Integrated Monitoring Report
2021 Season

Mississippi Lakes Subwatershed

Mississippi Valley Conservation Authority

Table of Contents

Cover photos
Top: Patterson Lake, Spring 2021
Bottom: Sharbot Lake, Spring 2021

Executive Summary

The purpose of this integrated monitoring report is to present an overview of the environmental monitoring that Mississippi Valley Conservation Authority (MVCA) undertook during the 2021 season. The emphasis of this report is on results of the lake monitoring program but also includes water levels and flow, snow pack, and stream monitoring data. MVCA samples each of its 10 subwatersheds on a 5-year rotation. The Mississippi Lakes watershed was the primary focus for 2021. Due to continued Covid-19 related program adjustments a revised lake sampling schedule was implemented that consisted of a reduced number of sampling days, with seven lakes being visited three times during the ice-free season. Restrictions remained in place throughout 2021 which limited MVCA's ability to conduct in-stream sampling, such as electro-fishing.

The most significant factor affecting the lakes and streams in the summer of 2021 was the reduced snow melt event, resulting in below average spring flows. The below average spring was followed by numerous rain events in late June and throughout July, which brought the lakes and streams up to normal conditions and sustained them throughout a hot and dry August. MVCA issued a Level 1 Low Water Condition Statement on June 9th, which was in place until July 19th. Refer to Pages 6-15.

The Mississippi Lakes subwatershed consists of Dalhousie Lake, Patterson Lake and Mississippi Lakes. Additionally, representing three other subwatersheds; Mazinaw Lake, Sharbot Lake, Clayton Lake and Taylor Lake were also monitored in 2021. The sampling of Mazinaw, Dalhousie and Mississippi Lakes is preformed more frequently as these lakes represent the water quality within the main Mississippi River. The sampled lakes maintained their typical nutrient profile characteristics as well as typical dissolved oxygen and temperature profiles for the seasons that were sampled. Refer to Pages 22-32.

Through the stream monitoring program, 15 sites within the Mississippi River Watershed were selected for thermal habitat assessment in 2021. One of these sites was found to support cold-cool water fish habitat, two supported cool water habitat and seven were classified as having cool-warm water habitat. Performing these monitoring programs annually helps account for the impacts of variable climate influences through analysis of long-term datasets. Refer to Pages 33-35.

This report emphasizes the value of the combined monitoring conducted through MVCA's Water Management, Lake Monitoring, and Stream Monitoring programs. The information gathered through these efforts supports MVCA's Stewardship program as well as the Planning and Regulations department.

Filtering a lake surface water sample

Introduction

The goal of the program is to accumulate reliable environmental data on the lakes within the watershed. Despite various adjustments to the protocol throughout the years, the program has remained a fundamental part of MVCA's environmental monitoring program. It continues to provide valuable baseline data while promoting stewardship within the watershed.

The main goal of the Lake Monitoring Program is to collect water quality data and monitor the lakes for changing trends. Due to the large number of lakes monitored within the MVCA area (45 lakes monitored out of over 300 lakes in total), a rotational sampling program is undertaken with the goal to collect baseline data and to monitor general trends. MVCA collects relatively simple data on parameters that are easy to repeat and are important indicators in water quality assessments. Many of the lakes not sampled on a regular basis by MVCA are sampled/monitored through other programs such as the Ministry of Environment, Conservation and Parks' Lake Partner Program (LPP). If lake stewards are interested in more detailed yearly assessments of their lake, they should consider the LPP which is coordinated through the Dorset Environmental Science Centre. Relying on volunteer effort, this program provides equipment and an excellent framework for yearly data collection. It is also an excellent means to promote awareness and ownership of lake health to the lake communities.

Accompanying the lake monitoring program is MVCA's Stream Monitoring program. This program collects valuable information on stream temperature, as well as fish and benthic communities of the watershed's many tributaries. It follows the Ontario Stream Assessment Protocol (OSAP) methods to conduct stream site identifications, electrofishing, benthic surveys, and temperature monitoring at various sites throughout the year. Due to Covid-19 restrictions, MVCA was only able to perform temperature monitoring with the Mississippi River subwatersheds, as many other stream assessment protocols required close physical contact.

The goal of MVCA's fish data collection is largely to determine the presence or absence of cold or cool water species. These species are indicators of the thermal regime of a stream as they require very specific conditions to thrive, and thus are sensitive to changes caused by climate change or nearby development pressure. Fish sampling was not carried out in the summer of 2021 but MVCA was able to monitor the water temperature at select sites throughout the watershed to confirm the potential thermal habitat available for fish populations. The results are also used for tracking thermal trends for longer-term climate analysis.

An example of the crew electrofishing Bolton Creek in 2019

Water Quantity Monitoring

Summary

Three types of water quantity monitoring occurred in the Mississippi Lakes subwatershed in 2021; snow pack, water levels and flow, and precipitation. Figure 1 shows the locations of the various gauges used to collect water level and flow data, the locations of snow courses where snow pack water content is measured, and the lakes monitored in 2021.

