## Executive Summary

Muskoka Watershed Council established the Algae Sub-committee in April 2017 to investigate the development of a citizen science algae monitoring program in order to build an understanding of algae and algal blooms in Muskoka. Recent confirmation of blue-green algal blooms in area lakes, and a growing impression among the public that algae are more abundant than they used to be, have contributed to a growing concern about the future impacts of algal blooms in Muskoka.

Algae are an essential component of lake ecosystems and should always be present, but without information on the occurrence of algae in our lakes, or on how abundances vary through the seasons, among years, or across lakes, mechanisms or management procedures to control lake algae cannot be devised. This project is a first step in building that needed information.

Modelled closely on the Cyanobacteria Monitoring Collaborative's (CMC) algae monitoring program, the Algae Sub-committee devised a pilot project to be undertaken on a limited number of lakes in Muskoka to:

- Plan and pilot methods for fluorometric analysis of phytoplankton for future use by lake associations interested in adding this to current water quality monitoring;
- Undertake explicit evaluations to ground-truth methods used;
- Develop information materials and a presentation on algae for delivery to lake associations and others; and
- Communicate these efforts to other lake associations across Muskoka during the year.

A protocol was developed using two different methods to collect water samples. Method 1, using an Integrated Tube Sampler (IT), is the method used by CMC in their program. Method 2, using a Composite Sampler (2xSecchi), more closely aligns with how other agencies collect algae samples in Muskoka. An analysis of the data obtained using these two methods shows that they are comparable, therefore it is recommended that the 2xSecchi method be used going forward.

While some slight modifications needed to be made to the sampling protocol, equipment, and analysis protocol over the course of the sampling season, program participants were able to obtain fluorescence data that made sense relative to what is expected of phytoplankton populations in area lakes, and a confirmed blue-green algal bloom that occurred on Three Mile Lake in August showed up as a prominent spike in the phycocyanin record in that lake over two subsequent sampling sessions. This indicates that a fluorescence monitoring program is feasible and produces relevant data.

Equally as important, feedback from lake association volunteers indicated that the sample collection protocol is easily carried out by trained volunteers, does not require large amounts of time or resources, and can be integrated with existing water quality monitoring programs.

It is recommended that the pilot project be carried out for a second year (2021) on the same four lakes so that collection methods and sample analysis can continue to be refined and finalized. Resources will be developed to educate the public on the importance of algae and what conditions contribute to algae blooms.

Funding will be sought over the next year to finalize the MWC Algae Monitoring Program based on the results of the 2-year pilot project, and implement it on a broad scale across Muskoka in 2022 and beyond.

## Contents

## Introduction

Phytoplankton, a type of algae, are a diverse group of mid-water, microscopic, single-celled or colonial, photosynthesizing organisms that are found at the base of every lake food web. Through photosynthesis, they use solar energy, carbon dioxide and water to build organic molecules that allow for their own growth and provide food to zooplankton, and ultimately to fish and other animals. In the process of photosynthesis, they generate significant amounts of oxygen that is released to the atmosphere. Every second breath you take provides you with oxygen originally placed into the atmosphere by phytoplankton in lakes and oceans.

Unfortunately, on occasion, conditions can be particularly favorable for algal growth and reproduction. At these times, algal populations can become quite large, resulting in a visible scum on the lake surface. These algal blooms can develop over just a few days and can disappear just as fast as algal cells die and decompose. Severe blooms can deplete a lake of oxygen when decomposing, leading to fish kills and other serious disruptions to the lake ecosystem. They can also prove noxious, in appearance as well as odor, degrading our enjoyment of our lakes. In rare instances, the bloom-causing species produce toxins that can cause serious health risks to people and animals drinking or bathing in the water.

The identification of phytoplankton is a demanding, specialized task, as is the task of determining phytoplankton abundance by counting cells in water samples. Fortunately, photosynthesis requires specific pigments that also happen to be fluorescent molecules. By measuring absorbance due to fluorescence at a given wavelength, it is possible to quantify the amount of a specific pigment in a water sample. This value is a reliable index of the abundance in the sample of the phytoplankton containing that pigment.

The pigment, chlorophyll *a*, is present in the cells of all algae that occur in Muskoka area lakes; the pigment, phycocyanin, is present in all cells of cyanobacteria (also known as blue-green algae). By quantifying fluorescence of chlorophyll *a* in a water sample, it should be possible to provide an index of the amount of all phytoplankton species combined (including blue-green algae). Similarly, by quantifying fluorescence of phycocyanin it should be possible to provide an index for the amount of blue-green algal species present in that water sample. This is the approach being used in this project.

## Objectives

Muskoka Watershed Council initiated this program in order to gain a greater understanding of algae by harnessing the efforts of volunteers to collect data on the distribution, abundance and seasonal cycles of phytoplankton across Muskoka area lakes so that, over time, it may be possible to identify conditions favoring algae blooms, detect trends in phytoplankton abundance, and provide management advice. Monitoring at species level, tracking the abundance of individual species of algae, while ideal, is well beyond the capacity of a routine, citizen-led monitoring program. During the open water season, the overall abundance of phytoplankton will sometimes be made up predominantly of certain algal species while at other times the abundance will be predominantly of different algal species. Tracking abundance of individual species would require microscopic counting and identification of algal cells in water samples. This program aims to monitor all algae combined, and all blue-green algae combined, using fluorometric techniques.

The 2019 pilot project was undertaken in collaboration with the following four lake associations:

- Leonard Lake Stakeholders Association | Leonard Lake
- Muskoka Lakes Association | Clark Falls (Lake Rosseau near Windermere)
- Peninsula Lake Association | Peninsula Lake
- Three Mile Lake Association | Three Mile Lake

The purpose of the pilot project was to:

- Plan and pilot methods for fluorometric analysis of phytoplankton for future use by lake associations interested in adding this to current water quality monitoring;
- Undertake explicit evaluations to ground-truth methods used;
- Develop information materials and a presentation on algae for delivery to lake associations and others; and
- Communicate these efforts to other lake associations across Muskoka during the year.

