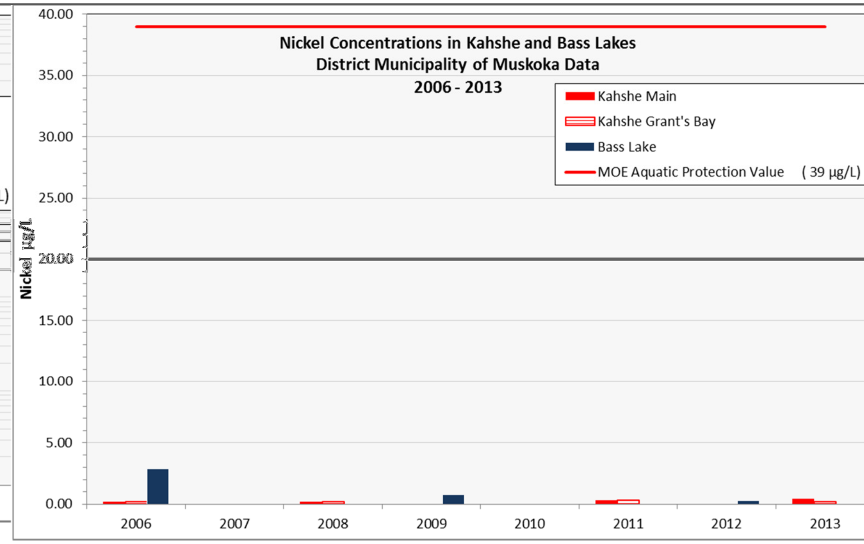


Manganese Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
BC Ambient Water Quality Criterion (620 µg/L)
Manganese µg/L
700
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013

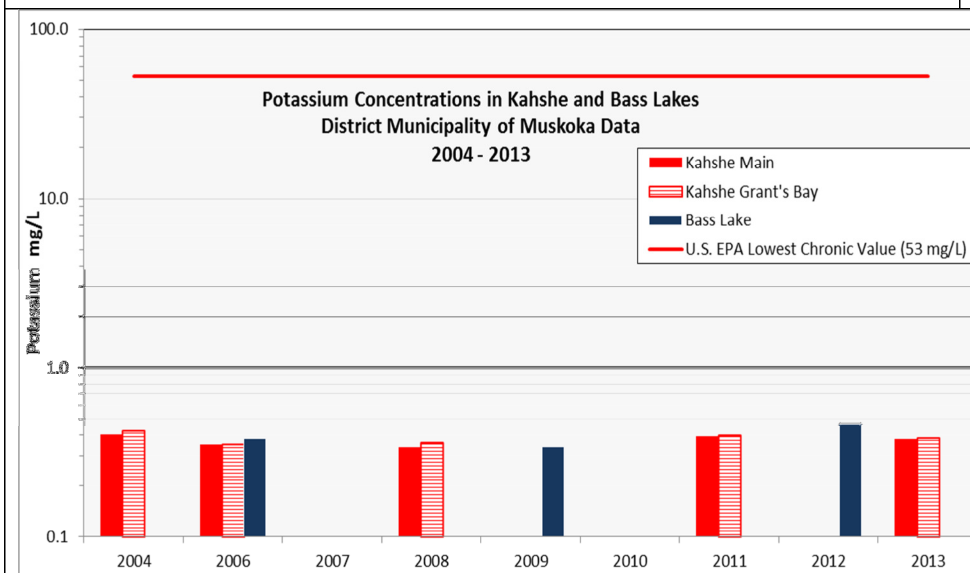
Cations



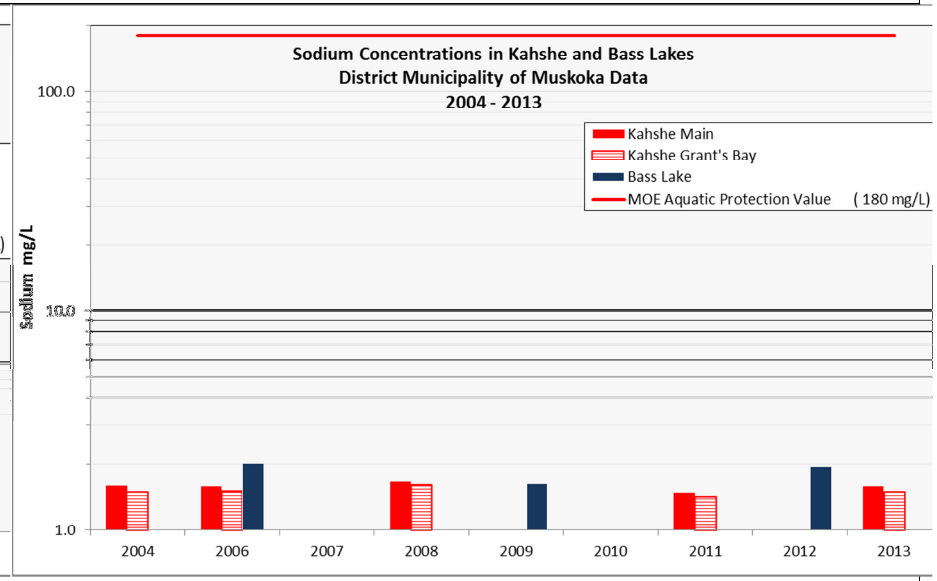
Molybdenum Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (730 µg/L)
Molybdenum µg/L
1,000.0
100.0
10.0
1.0
0.1
0.0
2006
2007
2008
2009
2010
2011
2012
2013



Nickel Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (39 µg/L)
Nickel µg/L
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013

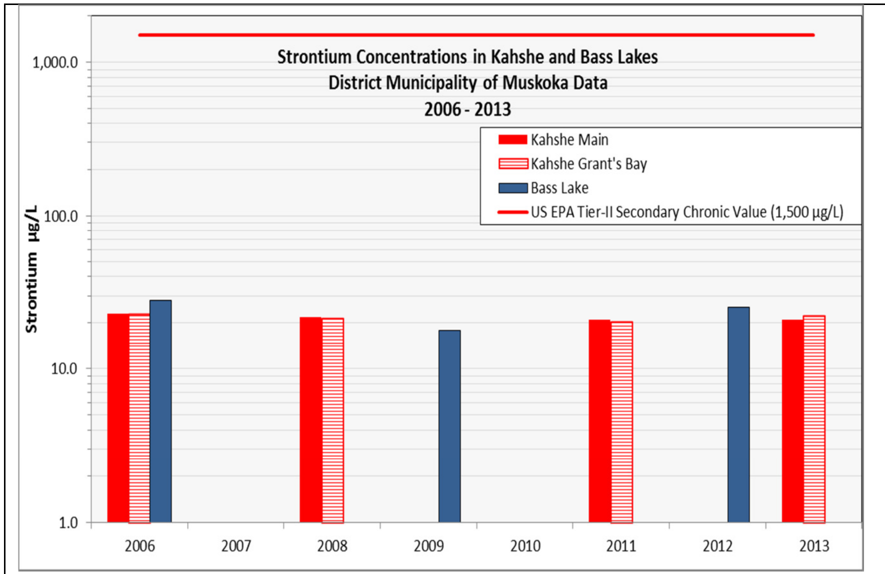


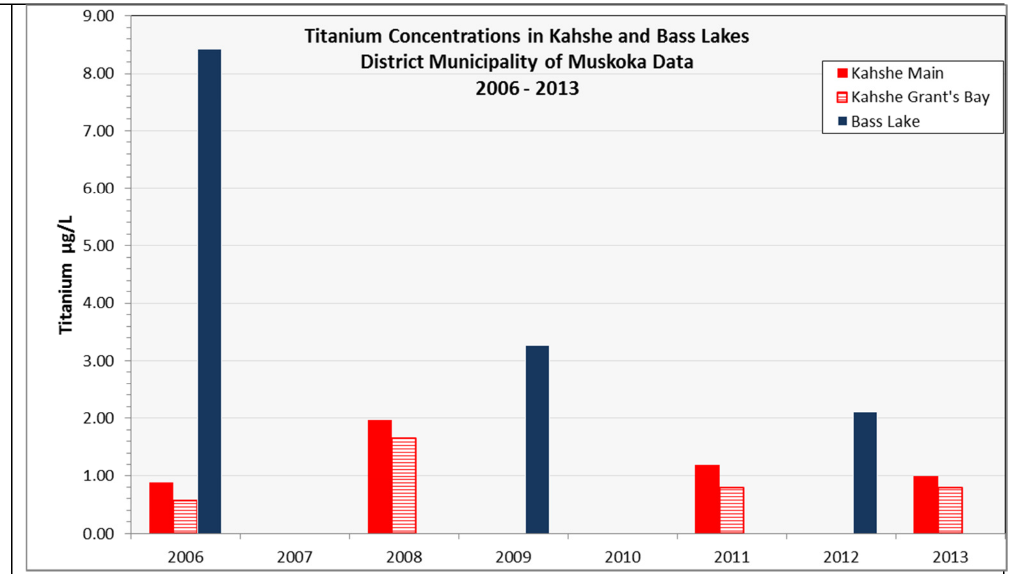
Potassium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
U.S. EPA Lowest Chronic Value (53 mg/L)
Potassium mg/L
100.0
10.0
1.0
0.1
2004
2006
2007
2008
2009
2010
2011
2012
2013