There are 6 flow stations, 7 level gauges, 6 precipitation gauges and 4 snow courses in the Mississippi Lake subwatershed.

The watershed did not experience a significant spring freshet/thaw in 2021. The freshet was early and had a below average peak flow on the main system. Ferguson Falls flow peaked on March 31st at 107 cm/s, which is below the historical peak average of 150 cm/s. There was below average rainfall for both April and May that, coupled with the early less predominant spring melt, resulted in below average flows as the season moved into June. MVCA issued a Level 1 Low Water Condition Statement on June 9th which was in place until July 19th. Rainfall for June and July were above average alleviating drought conditions on the system. While August had significantly hot dry weather, flow and levels did sustain normal conditions. September, October and November were all wet months leaving levels and flows higher than normal coming into the winter months.

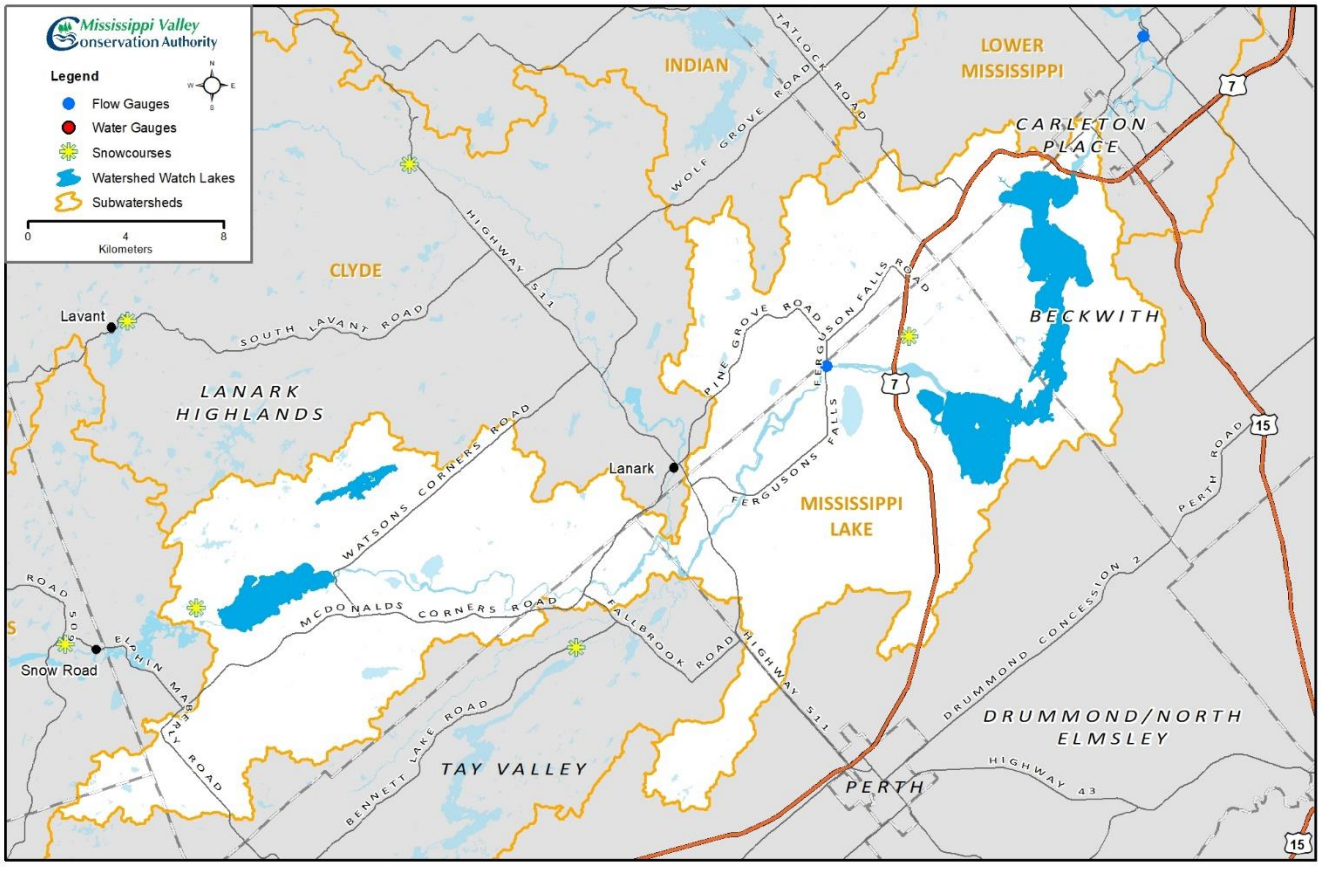


Figure 1: The various water quantity monitoring sites in the Mississippi Lake subwatershed, plus the lakes within the subwatershed that were monitored in 2021.