If the pilot project is successful, it is anticipated that the objectives of an ongoing Algae Monitoring Program would be to:

- Roll out phytoplankton monitoring to interested lake associations across Muskoka, as an addition to their existing water quality efforts;
- Deliver an 'information about algae' presentation/demonstration to interested lake associations across Muskoka;
- Continue collaboration with selected lake associations on additional algal sampling to address specific issues of prevalence and/or causation of algal nuisance blooms;
- Evaluate the program in 2025 and decide whether to continue beyond that date;
- Undertake explicit evaluations to ground-truth methods used;
- Develop information materials and presentations on algae for delivery to lake associations and others; and
- Communicate these efforts to other lake associations across Muskoka during the year.

## Background

The initial year of this pilot project was undertaken in recognition of the growing concern across Muskoka regarding potentially toxic algal blooms on our lakes. While blooms remain rare in Muskoka, and toxic blooms even rarer, this concern is understandable given the potential for serious health risks, and more generally the aesthetic and environmental consequences of algal blooms. As well, climate change seems likely to exacerbate problem algal blooms across Muskoka. At present, there is only limited information on algae in our lakes, yet it seems possible that the army of dedicated citizen scientists who currently monitor water quality across Muskoka could make a significant contribution towards building a richer database concerning local algal populations.

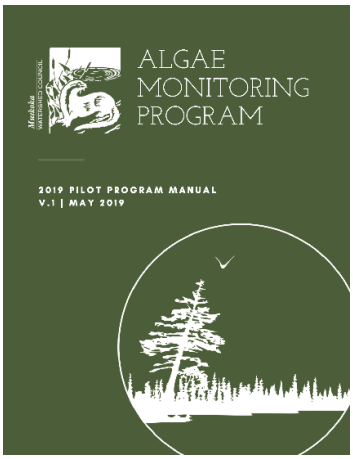
In designing the sampling program for the pilot project, we relied extensively on the experience of a group operating across the New England states to track the incidence of blue-green algal blooms. With leadership provided by the University of New Hampshire and the U.S. Environmental Protection Agency, and drawing upon a 30+ year history leading citizen science monitoring of lake water quality, the 'Cyanobacteria Monitoring Collaborative' (CMC) provides a web-based program to aid citizen groups exploring blue-green algae.

While the CMC protocol formed the basis of MWC's procedures for collecting algae samples, on the advice of the scientists on MWC's Algae Sub-committee, some modifications were made to take into account the different environmental conditions present in Muskoka.

The CMC protocol uses an *Integrated Tube* (IT) sampler to collect a sample of the water column from the surface to three metres in depth. As algae in Muskoka's generally clear waters are likely present to a deeper depth, it has been the conventional practice by scientists working here to collect samples to a depth of two times the Secchi depth (2x*Secchi*). A Secchi disk is a tool to measure the clarity of the water and provides an indication of how deep in the water light can penetrate. This approach was to be compared with the IT method during this pilot program. To collect the 2xSecchi samples, a composite sampler was designed and built by staff for testing during the pilot program. In order to see if there was any difference between samples collected using the IT method and the 2xSecchi method, both methods were used to collect samples for the entire pilot season.

The MWC Algae Monitoring Program Monitoring Protocol Manual (v1) (https://www.dropbox.com/s/tx74olttba5re3m/AlgaeMonitoringProgram-Manual_v1-May2019.pdf?dl=0) contains detailed instructions on the collection of algae samples using the IT method and 2xSecchi method for both offshore and nearshore samples.

As noted in the Protocol Manual, in addition to the regular sampling efforts, two "special collection" protocols were undertaken.




1) Triplicate samples were collected from all sites at least once during the field collection season in order to assess the patchiness in distribution of algae in the water column of the lake.

2) On one occasion during the field collection season an additional set of samples was collected for spectrophotometric analysis of chemically extracted samples to provide a direct measure of algal abundance as micrograms per litre (µg/L) of the specific pigment (chlorophyll *a* or phycocyanin). Fluorometers routinely report their measurements as µg/L, however these numbers must be considered relative estimates or proxies for algal abundance, rather than actual measurements except when analysing chemically extracted samples.

## Equipment and Protocol Adjustments

As the pilot progressed there were a few minor adjustments made to the composite sampler and the protocol itself. These changes are noted here and will be incorporated into the next version of the Protocol Manual.

### Composite sampler

- When testing the final prototype for the composite sampler, it was noted that the sampler would fill the first time it was submerged. However, when lowered for a second time, it would not fill as water would form a reverse meniscus over the hole which prevented secondary filling of the sampler. To circumvent this issue, two additional holes were drilled into the lid to allow air to escape while water flowed freely through the lid. The drawings and specifications for the composite sampler were amended to include this change.

## Analysis procedure

- When analyzing the first set of samples with the fluorometer, a high variability was seen between sub-samples. This was identified by measuring three sub-samples from each sample.
- In order to reduce the variability between sub-samples the protocol was modified to require agitating the sample for a minimum of 10 seconds prior to pouring out each sub-sample for analysis. This modification resulted in more consistent results among sub-samples.
- In order for the samples to thaw in a timelier manner, an aquarium heater was added to the water bath in which the sample bottles thawed.
- The fluorometer will be calibrated prior to the beginning of the sampling season using a primary standard. Following this calibration, several concentration readings will be taken using a secondary standard and the average will be calculated and recorded, along with the ambient temperature. Throughout the sampling season, prior to measuring a batch of samples, a reading of the secondary sample will be taken and compared to the previous record to ensure that the value hasn't changed more than 10%.

## Results

The data collected during the 2019 sampling season are available in Table 1, Figures 1-4, and the four tables in Appendix 1. The fluorometer (FluoroQuik™ Phycocyanin & Chlorophyll-a Dual-Channel Fluorometer (FQD-PC-CHL/IV-RATIO-C)) outputs data as phycocyanin (PC), chlorophyll *a* (CHL), and the ratio PC:CHL. These results should be considered as indices of abundance rather than actual abundance of the algae. The fluorometric readings obtained seemed consistent across the two water sampling methods, and appropriate for what would be expected for changes in algal abundance through the sampling season in the sampled lakes. Chlorophyll *a* (CHL) values were consistently quite low and showed little seasonal fluctuation in all four lakes, while phycocyanin (PC) values were larger and tended to trend upwards through the season. Phycocyanin values were substantially larger at both Three Mile Lake sites following a confirmed blue-green algal bloom on the south arm of that lake in August.