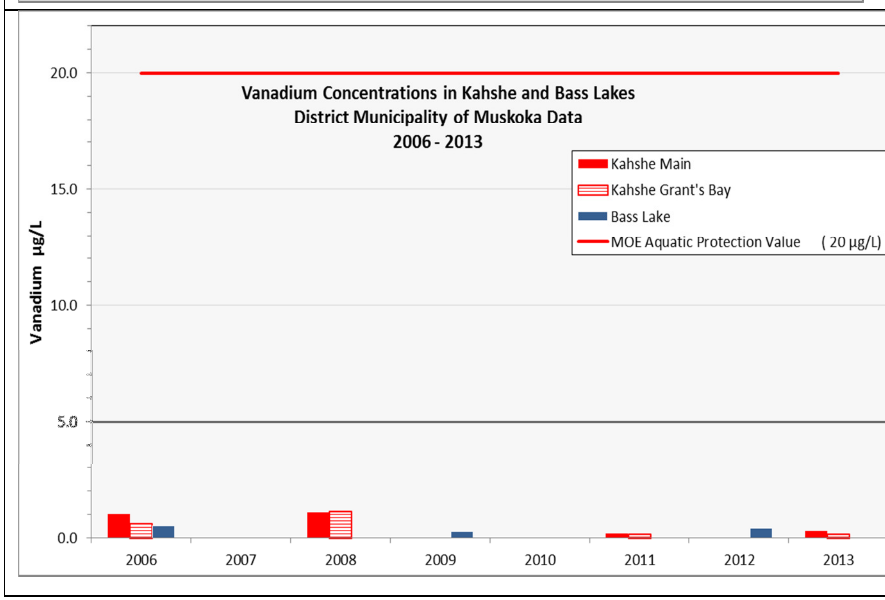


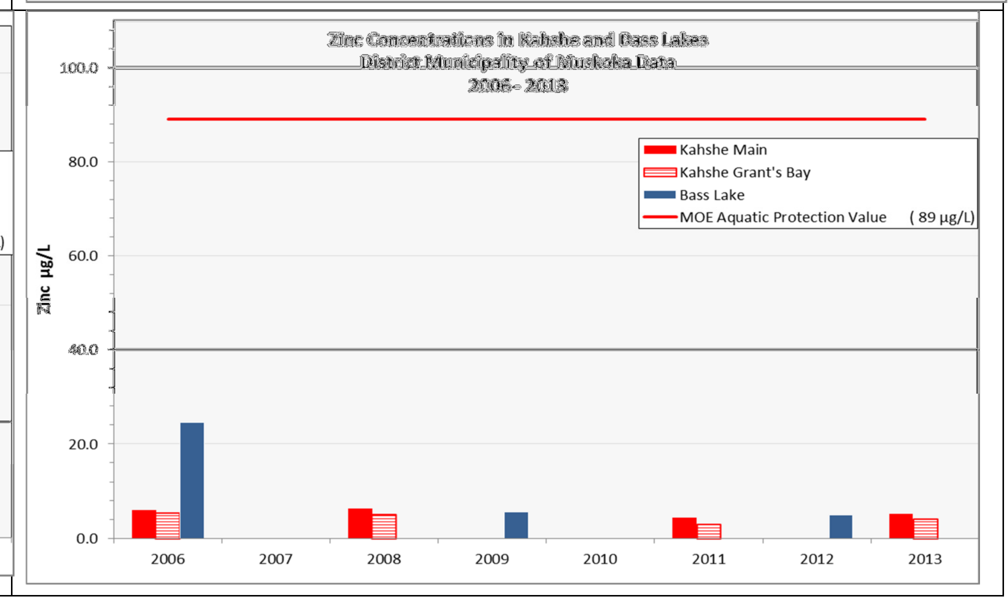
Sodium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2004 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (180 mg/L)
Sodium mg/L
100.0
10.0
1.0
2004
2006
2007
2008
2009
2010
2011
2012
2013

Cations


Strontium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
US EPA Tier-II Secondary Chronic Value (1,500 µg/L)
Strontium µg/L
1,000.0
100.0
10.0
1.0
2006
2007
2008
2009
2010
2011
2012
2013


Titanium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
Titanium µg/L
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2006
2007
2008
2009
2010
2011
2012
2013


Vanadium Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (20 µg/L)
Vanadium µg/L
20.0
15.0
10.0
5.0
0.0
2006
2007
2008
2009
2010
2011
2012
2013


Zinc Concentrations in Kahshe and Bass Lakes
District Municipality of Muskoka Data
2006 - 2013
Kahshe Main
Kahshe Grant's Bay
Bass Lake
MOE Aquatic Protection Value (89 µg/L)
Zinc µg/L
100.0
80.0
60.0
40.0
20.0
0.0
2006
2007
2008
2009
2010
2011
2012
2013

In the case of the new chemicals added in 2012 and 2013, there was insufficient data to generate a chart of concentrations over a sampling interval. Instead, Table 1 below shows the analysis results and the benchmarks against which these new chemicals have been compared.

Table 1: Chemical Analysis Data for Chemicals Added in 2012 (Bass L) and 2013 (Kahshe L)

New Substances Analyzed in 2012 & 2013					
Substance	Units	Kahshe Main	Kahshe Grant's Bay	Bass Lake	MOE Aquatic Protection Value
		2013		2012	
Antimony	µg/L	0.07	0.07	0.07	1600
Arsenic	µg/L	0.1	0.2	0.2	150
Boron	µg/L	4	4	0.48	3550
Selenium	µg/L	0.1	0.2	0.1	5
Silver	µg/L	0.08	0.08	0.08	0.12
Thallium	µg/L	0.08	0.08	0.08	40
Uranium	µg/L	0.08	0.08	0.08	33

Legend:
concentrations shown in coloured text are Method Detection Levels, as a quantifiable concentration was not found

What does this tell us?

- Although Palmer and Somers et al. have been able to detect changes in water chemistry associated with chloride (increasing); calcium and sulphate (decreasing), none of the charts of water quality for Kahshe or Bass Lakes are showing these trends.
- One of the main reasons why Kahshe Lake data would not be reflective of the long terms trends that are being seen in Muskoka is because for these substances, the monitoring has not been conducted for a long enough period (back to 2004).
- Note also, that in all cases where a surface water protection value was available for the above four substances, all water quality data were well below these values and do not represent a threat to aquatic receptors.
- As noted in the 2012 report, a few potential issues were identified with the water quality data that has been generated by the DMM for aluminum, cadmium, copper and lead, which each showed one or more exceedances of the surface water aquatic protection benchmarks.
- In the case of aluminum, the exceedances are concluded to be minor in nature, as aluminum toxicity to aquatic organisms is very complex and the benchmark that was selected from the US EPA is somewhat dated and has not been updated due to the complexity of aluminum toxicity in water and its relationship with several other substances.
- For the other three (lead, copper and cadmium), the aquatic benchmark exceedances which have been detected are most likely related to quality issues either at the collection or the analysis stage, as there have been no exceedances in sampling conducted after 2010.