Snow Pack

Snow pack is measured at 16 sites within the MVCA's jurisdiction. This program provides MVCA with information on the expected spring runoff for that year. This assists in decisions related to dam operations and flood forecasting. These water management efforts are critical to minimizing flood damage, maintaining flows and water levels for fish and wildlife, and meeting the target levels for summer recreational activities. Results from five snow course stations have been interpreted to describe the diversity of snowpack conditions across the Mississippi Valley watershed that contribute to the observed spring water levels. The five sites were selected for analysis due to their proximity to lakes that were studied in 2021 (Figure 1, Figure 5). Bon Echo is adjacent to Mazinaw Lake, Fallbrook is downstream of Sharbot Lake, Snow Road Station and High Falls are upstream of Dalhousie Lake, and Innisville is upstream of Mississippi Lakes. Results from these stations can be seen in Figures 2a and 2b.

Measuring snow depth and equivalent water content

It is evident that most of the Mississippi Lake subwatershed has below average for snow water content in 2021. Due to an early March melt the area was mostly clear of snow by middle of March with very little runoff due to sublimation. The snow courses in the rest of the Mississippi Valley showed a similar trend. Rather than melting, infiltrating and flowing into creeks and tributaries, the average snow pack sublimated into the air in early March accounting for the drop in snow levels shown in Figures 2a and 2b while contributing little melt water to the waterways.

It can be seen in Figure 2a that snow water equivalent levels at Bon Echo maintained an average trend throughout the winter of 2021. With the exception of a snow fall event in early February, all the other stations maintained a below average snow water equivalent trend.

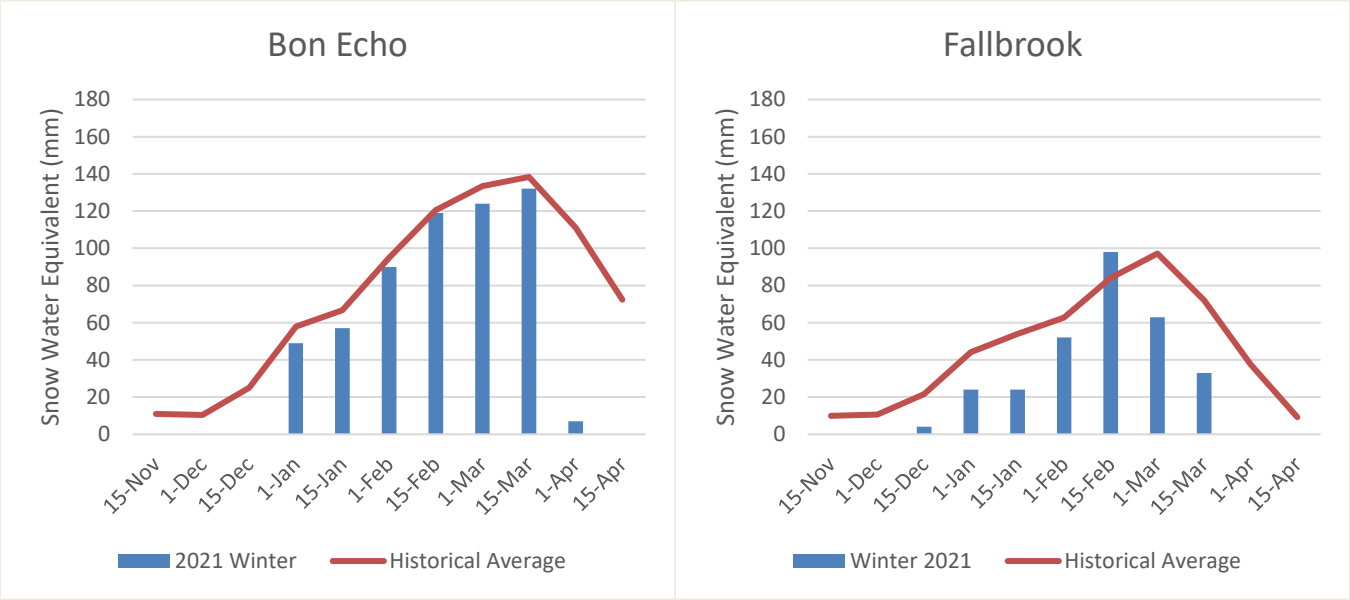


Figure 2a: 2021 snow water equivalent levels vs. historical averages sampled at the Bon Echo snow course station near Mazinaw Lake, and the Fallbrook snow course station downstream of Sharbot Lake.