All analyses of the fluorescence data have used the means of three sub-samples taken from each of the thawed water samples, as the best estimate of fluorescence of that water sample. These means are the values reported in Appendix 1.

## Equivalence of the two water sampling methods

A comparison of the results obtained from water samples collected using the IT method and 2xSecchi method was done using data from all four lakes collected over the five sampling periods between 11 July and 12 September. This comparison, using a paired-samples t-test, confirmed that there is no significant difference in PC fluorescence, and only a trivial difference in CHL fluorescence in samples of water collected using the two methods. Table 1 lists the fluorescence data used in this analysis. Over these five sampling periods, there are 10 pairs of samples tested for fluorescence by phycocyanin and by chlorophyll *a* per lake. Using paired-samples t-tests, the 40 pairs of fluorescence values for each pigment were compared.

Altogether, there were 40 pairs of samples taken at specific dates, sites and lakes. Paired-sample t-tests searched for any significant differences between pair members in the phycocyanin and the chlorophyll *a* data. For phycocyanin, readings from 2xSecchi samples averaged 8.20 ± 1.90 (mean ± standard error) while readings from IT samples averaged 7.94 ± 1.89. The resulting t value (0.92) was well below the value indicating 5% significance (meaning the differences between the pairs of

samples do not indicate a significant tendency for fluorescence to be greater in samples collected using one method or the other). For chlorophyll *a*, readings from 2xSecchi samples averaged 0.68 ± 0.04, and readings from IT samples averaged 0.76 ± 0.05. The t value (-2.23) yielded is significant at P<0.03, meaning that the IT samples yielded water that showed very slightly more CHL fluorescence than the 2xSecchi samples did, likely caused by the distribution of algae in the water column.

**Table 1.** Fluorescence data used in comparison of water sampling methods. The table shows the mean fluorescence values for phycocyanin and for chlorophyll *a* for samples taken by the 2xSecchi method and the IT method at offshore and nearshore sites in each lake.

| | PHYCOCYANIN | | | | CHLOROPHYLL *a* | | | |
|---|---|---|---|---|---|---|---|---|
| **ROSSEAU** | offshore | | nearshore | | offshore | | nearshore | |
| | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT |
| 14-Jul-19 | 4.00 | 3.82 | 2.98 | 7.18 | 0.84 | 0.82 | 0.44 | 1.69 |
| 26-Jul-19 | 5.20 | 4.12 | 5.86 | 6.82 | 0.55 | 0.56 | 0.94 | 1.09 |
| 11-Aug-19 | 2.38 | 2.92 | 8.74 | 8.68 | 0.48 | 0.56 | 1.16 | 0.87 |
| 24-Aug-19 | 5.50 | 6.22 | 2.98 | 3.70 | 0.42 | 0.55 | 0.70 | 0.97 |
| 7-Sep-19 | 6.22 | 6.10 | 5.56 | 5.80 | 0.49 | 0.61 | 0.86 | 0.92 |
| **LEONARD** | offshore | | nearshore | | offshore | | nearshore | |
| | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT |
| 10-Jul-19 | 2.80 | 2.44 | 3.34 | 1.60 | 0.48 | 0.65 | 0.54 | 0.60 |
| 25-Jul-19 | 4.96 | 2.26 | 7.24 | 2.50 | 0.55 | 0.55 | 0.60 | 0.59 |
| 9-Aug-19 | 3.88 | 1.60 | 4.78 | 3.68 | 0.51 | 0.42 | 0.61 | 0.55 |
| 23-Aug-19 | 4.96 | 4.96 | 4.24 | 4.42 | 0.46 | 0.49 | 0.54 | 0.47 |
| 5-Sep-19 | 6.10 | 3.85 | 5.72 | 4.72 | 0.50 | 0.53 | 0.48 | 0.49 |
| **PENINSULA** | offshore | | nearshore | | offshore | | nearshore | |
| | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT |
| 12-Jul-19 | 5.26 | 6.46 | 4.24 | 6.28 | 0.43 | 0.71 | 0.43 | 0.61 |
| 25-Jul-19 | 4.72 | 3.52 | 4.18 | 4.00 | 0.44 | 0.49 | 0.44 | 0.50 |
| 9-Aug-19 | 4.24 | 4.96 | 3.52 | 3.34 | 0.41 | 0.46 | 0.49 | 0.43 |
| 30-Aug-19 | 3.88 | 3.88 | 2.98 | 2.62 | 0.56 | 0.39 | 0.35 | 0.43 |
| 12-Sep-19 | 4.72 | 3.82 | 3.70 | 4.00 | 0.44 | 0.46 | 0.39 | 0.44 |
| **THREE MILE** | offshore | | nearshore | | offshore | | nearshore | |
| | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT | 2xSecchi | IT |
| 11-Jul-19 | 6.28 | 6.58 | 4.72 | 5.98 | 1.11 | 1.12 | 1.00 | 1.26 |
| 26-Jul-19 | 4.66 | 4.60 | 4.48 | 4.66 | 0.97 | 1.05 | 0.93 | 1.48 |
| 9-Aug-19 | 65.05 | 68.10 | 49.58 | 42.62 | 1.27 | 1.33 | 1.43 | 1.27 |
| 22-Aug-19 | 19.89 | 19.53 | 17.69 | 18.06 | 1.03 | 1.00 | 1.03 | 1.20 |
| 5-Sep-19 | 8.80 | 9.10 | 8.26 | 8.08 | 0.92 | 0.92 | 0.86 | 0.85 |

Despite the significant result for chlorophyll *a*, fluorescence values obtained from water collected by the two methods remain highly positively correlated (r = 0.72). This strong positive correlation in chlorophyll *a* fluorescence, the lack of significant differences in fluorescence of phycocyanin, and the greater ease of use in the field of the 2xSecchi method all lead to recommending that in future years sampling will be done using the 2xSecchi method only.

## Trends in algal abundances through the season.

The results shown in Figures 1-4 display data that were obtained using the FluoroQuik™ Fluorometer. Readings are correlated to algal abundance but not quantitatively equivalent. Numbers shown are the means of readings from three sub-samples of the water sample collected at the given time and site. In addition to values for fluorescence, the tables include the ratio of PC:CHL fluorescence values. This approach has been found useful by lake biologists because it emphasizes changes in the relative proportions of blue-green to other algae and can indicate when algae with phycocyanin are dominating the community.