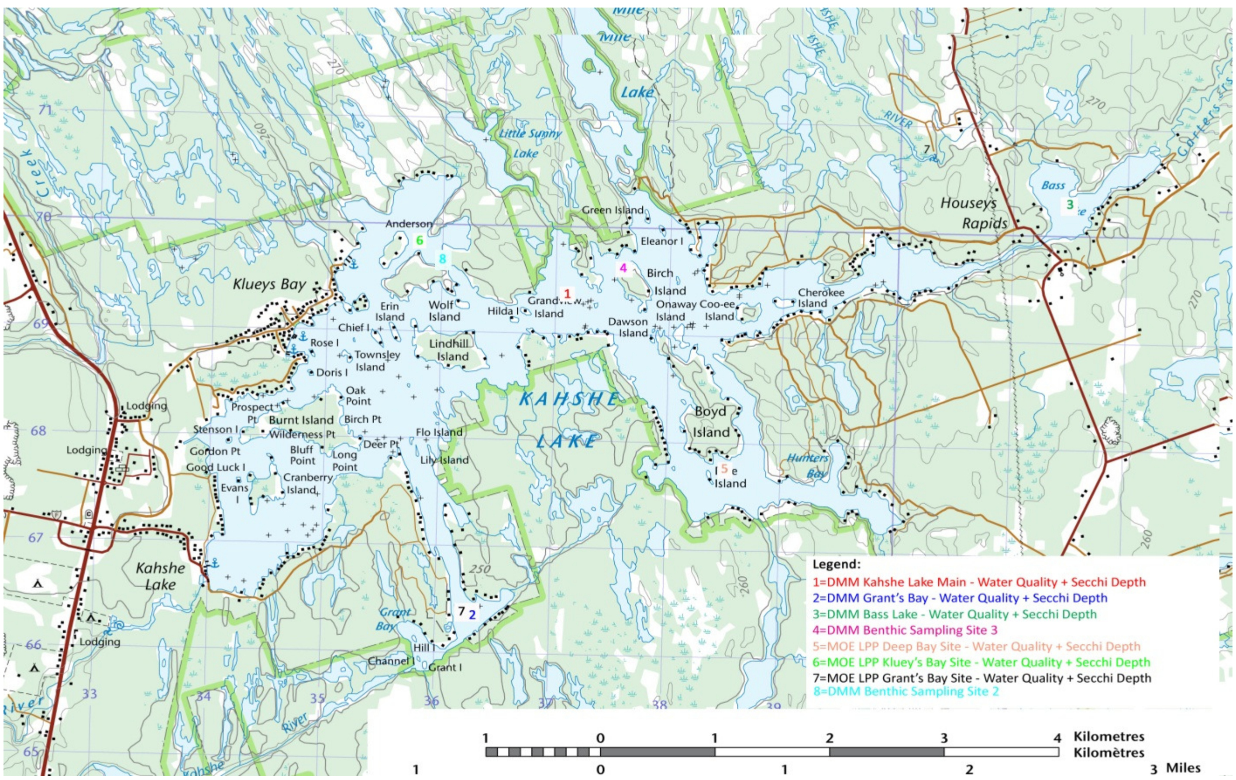
4.0 Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

Monitoring bottom-dwelling aquatic invertebrate communities has been carried out by the DMM since 2003. This type of monitoring provides an indirect measure of water quality and habitat disturbance, as the composition of the aquatic-invertebrate community and the relative abundances of different species can be used to evaluate the health of the ecosystem.

Aquatic invertebrates include worms, mollusks, insects, crustaceans, and mites. These animals are sensitive indicators of the health, or condition of lakes and streams, as different species have different sensitivities to environmental changes such as pollution or habitat alteration.

Aquatic invertebrates live from one to three years and are in constant contact with lake sediments.

Monitoring on Kahshe Lake is carried out at two locations as shown on the map below:



In 2013, the sampling was carried out on August 15 at Site 3, on the north side of Birch Island. Once three replicates of sediment from the shoreline area were collected, DMM staff and volunteers from Kahshe Lake (Clare Henderson and his son and grandson, Scott and Alex, Toby Fletcher, Adam Baron, David and Marilyn Guttman as well as my wife Gail and daughter-in-law Natasha Pearson who made the lunch happen) and from the Scales Nature Park (Brenan Ackert, Jory Mullen, Amanda Ammon plus visiting students from France, Pierre Barillon and Florian Guerit) carried out the counting and identification of the benthic organisms. The volunteers from the Scales Nature Park were coordinated by Hannah McCurdy-Adams who also attended the Kahshe Lake AGM and gave us an update on research activities to help preserve our snakes and turtles, so we are grateful for Hannah's assistance in organizing this volunteer participation. A couple of pictures of the sampling and counting activities have been shown below.

Kahshe Lake and Scales Nature Park Volunteers on Benthic Counting Day – August 15, 2013

DMM Biotechnician Dylan Moesker Taking Benthic Sample at Site 2 – August 15, 2013

The results of the sampling from both Site 2 and 3 have been combined and compared to the Muskoka average, which is based on 147 samples from 76 reference lakes between 2004 and 2011. A summary of this information is presented in Appendix Table M.

To understand how the sample findings are compared in the chart below, it is necessary to understand the scoring system which uses indices of organism groupings. This s is shown in Table 2 below.

Table 2: Indices Used to Summarize Aquatic Invertebrate Composition in Muskoka

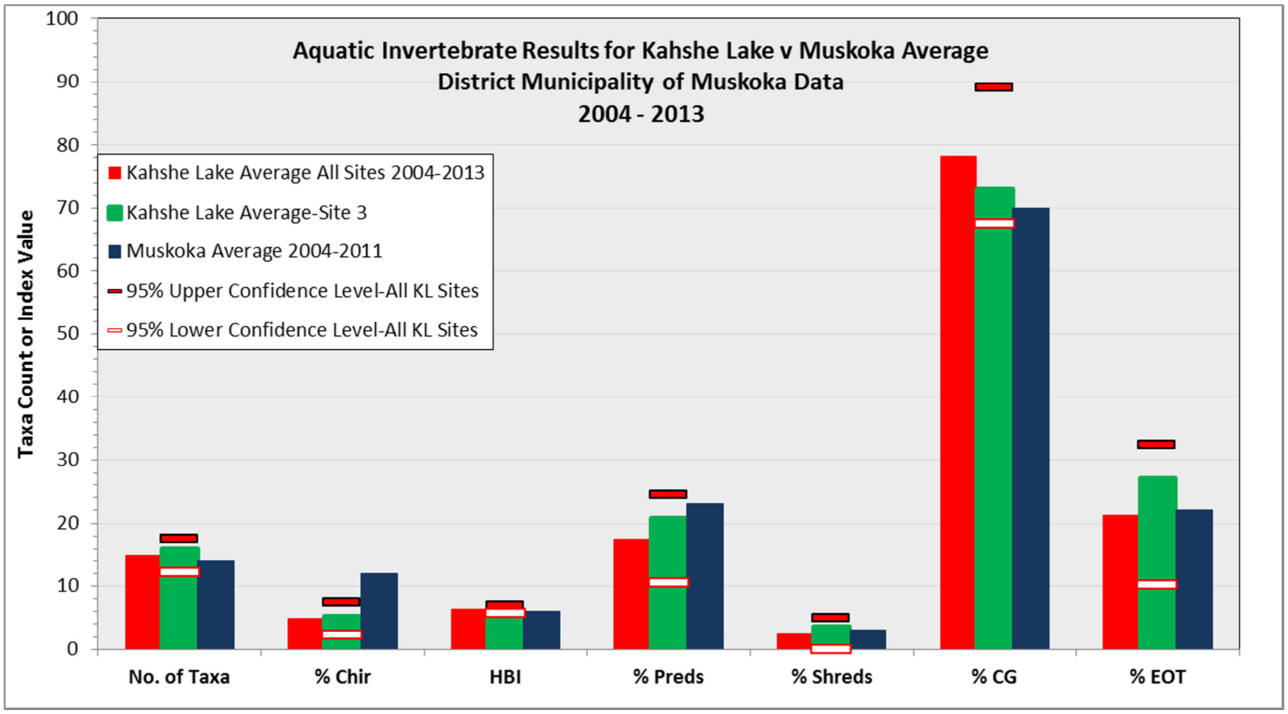
Name	Description	Explanation of the Index
No. of Taxa	Number of taxa collected (Richness)	The number of taxa is a measure of biological diversity. Richness increases with increasing habitat diversity, suitability, and water quality; therefore, the healthier a site's community, the greater it's number of taxa.
% Chir	Percent of collection	Midges (true flies in the family Chironomidae) are

Name	Description	Explanation of the Index
	made-up of midges (% Chironomidae)	tolerant of pollution and habitat changes so their dominance indicates water quality problems.
HBI	Organic pollution score (Hilsenhoff index value)	The Hilsenhoff index combines information about the abundances of different types of animals collected at a site with information about those animals' sensitivities to sewage pollution, farm wastes, and other sources of nutrients like phosphorus, nitrogen, and carbon. High values of this index indicate pollution; low values indicate good water quality.
% Preds	Percent of collected animals that are predators (% predators)*	In a healthy ecosystem, the numbers of predators and prey are maintained within a narrow range. Extreme fluctuations in this balance signify that the ecosystem is sick.
% Shreds	Percent of collected animals that are adapted to feeding on coarse plant matter (% shredders)*	Shredders are a group of plant eaters adapted to breaking down leaves, wood, and other plant matter that originates on land but gets transported into water bodies. Such animals should be abundant if there is a good connection between a lake and its watershed. In addition to recycling nutrients, shredders are food for other animals.
% GC	Percent of collected animals that are adapted to feeding by collecting small pieces of organic matter (% collector/gatherers)*	Collector-gatherers feed on small pieces of organic matter that arise from the processing activities of shredders (described above). Their presence indicates a good population of shredders, which provide them with food. Like shredders, these animals perform a vital role in energy cycling, and are prey for other animals.