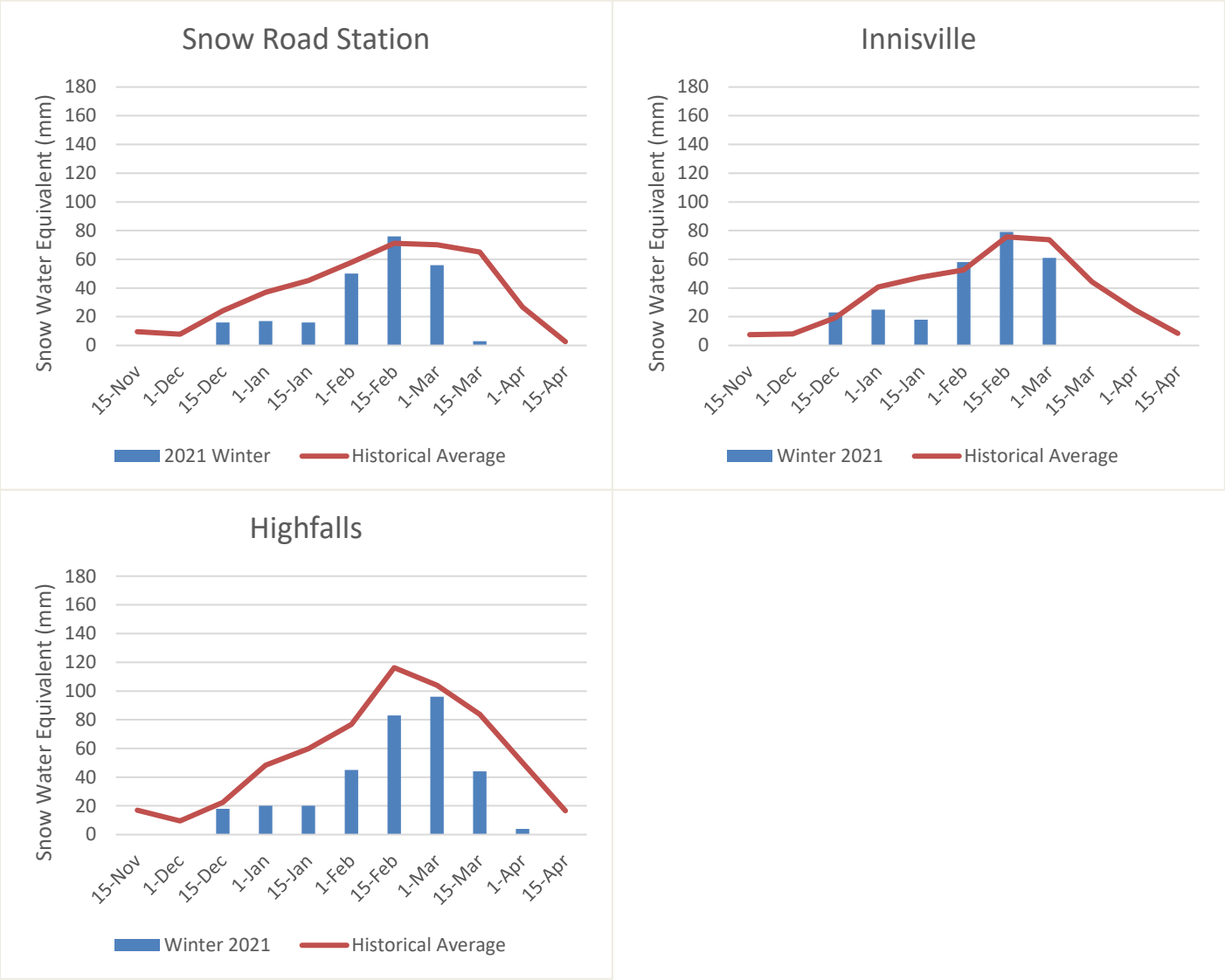


Figure 2b: 2021 snow water equivalent levels vs. historical averages sampled at the Snow Road, High Falls and Innisville snow course stations within the Mississippi Lakes subwatershed.

Stream Flow and Precipitation

Precipitation gauges are located with streamflow gauge stations across the watershed. These gauges inform us of the weather events or climactic conditions which influence water levels on the Mississippi River. This report will focus on 2021 data from the stream flow and rain gauge station at the outlet of Marble Lake downstream of Mazinaw Lake in Myer's Cave, the outlet of Dalhousie Lake, and in the community of Ferguson's Falls upstream of Mississippi Lakes. The daily total precipitation and the daily mean flows at this station can be seen below in Figure 3a, 3b and 3c respectively.

The Figures show peak flows occurred on March 30th to April 2nd during a below average spring freshet. In early June MVCA issued a Level 1 Low Water Condition Statement which was in place for a month until above average rains came in late June bringing the system back to normal conditions.

Figures 3a, b and c illustrate the precipitation events that occurred throughout the year. The largest precipitation event occurred on September 22, 2021 and contributed close to 100 mm to the Mississippi lake area. Due to the continued rainfall into the Fall season experienced in 2021, the majority of the system experienced higher than normal conditions into December.