For convenience, the three sets of data are plotted on the same y-axis in each figure as trend lines through the season. These trends can be compared with each other or between lakes, so long as the relative heights of the trend lines are not interpreted to mean anything about actual abundance of blue-green or other algae. (To clarify, in Leonard Lake (Figure 1) for example, the trend line for phycocyanin is consistently well above that for chlorophyll *a* (and the ratio trend is higher still), but that does not mean that blue-green algae were more abundant than algae of other types.)

The data show the relative fluorescence of each pigment and provide an indication of how the blue-green and the total algal communities varied throughout the sampling season.

Looking at overall trends in fluorescence for all four lakes, chlorophyll *a* (CHL) levels were consistent throughout the sampling season (May-September/October), typically staying below 1. Beyond a large spike in phycocyanin (PC) in Three Mile Lake in August (Figure 4), PC levels in all four lakes generally stayed below 10, but were clearly more variable than were CHL values. There may be a slight tendency for higher PC values to be more frequent later in the sampling season. Plotting the PC:CHL ratio can provide insight as to when cyanobacteria are increasing in presence, as indicated by spikes in the ratio.

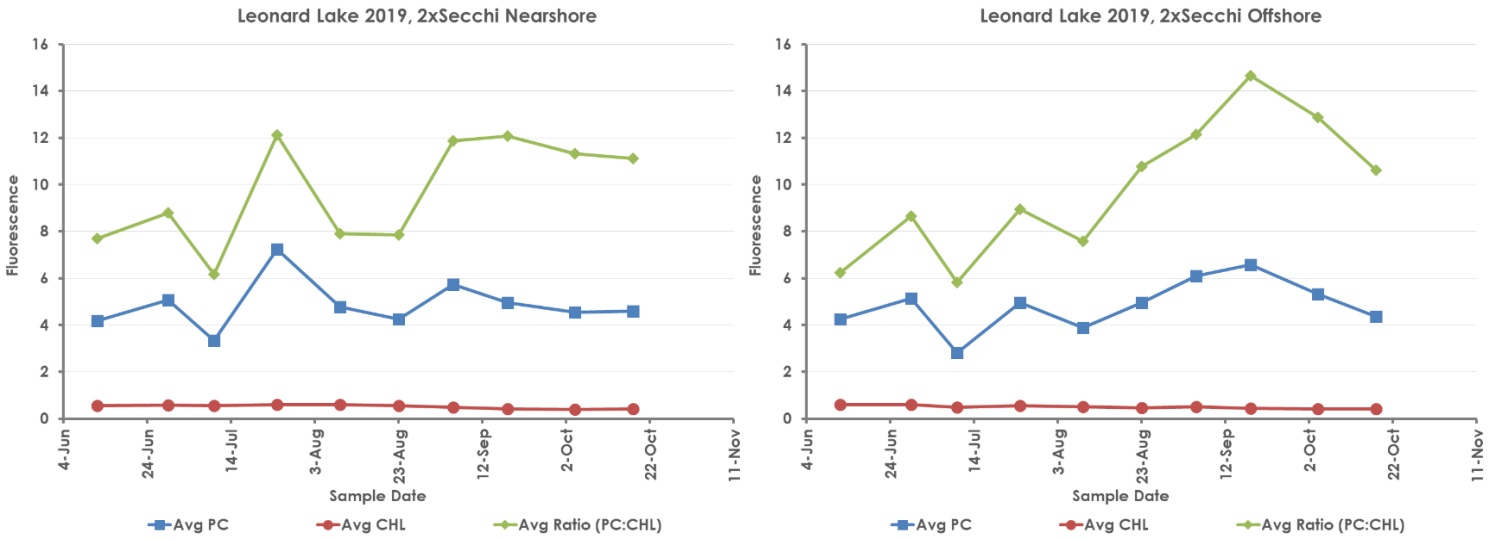



**Figure 1.** Chart with chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi method on Leonard Lake in 2019 for the nearshore (left) and offshore (right) sites. The green line with diamonds shows the ratio of phycocyanin to chlorophyll *a* (PC:CHL).

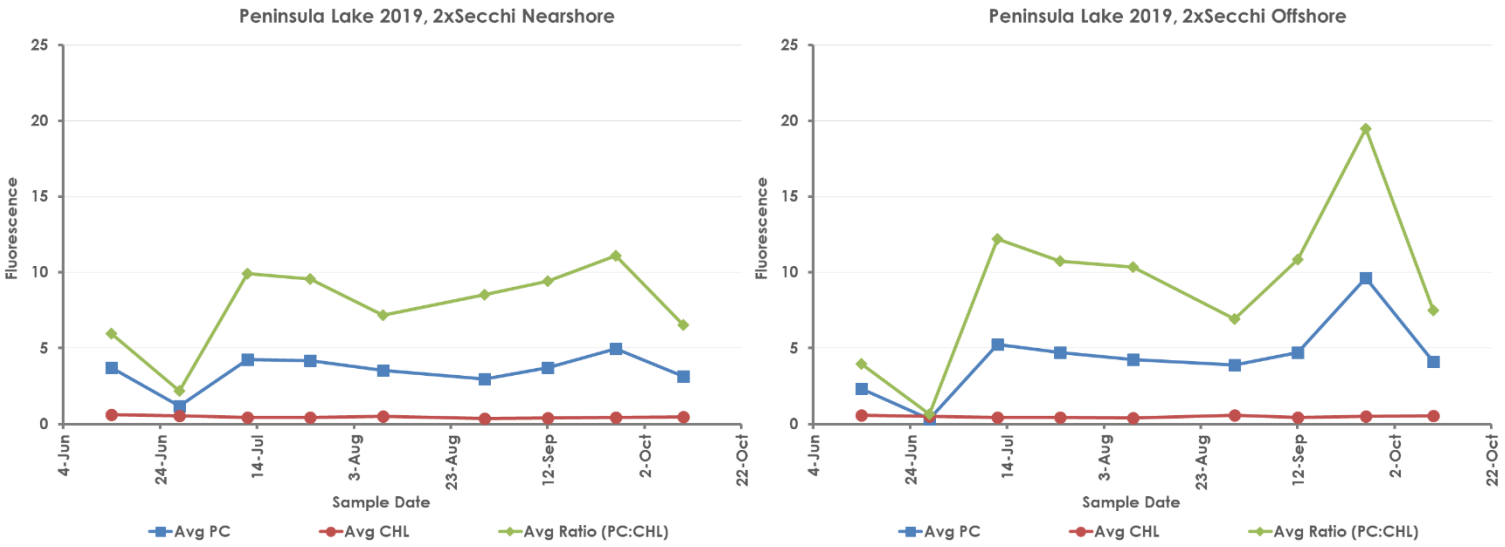



**Figure 2.** Chart with chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi method on Peninsula Lake in 2019 for the nearshore (left) and offshore (right) sites. The green line with diamonds shows the ratio of phycocyanin to chlorophyll *a* (PC:CHL).