Legend:
∗ In healthy ecosystems, the proportion of the aquatic-invertebrate community that is made-up of predators, shredders, collector/gatherers, and other animals is maintained within a narrow range. Marked divergences in abundances of any type of animal signify a stressed ecosystem.

Source: This table provided by DMM

Using these benthic indices, the results for Kahshe Lake have been plotted against the Muskoka average values in the chart below.



What does this tell us?

- As shown above, the benthic data from both sites on Kahshe Lake are, in all but one case, similar to those of Muskoka lakes chosen by the DMM as reference values.
- When the variability in the Kahshe Lake data are considered by showing the upper and lower confidence levels (to represent the expected range in mean concentrations at the 95% level of confidence), all the indices except one are further shown to be well within the expected range based on the Muskoka reference site comparisons.
- The exception to these findings is for the % Chironomidae, where the average Muskoka value is higher than the corresponding value for Kahshe Lake.
- However, as shown in Table 2 above, Chironomidae are tolerant of pollution and habitat changes, so their dominance indicates water quality problems. As such, the lower value for the Kahshe Lake data is actually desirable.
- Based on these findings, the benthic monitoring results from sampling on Kahshe Lake over the period from 2004 to 2013 have not identified any problems in the growth and survival of aquatic invertebrate which can be related to contamination or habitat disturbance. For all growth and survival metrics, the Kahshe Lake invertebrate populations were similar to or better than the corresponding indices of selected reference lakes in Muskoka.

5.0 Summary and Conclusions

In accordance with the goals and objectives which have been set out for the Kahshe Lake Steward by the Kahshe Lake Ratepayers Association (KLRA), a comprehensive review and analysis of all historical environmental monitoring on Kahshe and Bass Lakes has now been completed and presented in this 2013 Kahshe Lake Steward Report.

5.1 Summary of Findings

The sampling and analysis of Kahshe and Bass Lake water and aquatic invertebrate organisms has been ongoing for up to 30 years under two main programs operated by the Ontario Ministry of the Environment (MOE) and the District Municipality of Muskoka (DMM).

These two programs are briefly summarized below:

Lake Partner Program	operated by MOE with sampling and measurement being undertaken by Muskoka Lake Stewards **every year**

- The MOE LPP program consists of the sampling and analysis of lake water for total phosphorus at three locations during the spring turnover period and the measurement of water clarity at the same three locations via use of a Secchi disc at two week intervals during the ice-free period each year.
- The program is carried out by the Lake Steward and the results of the analysis and water clarity measurements are published by the MOE on the LPP web-site.

Lake System Health Program	operated by DMM with input and assistance by the MOE and the Muskoka Watershed Council (MWC) – carried out **every two years**

The DMM program consists of sampling at two locations on Kahshe and one on Bass Lake for water chemistry every two years and two additional sites for aquatic invertebrate (benthic) monitoring on Kahshe Lake. The components of the DMM program include:

- Spring phosphorus sampling/analysis conducted in May;
- Water sample collection for base chemical parameters (anions, cations) in May;
- Secchi depth measurements collected in May and August;
- Temperature and dissolved oxygen readings collected in May and August;
- Benthic macro-invertebrate sampling in August.

In addition to a year-end report and data summaries for total phosphorus, water clarity, dissolved oxygen and water temperature which are published by the DMM and available on their web-site, the information from the DMM program is consolidated into a Watershed Report Card every four years by the MWC.

Although the MWC Report Card is not specific to Kahshe Lake, the findings from the most recent report in 2010 have been examined and the Kahshe Lake Sub-Watershed received a Grade of A for water quality and B for land.

As the MOE program does not include an annual interpretative report, this analysis of Kahshe Lake water quality has focused on the findings from the DMM program.

The review and analysis was sub-divided into the following components:

A. Evaluation of DMM Year-End Findings – 2013 Kahshe Lake Water Quality and 2012 Bass Lake Water Quality

B. Additional Analysis of Kahshe and Bass Lake Water Quality Data, to answer three questions:

Question 1: Do the DMM results for total phosphorus and Secchi depth signal a need for concern regarding water quality and clarity in Kahshe and Bass Lakes?

Question 2: How do DMM results for Kahshe and Bass Lake compare to results from MOE's LPP Sampling Program?

Question 3: Can any conclusions be drawn based on the results of a large suite of physical and chemical parameters that have been analyzed by DMM but not all included in the Year-End report?

A. DMM Year-End Findings for Kahshe and Bass Lakes

Kahshe Lake

- Based on a chart showing the analysis results for total phosphorus in all Muskoka lakes sampled in 2013, Kahshe Lake's total phosphorus concentrations were in the range of 11 - 20 µg/L and lakes with total phosphorus concentrations in this range are termed **Mesotrophic lakes.**
- In a similar chart of Secchi depth findings for all Muskoka lakes sampled in 2013, it was demonstrated that Kahshe Lake had an average clarity depth of 2.5 m, placing it in about the median (50^{th} percentile) point of the 30 Muskoka lakes with a moderate range of Dissolved Organic Carbon (DOC).
- However, for a lake classed as Mesotrophic, the water clarity results in 2013 are below the expected range in Secchi depth of 3-4.9 m as noted in the DMM year-end report.
- To better understand this charting of water clarity via Secchi depth measurements, it's important to consider that water clarity in Muskoka lakes is determined by two factors:
    - The first is DOC which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.
    - The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.
- The charts showing the results of total phosphorus and Secchi depth sampling of Kahshe Lake over the past 30 years (1983-2013) showed how both total phosphorus and Secchi depth measurements have varied over the 30 year period with no detectable upward or downward trend.

- In the case of water temperature and Dissolved Oxygen, the 2013 results show fairly typical thermal stratification effects which have been further evaluated in the next section.

Bass Lake

- The chart of total phosphorus concentrations in all Muskoka lakes sampled in 2012 showed that Bass Lake's total phosphorus concentration of 17.6 µg/L was the highest of all Muskoka Lakes sampled.
- However, as noted later in this report, Bass Lake is considered a **Mesotrophic Lake** with total phosphorus concentrations in the 11-20 µg/L range.
- While Bass Lake is classed as having a moderate amount of DOC, the Secchi disk clarity measurements are at the low end of the range for the 25 Muskoka lakes in the moderate DOC category – i.e. for a lake with moderate DOC, water clarity is lower than expected.
- In addition, it is noted that for a lake classed as Mesotrophic, the water clarity result in 2012 (2.2 m) was below the expected range in Secchi depth of 3-4.9 m as noted in the DMM year-end report.
- The plots of total phosphorus and Secchi depth over the 22-30 year period confirm a fairly normal amount of variability from year to year, with no apparent upward or downward trend for either parameter.
- In the case of water temperature and Dissolved Oxygen, the 2012 results show fairly minimal thermal stratification effects which is expected in a shallow lake.

B. Additional Analysis of Kahshe and Bass Lake Water Quality Data

Given the amount of data available from sampling programs conducted on Kahshe and Bass Lakes that have not been included in the 2012 and 2013 DMM Year End reports or not discussed by DMM on a lake-specific basis, this report further explores and compares the findings for Kahshe and Bass Lakes in an attempt to answer the three questions identified above.

Question 1: Do the DMM results for total phosphorus and Secchi depth signal a need for concern regarding water quality and clarity in Kahshe and Bass Lakes?