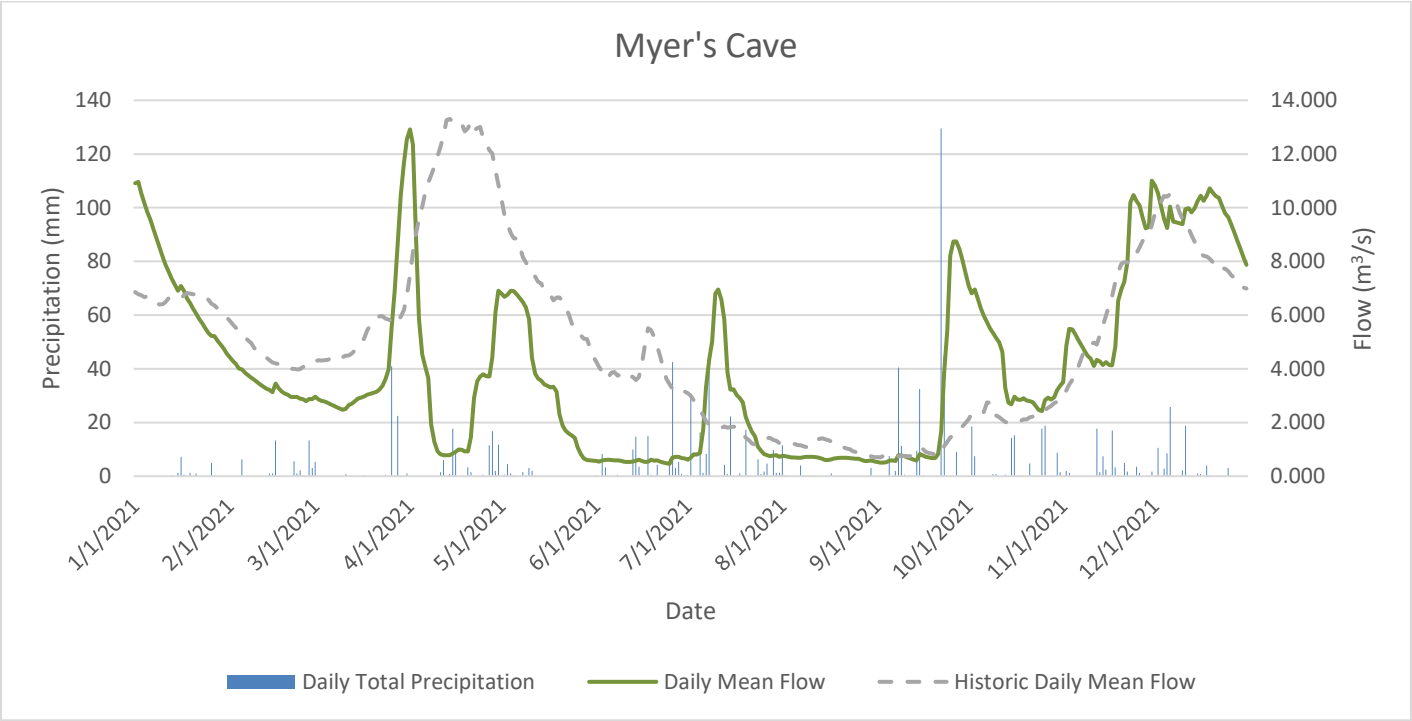


Figure 3a: Daily total precipitation and daily mean water flows at the Myer's Cave gauge station (at the outlet of Marble Lake) for 2021 compared to the historic daily mean flows for the site.