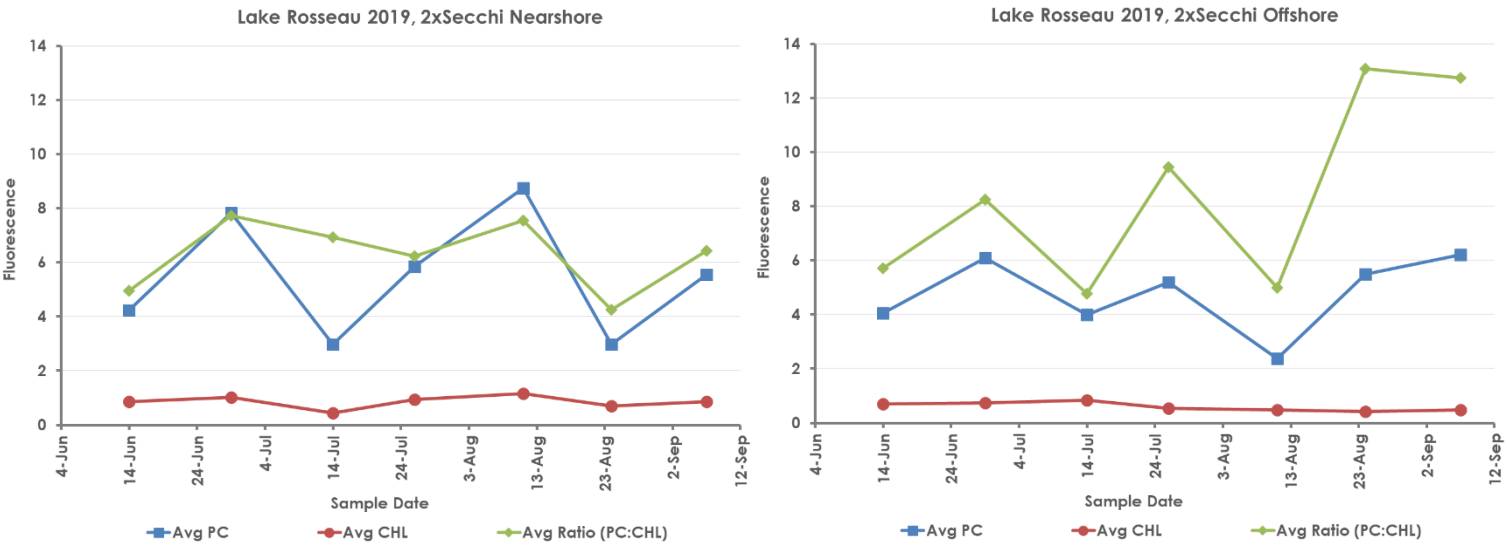



**Figure 3.** Chart with chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi method on Lake Rosseau in 2019 for the nearshore (left) and offshore (right) sites. The green line with diamonds shows the ratio of phycocyanin to chlorophyll *a* (PC:CHL).

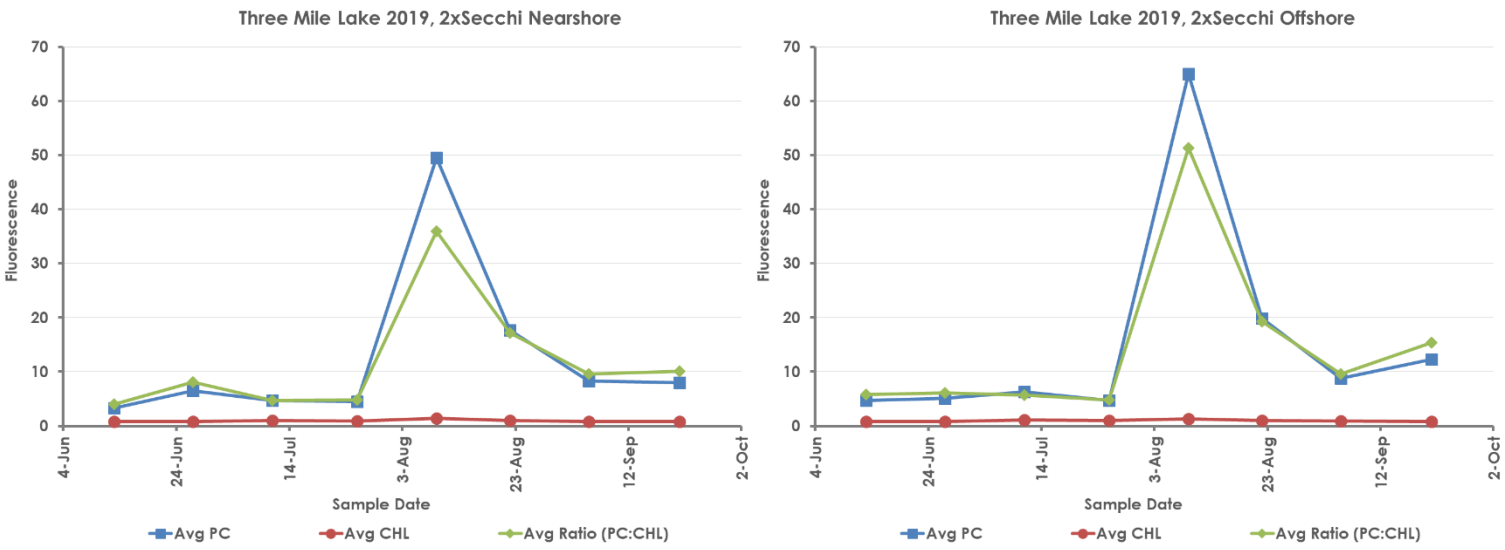



**Figure 4.** Chart with chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi method on Three Mile Lake in 2019 for the nearshore (left) and offshore (right) sites. The green line with diamonds shows the ratio of phycocyanin to chlorophyll *a* (PC:CHL).