- To answer this question, the report presented some general information on the importance of total phosphorus and water clarity measurements which are briefly summarized below.

- Phosphorus is a natural substance required by all living organisms. It enters a lake naturally through: release from bottom sediments and wetland areas and via precipitation and soil erosion.

- Phosphorus is also released from human activities such as:
    - leaching from septic systems,
    - use of phosphorus-based cleaning supplies, and,
    - from use of lawn fertilizers which eventually leach to the lake or are carried via soil erosion.

- The reason for focusing on total phosphorus is that it is typically the best chemical indicator of lake eutrophication or enrichment and has been found to be the best chemical signal as a warning sign for potential algal blooms.
- Water clarity in the lakes in Muskoka is determined by two main factors:
  - The first is dissolved organic carbon (DOC) which colours the water orange-brown. DOC compounds are formed by the decomposition of organic plant matter in wetland areas and concentrations in lake waters are determined by the amount of wetland in the catchment of a lake. The influence of DOC on transparency is entirely natural and cannot be managed to improve water clarity.
  - The second determinant of transparency is the level of the plant pigment chlorophyll *"a"* in the water. This pigment is contained in algae which grow in the water and so the amount of chlorophyll reflects the amount of algae in the water.
- In general, where a lake is not coloured by DOC, the higher the Secchi depth reading, the clearer the lake and the less nutrients it contains.
- Water clarity can change weekly or yearly as a result of weather, length of winter ice cover, shoreline development, natural seasonal trends or other impacts. However, when the primary determinant of water clarity is a function of nutrient enrichment, a long-term trend that indicates a reduction in water clarity is an indication of reduced water quality.
- Based on a review of the science, the DMM has opted to conservatively preserve the levels of total phosphorus equated with eutrophication and algal bloom problems based on their predicted background or undeveloped concentrations.
- In the case of Kahshe Lake, the background was set at 9.5 µg/L, resulting in a total phosphorus threshold of 14.2 µg/L (background + 50%). The threshold for Bass Lake has been set at 30.9 µg/L, as the background was higher.
- There are two criteria that must be examined to determine if a lake has exceeded its acceptable threshold for phosphorus. If a lake meets both of these criteria, then it is considered to be Over Threshold:
  - Total phosphorus concentration, as estimated by the Muskoka Water Quality Model, exceeds the "Background + 50%" threshold; and,
  - The long-term (10 years) measured total phosphorus concentration, as determined by the DMM Program, also exceeds the "Background + 50%" threshold value.

- A lake that is Over Threshold will be de-listed only after the long-term average of total phosphorus is less than the threshold established for the lake and there have been three consecutive phosphorus measurements below its threshold value.
- The good news is that Kahshe Lake is listed as being at a level of background + 23% - well below the threshold of background + 50% - and is shown as being low in terms of total phosphorus responsiveness. However, because of limited soil attenuation potential, the phosphorus mobility rating is high. The combination of these two factors results in a moderate sensitivity classification for Kahshe Lake. Bass Lake also is rated as moderate in sensitivity.
- Bass Lake also is in good condition with respect to total phosphorus, as it is currently at a level of background + 3%. It too is classed as moderate in sensitivity.
- Based on the water clarity findings, it would appear that Kahshe Lake has water clarity depths that are at the low end of the range of expected clarity readings for a Mesotrophic lake while Bass Lake's water clarity is well below the expected range in water clarity.
- However, the levels of total phosphorus in both lakes are well below threshold values, so other factors appear to be involved.
- In addition, based on the chemical analysis measurements in both Kahshe and Bass Lakes, it is apparent that total phosphorus concentrations are not increasing, and with continued analysis it may be possible to confirm that total phosphorus concentrations are decreasing as in other Muskoka lakes.
- The final evaluation made in this section was to explore the statistical relationship between total phosphorus and water clarity. This was based on the findings for all Muskoka lakes which were studied by the MOE in order to determine whether water clarity was being impacted by total phosphorus concentrations.
- In that study, it was demonstrated that when DOC levels were taken into consideration, there was a statistically significant relationship between total phosphorus concentrations and water clarity as measured by Secchi depth, with 65% of the variability in water clarity being predicted by total phosphorus.
- To explore if this was happening on Kahshe Lake, paired total phosphorus and Secchi depth data for the 30 year period from 1983 to 2013 were evaluated via regression analysis and there was no significant relationship between these two parameters. In other words, based on this analysis, total phosphorus concentrations have had no detectable negative impact on Kahshe Lake water clarity.
- While this may be true, it should be noted that there are many factors which could be masking a relationship between these parameters. One factor could be timing, as there may be a lag period

required before the algal growth stimulation effect of total phosphorus is manifested in water clarity degradation. If this was the case, Secchi depth measurements taken at the same time as spring phosphorus sampling may not capture potential increased growth of algae at a later date.

Question 2: How do DMM results for Kahshe and Bass Lake compare to results from MOE's Sampling Program?

- This comparison was limited to the results from Kahshe Lake, as there has been no MOE-LPP sampling conducted on Bass Lake.

- Keeping in mind the variability that exists within the total phosphorus database, it is apparent that when analysis results for similar sampling dates over the period from 1983 to 2013 are plotted, both programs have generated similar results.

- In the case of Secchi depth, the results of the two sampling programs also show a considerable degree of variability over the period from 1983 to 2013, but also are in general agreement in most years, and on average, are in the range of 2.5 to 3.5 m in depth.

- As was the case with total phosphorus, there has been no detectable upward or downward trend in water clarity over this 30 year period.

Question 3: Can any conclusions be drawn based on the results of a large suite of physical and chemical parameters that have been analyzed by DMM but not all included in the Year-End report?

In addition to the total phosphorus and Secchi depth measurements, the DMM program includes the analysis of a large suite of additional chemical and physical water quality parameters.

Physical Parameters

- This group included dissolved oxygen (DO), water temperature, dissolved organic carbon (DOC), electrical conductivity (EC) and pH.

- The combination of thermal stratification and biological activity causes characteristic patterns in water chemistry. In the summer, deep lakes stratify with warm water on top and cold water below. Because cold water is more dense than warm water, these two layers do not mix and atmospheric oxygen cannot reach the bottom layer.

- In general, the dissolved oxygen concentration in the epilimnion (top layer of water in a lake) remains high throughout the summer because of photosynthesis, which produces oxygen, and diffusion of oxygen from the atmosphere. Conditions in the hypolimnion (the bottom layer of water in a lake) vary with trophic status and dissolved oxygen declines during the summer because organisms continue to consume oxygen. In some lakes, the bottom layer may eventually become anoxic (almost totally devoid of oxygen).

- It is apparent from the Kahshe Lake DO data that in almost all years for which DO has been analyzed, the spring turnover concentrations have been well above the optimal level for aquatic organisms. The only exceptions have occurred in 1994, when optimal levels were not met at depths below 7 m.

- As for DO, water temperature at increasing depths has been monitored on both Kahshe and Bass Lakes by DMM since the 1980s. Up until 2008, these measurements were taken at least twice during the spring and summer season and in several cases, at monthly intervals.

- In 2011, the data appeared to indicate a possible warming trend in the upper 4 m of the Kahshe Lake water column during the spring turnover sampling event. However, the 2013 data demonstrate that this apparent trend was not evident based on the 2013 data.

- Based on these finding, the apparent warming effect in Muskoka lakes as reported by Dr. M. Palmer (Palmer, 2012) and by Somers et al. (2009) has not been detected in the waters of Kahshe Lake, as the variability is too great on this single lake.

- The other three physical parameters evaluated in the DMM sampling program for Kahshe and Bass Lakes included DOC, EC and pH.

- In the case of DOC, it is noted that the concentrations in Bass Lake are typically higher than those in Kahshe Lake. The aesthetic objective in drinking water is 5 mg/L, and values greater than 7 mg/L are considered high for recreational use. As such, even though DMM considers both lakes to fall in the moderate category, the DOC concentrations in Bass Lake exceed the aesthetic objective for recreational use.

- In the case of EC, which is a measure of dissolved salts (ions), both lakes fall within the normal range for natural waters of between 50-1,500 µS/cm.

- Finally, in the case of pH, the acidity of both lakes is just under the Provincial water quality objective of between 6.5 and 8.5; however, neither lake has pH below 5 or above 9, values that are known to be harmful to some aquatic organisms.