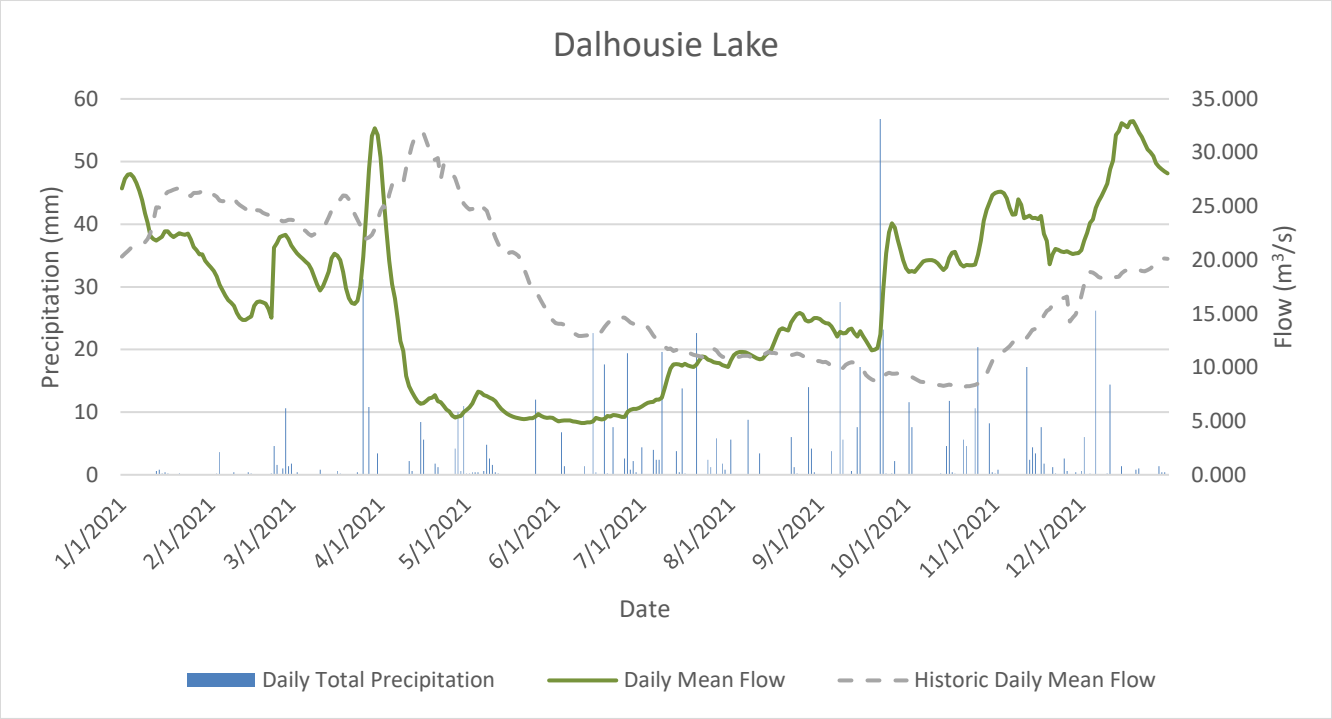


Figure 3b: Daily total precipitation and daily mean water flows at the Dalhousie Lake gauge station for 2021 compared to the historic daily mean flows for the site.

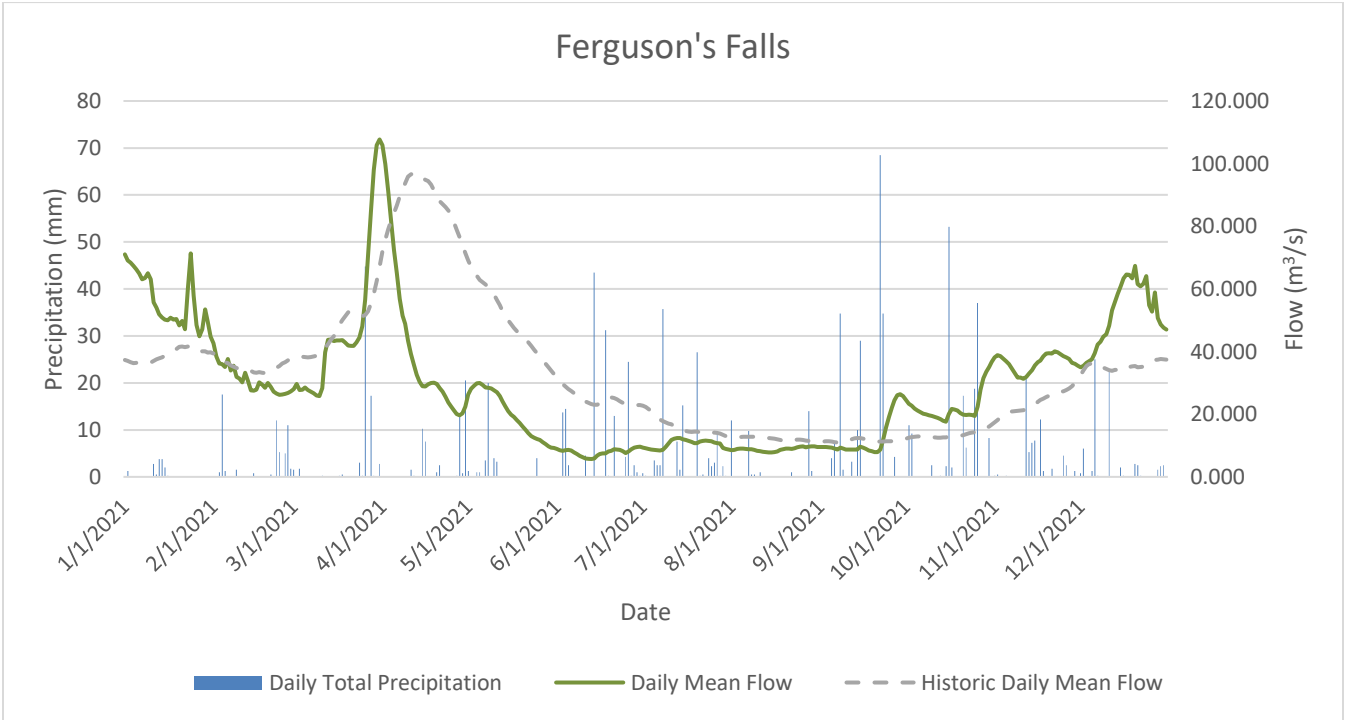
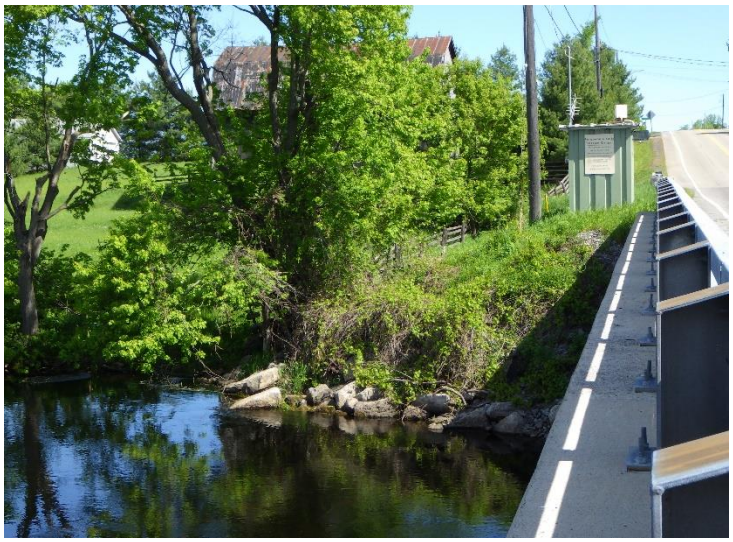