Only one participating lake, Three Mile Lake, experienced a confirmed blue-green algae bloom in 2019. Figure 4 shows a spike in PC from the samples taken on August 9, 2019 for both the nearshore and offshore sites. The Simcoe Muskoka District Health Unit (SMDHU) issued an advisory for a bloom in the west end of Three Mile Lake based on lab results from the Ministry of Environment, Conservation and Parks (MECP) on samples collected on August 3rd. There is no evidence of an impending bloom in samples taken for this project on July 26th, but it would have been interesting to see if samples taken closer to the end of July would have detected the inception of bloom conditions.

The sharp increase in the PC:CHL ratio in mid-August through September at all lakes, especially at offshore sites, indicates an increase in the proportion of the algal community composed of cyanobacteria at this time of year. Three Mile Lake, despite its enormous spike in that ratio in early August, still shows this trend to higher values in September than in June (September values are 9 to 15 while June and July values are 4 to 8). Other lake characteristics and environmental factors such as turbidity, water temperature, and nutrient loading likely influence PC and CHL concentrations and help account for the differences in trends among lakes.

## Remaining analyses

Triplicate samples were collected 22-30 August and the data are included in the tables in Appendix 1. The triplicate samples can provide a measure of the small-scale spatial variability of phytoplankton, and hence the reliability of a single sample as a characterization of algal abundance at that lake location. Statistical analyses to compare the triplicates have not yet been completed.

Non-frozen and frozen samples were collected 8-11 August and were provided to the MECP for further analysis.

## Recommendations

### Year 2 (2021) Pilot Project

Overall, the 2019 Pilot Project was a success. Only minor issues were found with the equipment and the procedure for analyzing the samples and these were quickly addressed. It is recommended that the pilot project proceed for a second year (2021) on the same set of lakes and with the same volunteers, with the following changes:

- Volunteers drop their samples off at one location instead of staff driving to each lake and collecting them. To implement this, a central location with a freezer needs to be found.
- Eliminate sample collection using the Integrated Tube sampler. Analysis of the data collected in 2019 indicates that the 2xSecchi and IT methods provide equivalent water samples for analysis, and the 2xSecchi method is easier to use in most situations. An alternate protocol for sampling shallow water sites will need to be developed and included in the Protocol Manual.
- All samples collected, including the triplicate samples, will have three sub-samples analyzed using fluorometry and the results for each sample will be reported as the mean of the three sub-samples.
- The Algae Sub-committee should investigate the possibility of including more opportunistic sampling during times when blooms seem most likely to occur for implementation during the 2021 pilot project. The data obtained from Three Mile Lake showed that a blue-green bloom would show up conspicuously in PC fluorometry results. More interesting will be to see if fluorometric data can anticipate a bloom by several days, but more frequent sampling seems infeasible as a routine procedure.

### Beyond 2021

The Algae Sub-committee will continue to seek funding to implement the Algae Monitoring Program broadly across Muskoka based on the results of the 2-year pilot project. As part of the plan for broader implementation, MWC will investigate the potential for each lake association or group of associations to have their own fluorometer to conduct their own analyses. The data would then be submitted to MWC for inclusion in the database. Ideally, lake associations that would like to participate in the program will purchase a kit that includes a fluorometer, composite sampler, 500 ml bottles, 125 ml bottles, etc. (components listed in the Protocol Manual). As the cost of such a kit is likely to be in the $4,000 dollar range, it may be too costly for the average lake association to purchase without access to subsidies.


## Acknowledgements

MWC would like to thank all who participated on the Algae Sub-committee (Appendix 2) for providing input and assisting with the development of this pilot program.

We are particularly grateful for the scientific expertise provided by Claire Holeton, Dr. Andrew Paterson and Dr. Jim Rusak, who assisted MWC in adapting the CMC protocol for use in Muskoka area lakes, as well as provided laboratory space and access to equipment.

No citizen science monitoring program can exist without the citizen scientists, so MWC would like to thank the many volunteers from the Leonard Lake Stakeholders' Association, Muskoka Lakes Association, Peninsula Lake Association, and Three Mile Lake Association (Appendix 3) for donating their time and enthusiasm to collect water samples and helping MWC discover and solve issues related to the protocol and equipment.

MWC would like to thank Michael Peitz, a co-op student from Georgian College, for taking on the monumental task of coordinating a brand-new citizen science program and making it work.

And finally, MWC would like to thank Colleges and Institutes Canada for providing us with a Clean Tech Intern, Carley Rennie, funded by Environment and Climate Change Canada's Science Horizons Youth Internship Program, to assist with the analysis of samples and development of this interim report.

## Appendix 1: Fluorometric Data Collected by Lake

**Table A1.** Chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi and IT methods on Leonard Lake in 2019 for the nearshore (2476-a02n) and offshore (2476-a01o) sites, as well as the ratio of phycocyanin to chlorophyll *a* (PC:CHL). This relative fluorescence is correlated to the amount of algae (CHL) and cyanobacteria (PC), but is not equivalent to the concentration of pigments or cells.