Chemical Parameters

- The DMM has analyzed water samples for a much larger suite of chemical parameters than those that are routinely reported in their year-end and data sheet summaries each year. In a few cases, the substances analyzed in lake water samples from Kahshe and other Muskoka lakes were included in the long term analysis presentations by Palmer (2012) and Somers et al. (2009), so in those cases, the findings from this suite of non-nutrient analyses have been assessed for the combined Muskoka lakes dataset.

- However, this still left a large number of chemicals that have been analyzed but which have not been evaluated for long term trends or for their potential to impact lake quality.

- In 2012 and 2013, the DMM year-end report does include a summary table for each lake as well as some information on a few of the additional chemicals analyzed. This included calcium, chloride, sodium, nitrate, total Kjeldahl nitrogen and sulphate.

- However, there are still a large number of chemicals that have not been reported on by DMM. These include: nitrogen (ammonia + ammonium), nitrogen (nitrite+nitrate), aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silicon, sodium, strontium, titanium, vanadium, zinc. In addition, the following new chemicals were added to the suite of chemicals in 2012 and 2013: antimony, arsenic, boron, selenium, silver, thallium and uranium.

- For the anions and cations and other parameters included in the DMM dataset, the findings have been compared to currently available aquatic protection values (APVs) used by the Ontario MOE (MOE, 2011). These values represent the highest concentration of a contaminant in surface water to which an aquatic community can be exposed indefinitely without resulting in an adverse impact.

- In cases where an MOE APV was not available, a similar format to the one used by the MOE in protecting surface water from ground water discharges associated with contaminated sites (*O. Reg. 153/04* as amended) has been followed. This involved first checking for a U.S. EPA chronic ambient water quality criterion (based on a continuous chronic criterion, (U.S. EPA, 2012; U.S. EPA, 1986));

- If neither of these sources had a value, a Canadian Water Quality Guideline (CCME, 2012), a B.C. Ambient Water Quality Criterion (B.C. 2000; B.C. 2001) or a U.S. EPA Tier-II Secondary Chronic Value (Suter II and Tsao, 1996) was used.

- In all cases, the surface water protection provided via these benchmarks is for <u>long term exposure to concentrations that are considered chronic</u>, as opposed to short-term protection against acute effects.

- Although Palmer and Somers et al. have been able to detect changes in water chemistry associated with chloride (increasing); calcium and sulphate (decreasing), none of the charts of water quality for Kahshe or Bass Lakes show these trends.

- One of the main reasons why Kahshe Lake data would not be reflective of the long terms trends that are being seen in Muskoka is because for these substances, the monitoring has not been conducted for a long enough period (back to 2004).

- Note also, that in all cases where a surface water protection value was available for the above four substances, all water quality data were well below these values and do not represent a threat to aquatic receptors.

- As noted in the 2012 report, a few potential issues were identified with the water quality data that have been generated by the DMM for aluminum, cadmium, copper and lead, each of which showed one or more exceedances of the surface water aquatic protection benchmarks.

- In the case of aluminum, the exceedances are concluded to be minor in nature, as aluminum toxicity to aquatic organisms is very complex and the benchmark that was selected from the US EPA is somewhat dated and has not been updated due to the complexity of aluminum toxicity in water and its relationship with several other substances.

- For the other three (lead, copper and cadmium), the aquatic benchmark exceedances which have been detected are most likely related to quality issues either at the collection or the analysis stage, as there have been no exceedances in sampling conducted after 2010.

C. Evaluation of the DMM Benthic Monitoring Results for Kahshe Lake

- Monitoring bottom-dwelling aquatic invertebrate communities has been carried out by the DMM since 2003. This type of monitoring provides an indirect measure of water quality and habitat disturbance, as the composition of the aquatic-invertebrate community and the relative abundances of different species can be used to evaluate the health of the ecosystem.

- Aquatic invertebrates include worms, mollusks, insects, crustaceans, and mites. These animals are sensitive indicators of the health, or condition of lakes and streams, as different species have different sensitivities to environmental changes such as pollution or habitat alteration.

- In the comparison made of all benthic sampling results on Kahshe Lake, it was apparent that in all but one case, the benthic data from both sites on Kahshe Lake were statistically similar to those of Muskoka lakes chosen by the DMM as reference values.

- The exception to these findings is for the % Chironomidae, where the average Muskoka value is higher than the corresponding value for Kahshe Lake.

- However, as shown in Table 2 above, Chironomidae are tolerant of pollution and habitat changes, so their dominance indicates water quality problems. As such, the lower value for the Kahshe Lake data is actually desirable.

- Based on these findings, the benthic monitoring results from sampling on Kahshe Lake over the period from 2004 to 2013 have not identified any problems in the growth and survival of aquatic invertebrate which can be related to contamination or habitat disturbance. For all growth and survival metrics, the Kahshe Lake invertebrate populations were similar to or better than the corresponding indices of selected reference lakes in Muskoka.

5.2 Final Conclusions

Based on the findings from up to 30 years of water quality sampling and analysis carried out every other year by The District Municipality of Muskoka (DMM) and every year for a more limited set of parameters by the Ontario Ministry of the Environment (MOE) with sampling by the Kahshe Lake Steward, the following conclusions regarding the water quality and biological health of Kahshe and Bass Lakes can been drawn:

Total Phosphorus Concentrations

- In terms of total phosphorus concentrations, Kahshe Lake is currently at a level of background + 23%, which is well below the background-based threshold of 14.2 µg/L. As such, Kahshe Lake has not been identified by DMM as an Over Threshold lake.

- Bass Lake is currently at a level of background + 3%, which also is well below the background-based threshold of 30.9 µg/L, meaning that Bass Lake also is not considered an Over Threshold lake by DMM.

- Both Kahshe and Bass Lakes also have been determined by DMM to be low in terms of responsiveness to phosphorus input, meaning they have some buffering capacity. However, because of limited soil attenuation potential, the phosphorus mobility rating is considered high. The combination of these two factors results in a Moderate Sensitivity classification for both Kahshe and Bass Lakes.

- Based on an evaluation of the variability in total phosphorus concentrations over the past 30 years, it can be concluded that total phosphorus levels in Kahshe and Bass Lakes have not increased or decreased over this time period.

- One of the most important factors which could influence the relationship between total phosphorus and algal blooms is lake temperature. While the 2012 and 2013 water temperature findings did not show the same type temperature elevation as was observed in 2011, it is still likely that the trend towards warmer lake waters which has been observed and documented in MOE studies involving a larger data set will result in warmer water in future years and if this does happen, it has the potential to accelerate algal growth which is nourished by total phosphorus.

Secchi Depth (Water Clarity)

- The clarity of water is affected by the amount of dissolved organic carbon (tea colouring) and also by algal growth which is known to be stimulated by total phosphorus and other nutrients like nitrogen.

- Both Kahshe and Bass Lakes are rated as a moderate in terms of their dissolved organic carbon concentrations; however, based on the DMM and MOE measurements over the years, the clarity level is which range from 2.5-3.5 m for Kahshe and 1.5-2.5 m for Bass Lake, are both lower than the 3-4.9 m typical depth for a Mesotrophic lake and more representative of clarity in a mildly Eutrophic lake.

- Based on these findings, it is important to remain vigilant about monitoring of water clarity and total phosphorus, especially in view of the potential influence increased lake water temperatures can have on algal growth.

Dissolved Oxygen and Water Temperature

- DMM's evaluation of these two parameters has been ongoing for several years, and is important as both can have impacts on the health of aquatic receptors and, in the case of water temperature, on the potential for algal blooms.

- Based on the findings to date, the dissolved oxygen levels in both Kahshe and Bass Lakes appear to be well within the normal and healthy range for most aquatic organisms and do not appear to have changed over the sampling period.

- Water temperature in the upper layers of both lakes in the most recent sampling did not confirm an apparent warming trend for the upper layers which was apparent based on the 2011 data.

Other Chemicals

- To evaluate the significance of the analytical results for a large suite of chemical parameters which have been analyzed for but not all reported on by DMM, the data were assessed against surface water quality benchmarks set by the MOE and other agencies to protect aquatic receptors against impacts over long-term exposure periods.

- While exceedances of the benchmarks for aluminum, cadmium, copper and lead were identified in some of the earlier sampling results for Kahshe and Bass Lakes, these exceedances appear to be related to quality control issues, as with the exception of aluminum, no exceedances have been observed in the past few years.

- In the case of aluminum, the exceedances are concluded to be minor in nature, as aluminum toxicity to aquatic organisms is very complex and the benchmark that was selected from the US EPA is somewhat dated and has not been updated due to the complexity of aluminum toxicity in water and its relationship with several other substances.