| Leonard Lake | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | Date | 2xSecchi | | | IT | | |
| | | PC | CHL | Ratio | PC | CHL | Ratio |
| 2540-a01o | 12-06-2019 | 4.24 | 0.60 | 6.23 | – | – | – |
| 2540-a01o | 29-06-2019 | 5.14 | 0.60 | 8.66 | 4.24 | 0.62 | 6.87 |
| 2540-a01o | 10-07-2019 | 2.80 | 0.48 | 5.82 | 2.44 | 0.65 | 3.77 |
| 2540-a01o | 25-07-2019 | 4.96 | 0.55 | 8.96 | 2.26 | 0.55 | 4.08 |
| 2540-a01o | 09-08-2019 | 3.88 | 0.51 | 7.57 | 1.60 | 0.42 | 3.79 |
| 2540-a01o | 23-08-2019 | 4.96 | 0.46 | 10.78 | 4.96 | 0.49 | 10.12 |
| 2540-a01o | 05-09-2019 | 6.10 | 0.50 | 12.14 | 3.85 | 0.53 | 10.94 |
| 2540-a01o | 18-09-2019 | 6.58 | 0.45 | 14.65 | 2.92 | 0.42 | 7.22 |
| 2540-a01o | 04-10-2019 | 7.48 | 0.46 | 16.14 | 7.48 | 0.46 | 16.14 |
| 2540-a01o | 18-10-2019 | 4.36 | 0.41 | 10.62 | 4.96 | 0.43 | 11.53 |
| 2540-a02n | 12-06-2019 | 4.18 | 0.54 | 7.69 | – | – | – |
| 2540-a02n | 29-06-2019 | 5.08 | 0.57 | 8.79 | 4.30 | 1.48 | 2.90 |
| 2540-a02n | 10-07-2019 | 3.34 | 0.54 | 6.15 | 1.60 | 0.60 | 2.65 |
| 2540-a02n | 25-07-2019 | 7.24 | 0.60 | 12.13 | 2.50 | 0.59 | 4.17 |
| 2540-a02n | 09-08-2019 | 4.78 | 0.61 | 7.89 | 3.68 | 0.55 | 6.57 |
| 2540-a02n | 23-08-2019 | 4.24 | 0.54 | 7.85 | 4.42 | 0.47 | 9.40 |
| 2540-a02n | 05-09-2019 | 5.72 | 0.48 | 11.87 | 4.72 | 0.49 | 9.60 |
| 2540-a02n | 18-09-2019 | 4.96 | 0.41 | 12.07 | 3.64 | 0.43 | 8.47 |
| 2540-a02n | 04-10-2019 | 4.54 | 0.40 | 11.33 | 5.03 | 0.43 | 11.99 |
| 2540-a02n | 18-10-2019 | 4.60 | 0.41 | 11.13 | 4.60 | 0.43 | 10.79 |

**Table A2.** Chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi and IT methods on Peninsula Lake in 2019 for the nearshore (4309-a02n) and offshore (4309-a01o) sites, as well as the ratio of phycocyanin to chlorophyll *a* (PC:CHL). This relative fluorescence is correlated to the amount of algae (CHL) and cyanobacteria (PC), but is not equivalent to the concentration of pigments or cells.

| Peninsula Lake | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | Date | 2xSecchi | | | IT | | |
| | | PC | CHL | Ratio | PC | CHL | Ratio |
| 4309-a01o | 14-06-2019 | 2.32 | 0.58 | 3.96 | – | – | – |
| 4309-a01o | 28-06-2019 | 0.33 | 0.49 | 0.65 | – | – | – |
| 4309-a01o | 12-07-2019 | 5.26 | 0.43 | 12.22 | 6.46 | 0.71 | 9.14 |
| 4309-a01o | 25-07-2019 | 4.72 | 0.44 | 10.75 | 3.52 | 0.49 | 7.19 |
| 4309-a01o | 09-08-2019 | 4.24 | 0.41 | 10.34 | 4.96 | 0.46 | 10.78 |
| 4309-a01o | 30-08-2019 | 3.88 | 0.56 | 6.92 | 3.88 | 0.39 | 9.94 |
| 4309-a01o | 12-09-2019 | 4.72 | 0.44 | 10.83 | 3.82 | 0.46 | 8.36 |
| 4309-a01o | 26-09-2019 | 9.64 | 0.50 | 19.48 | 4.30 | 0.40 | 10.64 |
| 4309-a01o | 10-10-2019 | 4.12 | 0.55 | 7.48 | 3.70 | 0.52 | 7.08 |
| 4309-a02n | 14-06-2019 | 3.71 | 0.62 | 5.98 | – | – | – |
| 4309-a02n | 28-06-2019 | 1.19 | 0.54 | 2.20 | – | – | – |
| 4309-a02n | 12-07-2019 | 4.24 | 0.43 | 9.93 | 6.28 | 0.61 | 10.34 |
| 4309-a02n | 25-07-2019 | 4.18 | 0.44 | 9.55 | 4.00 | 0.50 | 8.05 |
| 4309-a02n | 09-08-2019 | 3.52 | 0.49 | 7.18 | 3.34 | 0.43 | 7.76 |
| 4309-a02n | 30-08-2019 | 2.98 | 0.35 | 8.51 | 2.62 | 0.43 | 2.98 |
| 4309-a02n | 12-09-2019 | 3.70 | 0.39 | 9.41 | 4.00 | 0.44 | 9.04 |
| 4309-a02n | 26-09-2019 | 4.96 | 0.44 | 11.10 | 6.52 | 0.62 | 10.58 |
| 4309-a02n | 10-10-2019 | 3.16 | 0.48 | 6.53 | 1.96 | 0.46 | 4.21 |

**Table A3.** Chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi and IT methods on Lake Rosseau in 2019 for the nearshore (2476-a02n) and offshore (2476-a01o) sites, as well as the ratio of phycocyanin to chlorophyll *a* (PC:CHL). This relative fluorescence is correlated to the amount of algae (CHL) and cyanobacteria (PC), but is not equivalent to the concentration of pigments or cells.

| Lake Rosseau | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | Date | 2xSecchi | | | IT | | |
| | | PC | CHL | Ratio | PC | CHL | Ratio |
| 2476-a01o | 14-06-2019 | 4.06 | 0.71 | 5.72 | – | – | – |
| 2476-a01o | 29-06-2019 | 6.10 | 0.74 | 8.26 | 6.76 | 1.05 | 6.48 |
| 2476-a01o | 14-07-2019 | 4.00 | 0.84 | 4.78 | 3.82 | 0.82 | 4.64 |
| 2476-a01o | 26-07-2019 | 5.20 | 0.55 | 9.44 | 4.12 | 0.56 | 7.30 |
| 2476-a01o | 11-08-2019 | 2.38 | 0.48 | 4.99 | 2.92 | 0.56 | 5.24 |
| 2476-a01o | 24-08-2019 | 5.50 | 0.42 | 13.09 | 6.22 | 0.55 | 11.30 |
| 2476-a01o | 07-09-2019 | 6.22 | 0.49 | 12.74 | 6.10 | 0.61 | 10.05 |
| 2476-a02n | 14-06-2019 | 4.24 | 0.85 | 4.95 | – | – | – |
| 2476-a02n | 29-06-2019 | 7.84 | 1.01 | 7.73 | 8.86 | 1.11 | 7.95 |
| 2476-a02n | 14-07-2019 | 2.98 | 0.44 | 6.94 | 7.18 | 1.69 | 4.24 |
| 2476-a02n | 26-07-2019 | 5.86 | 0.94 | 6.23 | 6.82 | 1.09 | 6.21 |
| 2476-a02n | 11-08-2019 | 8.74 | 1.16 | 7.56 | 8.68 | 0.87 | 9.93 |
| 2476-a02n | 24-08-2019 | 2.98 | 0.70 | 4.25 | 3.70 | 0.97 | 3.81 |
| 2476-a02n | 07-09-2019 | 5.56 | 0.86 | 6.44 | 5.80 | 0.92 | 6.32 |

**Table A4.** Chlorophyll *a* (CHL) and phycocyanin (PC) data collected using the 2xSecchi and IT methods on Three Mile Lake in 2019 for the nearshore (5362-a02n) and offshore (5362-a01o) sites, as well as the ratio of phycocyanin to chlorophyll *a* (PC:CHL). This relative fluorescence is correlated to the amount of algae (CHL) and cyanobacteria (PC), but is not equivalent to the concentration of pigments or cells.

| Three Mile Lake | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | Date | 2xSecchi | | | IT | | |
| | | PC | CHL | Ratio | PC | CHL | Ratio |
| 5362-a01o | 13-06-2019 | 4.66 | 0.79 | 5.83 | – | – | – |
| 5362-a01o | 27-06-2019 | 5.14 | 0.84 | 6.13 | 5.29 | 0.97 | 5.52 |
| 5362-a01o | 11-07-2019 | 6.28 | 1.11 | 5.69 | 6.58 | 1.12 | 5.91 |
| 5362-a01o | 26-07-2019 | 4.66 | 0.97 | 4.79 | 4.60 | 1.05 | 4.39 |
| 5362-a01o | 09-08-2019 | 65.05 | 1.27 | 51.35 | 68.10 | 1.33 | 51.08 |
| 5362-a01o | 22-08-2019 | 19.89 | 1.03 | 19.31 | 19.53 | 1.00 | 19.53 |
| 5362-a01o | 05-09-2019 | 8.80 | 0.92 | 9.60 | 9.10 | 0.92 | 9.93 |
| 5362-a01o | 21-09-2019 | 12.25 | 0.80 | 15.39 | 8.14 | 0.81 | 10.04 |
| 5362-a02n | 13-06-2019 | 3.31 | 0.82 | 4.03 | – | – | – |
| 5362-a02n | 27-06-2019 | 6.53 | 0.81 | 8.07 | 5.71 | 1.05 | 5.41 |
| 5362-a02n | 11-07-2019 | 4.72 | 1.00 | 4.72 | 5.98 | 1.26 | 4.75 |
| 5362-a02n | 26-07-2019 | 4.48 | 0.93 | 4.81 | 4.66 | 1.48 | 3.15 |
| 5362-a02n | 09-08-2019 | 49.58 | 1.43 | 35.95 | 42.62 | 1.27 | 33.56 |
| 5362-a02n | 22-08-2019 | 17.69 | 1.03 | 17.17 | 18.06 | 1.20 | 15.05 |
| 5362-a02n | 05-09-2019 | 8.26 | 0.86 | 9.63 | 8.08 | 0.85 | 9.54 |
| 5362-a02n | 21-09-2019 | 8.02 | 0.79 | 10.11 | 7.42 | 0.87 | 8.51 |

## Appendix 2: Participants of the Muskoka Watershed Council Algae Sub-committee

| Name | Affiliation |
|---|---|
| **Chair**: Dr. Peter F Sale | Muskoka Watershed Council |
| Kevin Boyle | District Municipality of Muskoka |
| Chris Cragg | Muskoka Lakes Association |
| Christy Doyle | Muskoka Watershed Council |
| Vincent Evans-Lucy | Muskoka Watershed Council |
| Rob Fullerton | Three Mile Lake Association |
| Ken Harper | Peninsula Lake Association |
| Claire Holeton | Ministry of the Environment, Conservation & Parks |
| Dr. Neil Hutchinson | Hutchinson Environmental Sciences Ltd. |
| Jim Marshall | Peninsula Lake Association |
| Christiane Masters | District Municipality of Muskoka |
| Dr. Andrew Paterson | Ministry of the Environment, Conservation & Parks |
| Michael Peitz | Muskoka Watershed Council |
| Carmen Pereira | Queen's University |
| Carley Rennie | Muskoka Watershed Council |
| Dr. Ken Riley | Leonard Lake Stakeholders' Association |
| Dr. Jim Rusak | Ministry of the Environment, Conservation & Parks |
| Dr. Ryan Sorichetti | Ministry of the Environment, Conservation & Parks |
| Wendy Somerville | Peninsula Lake Association |
| Rob Tanner | Three Mile Lake Association |
| Kevin Trimble | Muskoka Watershed Council |
| Summer Valentine | District Municipality of Muskoka |
| Bill Walker | Three Mile Lake Association |
| Susan Walker | Three Mile Lake Association |
| Rebecca Willison | Muskoka Watershed Council |

# Appendix 3: Volunteers participating in the 2019 MWC Algae Monitoring Pilot Project

*Leonard Lake Stakeholders' Association*

- Esther Giesbrecht
- Art Hankey
- Bill Heatlie
- Betty Isbister
- Ken Riley
- Gordon Roberts
- Karen Welch

*Muskoka Lakes Association*

- Chris Cragg
- Carol Hergaarden
- Jane Schipper
- Katherine Seybold

*Peninsula Lake Association*

- Ken Harper
- Jim Marshall
- Wendy Somerville

*Three Mile Lake Association*

- Debra Boyce
- Doug Boyce
- Christine Condy
- Rob Fullerton
- Sharon Robertson
- Rob Tanner
- Susan Walker