Aquatic Invertebrate (Benthic) Monitoring

- Based on the findings from the aquatic invertebrate sampling and identification program which has been operated by the DMM with assistance from the Kahshe Lake Steward and many KL volunteers over the period from 2004 to the present, the abundance and composition of benthic life on Kahshe Lake is similar to or better than the average results for reference sites from a selected database of Muskoka lakes.

In conclusion, based on the analysis of a large number of chemical and physical parameters by both the DMM and the MOE, it is apparent that water quality and benthic structure in Kahshe Lake is in good condition and compares favourably with the results for other Muskoka lakes. Although there has been no MOE monitoring of Bass Lake and no benthic sampling either, the DMM results for water quality indicate that Bass Lake is in good condition, even though water clarity is lower than expected for a lake with naturally elevated DOC levels.

However, given the potential for increasing water temperatures which have been documented in Muskoka lakes, we need to remain vigilant in our sampling efforts and overall lake stewardship, as warmer waters are more prone to algal growth and may negate potential improvements in nutrient enrichment and other chemical indicators of lake health. As such, each of us needs to do our part to maintain the quality of the water by:

- managing our septic systems properly and having tanks pumped out regularly,
- avoiding the use of products containing phosphorus (detergents and cleaners),
- disposing of toxic wastes (batteries, paint, oil, old gas, construction waste) at approved land fill sites
- minimizing near-shore removal or management of vegetation and soil and ensuring that any shoreline disturbance is conducted in compliance with permitted uses,
- avoiding the use of any chemical fertilizers and pesticides in areas close to the shore, and,
- taking precautions to minimize the potential for introducing invasive species into the lake.

Finally, based on the above findings, both the DMM and MOE will be contacted to request that an additional monitoring site be located in the more shallow western part of Kahshe Lake, as this area has not been historically monitored and is at higher risk for algal growth due to the shallow water condition and the warmer water temperatures that will result.

6.0 References Cited

B.C. 2000. Ambient Water Quality Guidelines for Sulphate. Ministry of Environment, Lands and Parks, Province of British Columbia. Technical Appendix, November 2000.

B.C. 2001. Ambient Water Quality Guidelines for Manganese – Overview Report. Ministry of Environment, Lands and Parks, Province of British Columbia. ISBN 0-7726-4444-6. January 2001

CCME, 2012. *Canadian water quality guidelines for the protection of aquatic life: Nitrate Ion*. Canadian Council of Ministers of Environment. Winnipeg, Manitoba.

CCME. 2012. *Draft Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life : Cadmium*. October 2012.

Gartner Lee Limited. 2005. *Recreational Water Quality Management in Muskoka*. Prepared for the District Municipality of Muskoka. June 2005.

Gartner Lee Limited. 2008. *Review of Long Term Water Quality Data for the Lake System Health Program*. Prepared for the District Municipality of Muskoka.

MOE. 2011. *Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario*. April 15, 2011, Standards Development Branch, Ontario Ministry of the Environment. PIBS 7386e01

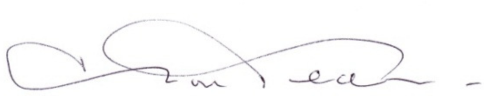
Palmer, M. Ontario Ministry of the Environment. *Our Lakes: How Have they Changed Over the Last 25 Years?* Environmental Lecture Series, Muskoka Watershed Council. July 26, 2012. Port Carling, Ontario.

Somers, K., Willison, R. Brouse, J. and Yan, N. 2009. *Muskoka's Water Quality: An Analysis of the Data from Your Lake.* Environmental Lecture Series. November 2009.

Suter II, G.W. and Tsao, C. L. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision*. U.S. Risk Assessment Program, Oak Ridge, Tennessee. ES/ER/TM-96/R2.

U.S. EPA. 1986. *Quality Criteria for Water 1986*. United States Environmental Protection Agency. Office of Water, Regulations and Standards, Washington, DC. EPA 440/5-86-001

U.S. EPA. 2012. National Recommended Water Quality Criteria. http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable



Ron Pearson

Kahshe Lake Steward

Attachment

Muskoka Watershed Report Card for the Kahshe Lake Sub-Watershed.

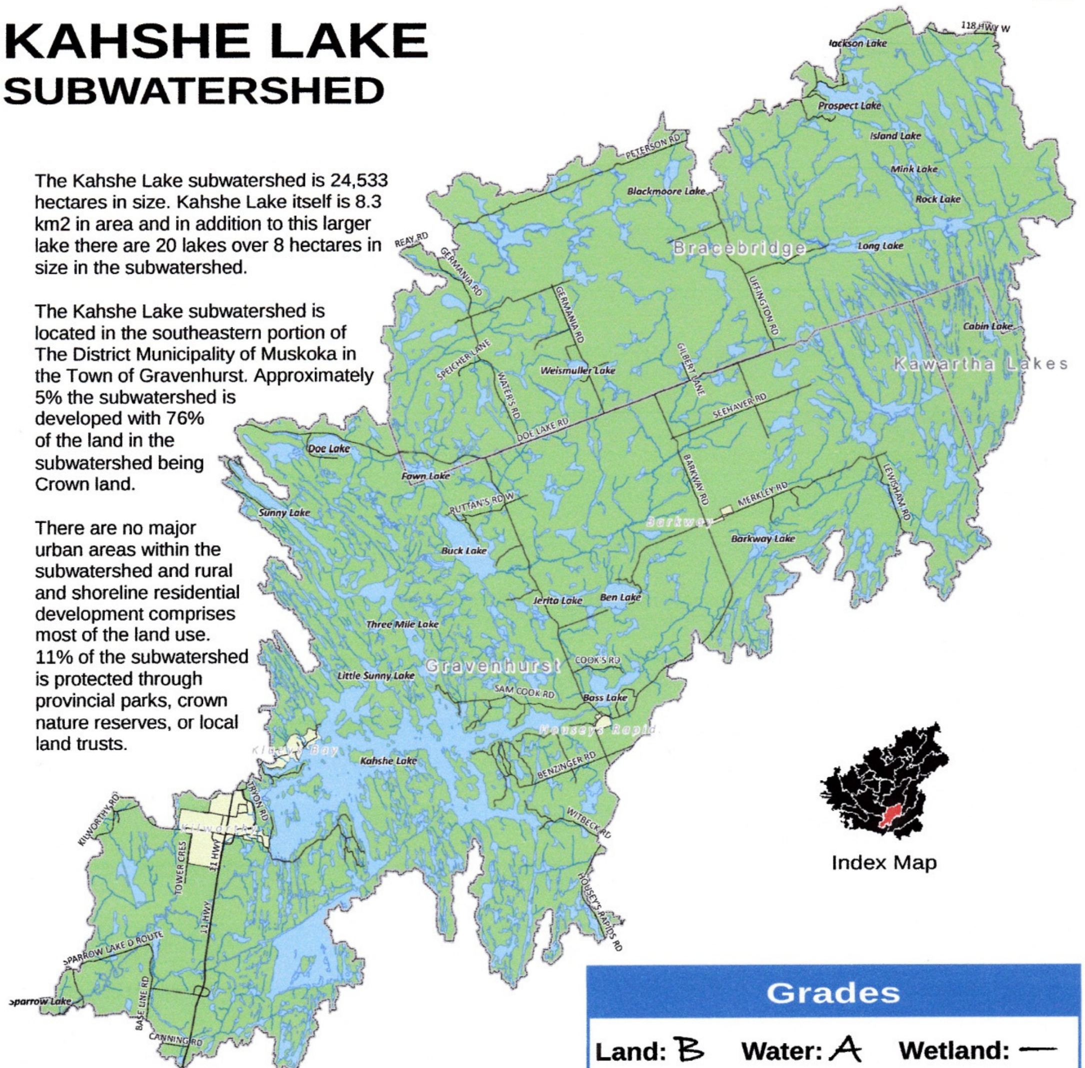
The Muskoka Watershed **REPORT CARD** 2010

KAHSHE LAKE SUBWATERSHED

The Kahshe Lake subwatershed is 24,533 hectares in size. Kahshe Lake itself is 8.3 km2 in area and in addition to this larger lake there are 20 lakes over 8 hectares in size in the subwatershed.

The Kahshe Lake subwatershed is located in the southeastern portion of The District Municipality of Muskoka in the Town of Gravenhurst. Approximately 5% the subwatershed is developed with 76% of the land in the subwatershed being Crown land.

There are no major urban areas within the subwatershed and rural and shoreline residential development comprises most of the land use. 11% of the subwatershed is protected through provincial parks, crown nature reserves, or local land trusts.



Index Map

Grades

Land: B **Water:** A **Wetland:** —

This report card describes the health of the land, water and wetlands of the Kahshe Lake subwatershed and is part of the larger report ***The 2010 Muskoka Watershed Report Card*** *that is posted on the MWC website www.muskokaheritage.org/watershed.*

Partnering with Nature — Muskoka WATERSHED COUNCIL

In Muskoka there are no notable point sources of industrial contamination in lakes and rivers. Most industrial contamination is generally a result of air pollutants traveling long distances and being deposited in local lakes. In inland lakes on the Canadian Shield, mercury in fish is the most significant contaminant.

Mercury levels in lakes does not pose a significant human health threat, however, wildlife like loons are more sensitive. Loons eat fish that are 4 to 10 centimeters in size. If fish in a particular lake do not reach the 0.033 ppm standard until the fish is over 10 centimeters, then loons will not be impacted. Otherwise, there could be a possible neurological impact. All four indicator fish species meet the mercury standard in the Kahshe Lake subwatershed.

Grade A

Water

The Kahshe Lake subwatershed is located in the south portion of Muskoka. Access to the area was available earlier than other areas of the District and many of the lakes have been developed since the late 1800's and early 1900's.

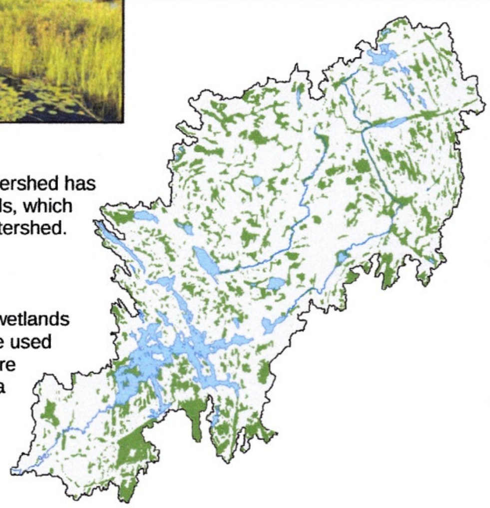
Total phosphorus is an indication of the nutrient level of waterbody. A background or undeveloped level of total phosphorus has been determined for each lake. Scientists indicate that a lake may become unhealthy with an increase in phosphorus greater than 50% from that background level. This is considered the threshold for that lake. There are no lakes that are Over Threshold in the Kahshe Lake subwatershed for a total of 0% of the total water surface area in the subwatershed.

Shoreline vegetation protects waterbodies from nutrients and toxic chemicals that can contribute to water quality issues. It also protects the lake edge from erosion caused by waves and ice. The shoreline zone provides critical habitat for fish and other animals, helping to maintain a natural balance in sensitive aquatic ecosystems. 10% of the shoreline of lakes in the Kahshe Lake subwatershed have been altered.

Indicator	Kahshe Lake		Muskoka Watershed		Indicator Description
	%	Grade	%	Grade	
% Surface Area Over Threshold	0	**A**	4.9	**B**	This is a measure of recreational water quality as phosphorus is generally the limiting nutrient in algae production.
% Natural Shoreline	90	**B**	91	**B**	This is a measure of fish habitat. Many fish species require overhanging vegetation, rock shoals, and aquatic vegetation found in undisturbed sites.
Mercury Levels in Fish Less Than 10 cm in Size	N/A	**A**	N/A	**B**	Mercury levels in lakes do not pose a significant human health threat, however, wildlife like loons are less tolerant to mercury and may be impacted in some cases.

No Grade

Wetlands



The Kahshe Lake subwatershed has 4,650 hectares of wetlands, which covers 19% of the subwatershed.

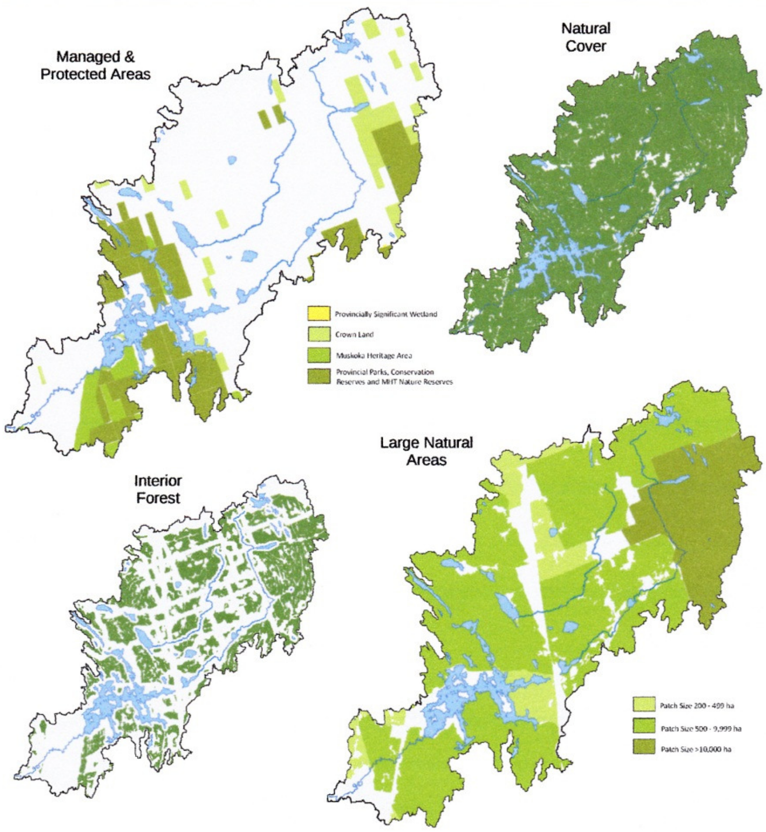
A value of no net loss of wetlands from the 2010 level will be used as the benchmark. In future report cards, wetland area will be measured as a deviation from current

Wetland Values

- Control and storage of surface water and recharge groundwater;
- Maintain and improve water quality, aid in flood control, and protect shorelines from erosion;
- Trap sediments which would otherwise fill watercourses;
- Support and initiate complex food chains;
- Provide important habitat
- Support species at risk;
- Provides fish populations;
- Provide active and passive recreational opportunities, including canoeing, bird watching, hunting and fishing.

Land

Grade B



The Kahshe Lake subwatershed is moderately sized and Kahshe Lake is the largest lake in the catchment. Mixed forest dominates the subwatershed with development focused along shorelines, the highway 11 corridor and in the rural area along roads. The development pattern has resulted in a fragmented landscape with reduced interior forest habitat which is an important landscape feature that supports local biodiversity. Natural areas are also important to help support local biodiversity, purify the air, maintain good water quality and provide a carbon sink.

78% of the subwatershed is privately owned and it is important to encourage a strong private land stewardship program to ensure that the long-term health of the subwatershed is maintained as development occurs. Private land stewardship activities such as participation in MFTIP, CLTIP, and donations to land trusts are encouraged to maintain the values enjoyed in this subwatershed.

Both healthy riparian areas and interior forests are important to support local wildlife and maintain good water quality.

Indicator	Kahshe Lake		Muskoka Watershed		Indicator Description
	%	Grade	%	Grade	
Natural Cover	95	A	94	A	Natural cover is defined as lakes, wetlands, forests, rock barrens and other natural systems.
Large Natural Areas	83	A	79	B	Areas of natural cover that are 200 ha or greater.
200 - 499 ha	8		7		
500 - 9,999 ha	60		52		
>10,000 ha	15		20		
Interior Forest	54	B	58	C	Interior forest is defined as a forested area with a 100-metre forested buffer surrounding it.
Managed & Protected Areas	28	D	48	A	Protected areas are defined as lands within national or provincial parks, Crown conservation reserves, Crown land, and land held by land trusts. Managed areas are defined as lands under the Managed Forest Tax Incentive Program or Conservation Land Tax Incentive Program, or have a conservation easement held by a reputable conservation organization.
Parks & Protected Areas	16		17		
Crown Land	6		26		
Private Stewardship	6		5		
Riparian Area	No Data	—	68	B	Riparian area is defined as the shoreline of a lake or river plus an area 20 metres inland from the shore.