Figure 3c: Daily total precipitation and daily mean water flows at the Ferguson's Falls gauge station for 2021 compared to the historic daily mean flows for the site.

Lake Water Levels

Water levels are measured from gauges installed at many dams and gauge stations throughout the watershed. Water levels in two of the lakes monitored in 2021 is managed by dams (Mazinaw Lake and Mississippi Lake). MVCA operates 18 dams throughout the watershed. Water levels in Sharbot Lake (Figure 4b) and Dalhousie Lake (Figure 4c) are not controlled by dams and the data used for analysis comes from Water Survey of Canada Gauge stations at their outlets.

Due to the dry, below average spring, the lakes started the season with below average water levels. Although there was a Level 1 drought throughout May and June, the lakes with control structures were able to be operated to near target levels throughout the season (Figures 4a, b, and c).



The stream flow and rain gauge station on Mississippi River at Ferguson's Falls upstream of Mississippi Lake.

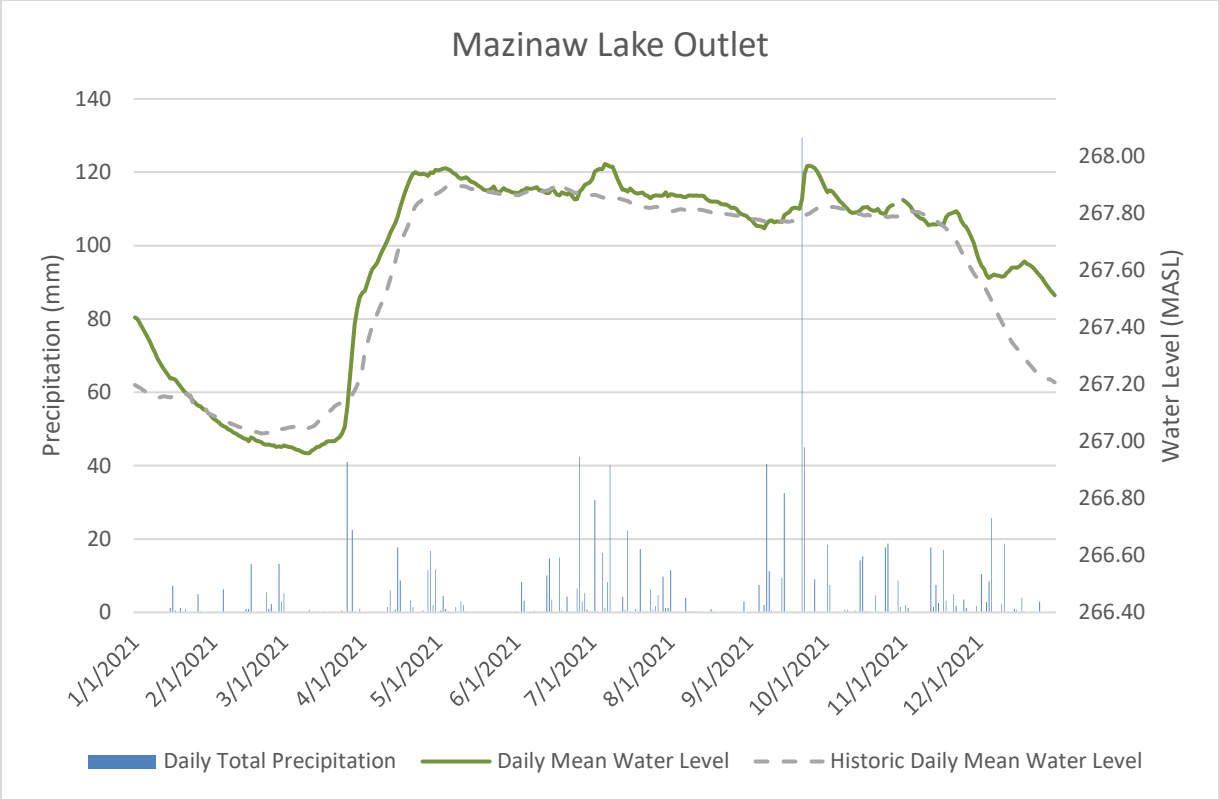


Figure 4a: 2021 and historic daily mean water levels (meters above sea level - MASL) at the Mazinaw Lake dam compared to the 2021 daily total precipitation at the nearby Myer's Cave stream gauge station.

The dam and gauge at the outlet of Mazinaw Lake

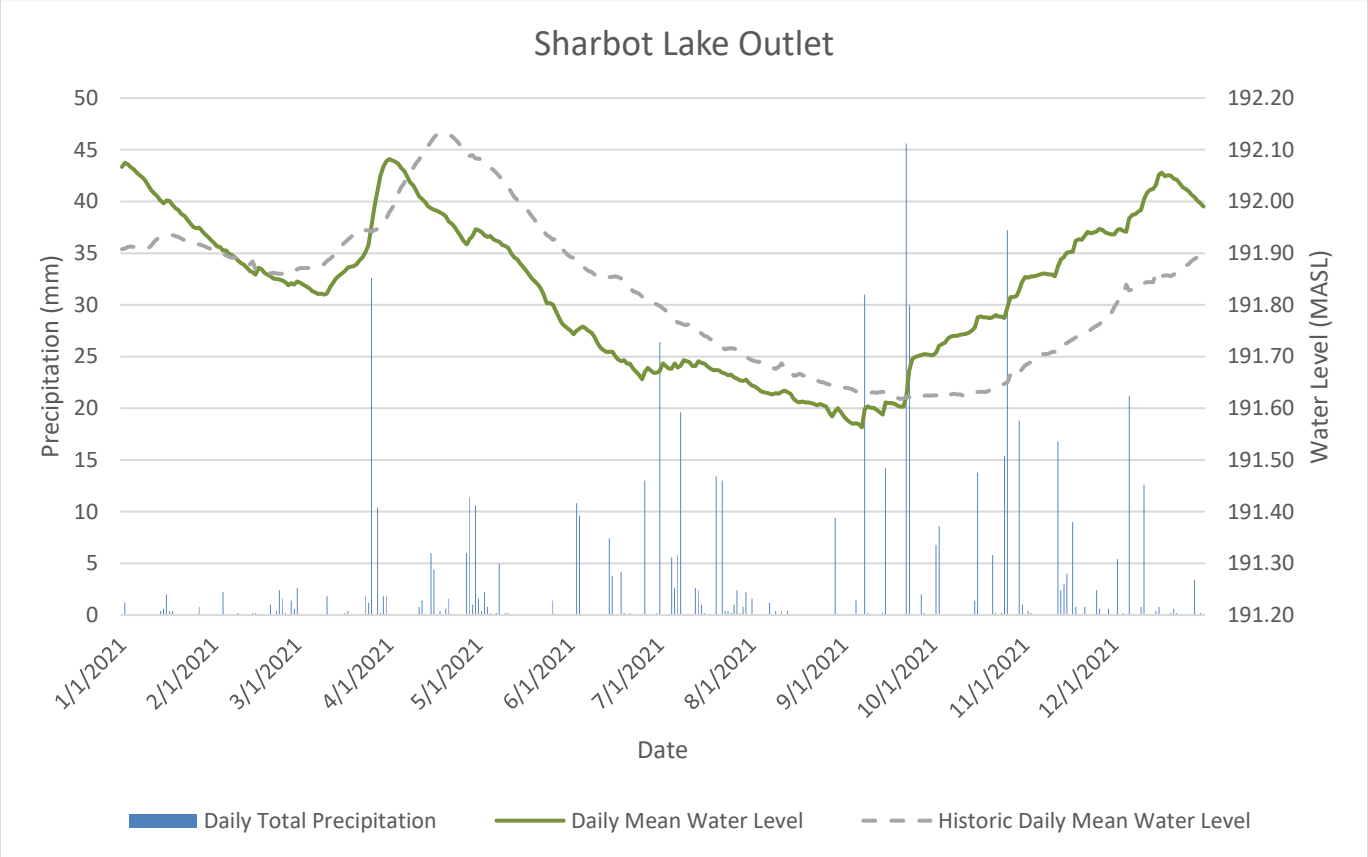


Figure 4b: 2021 and historic daily mean water levels (meters above sea level - MASL) at the Sharbot Lake gauge compared to the 2021 daily total precipitation at the same gauge.

The gauge station at the outlet of Sharbot Lake

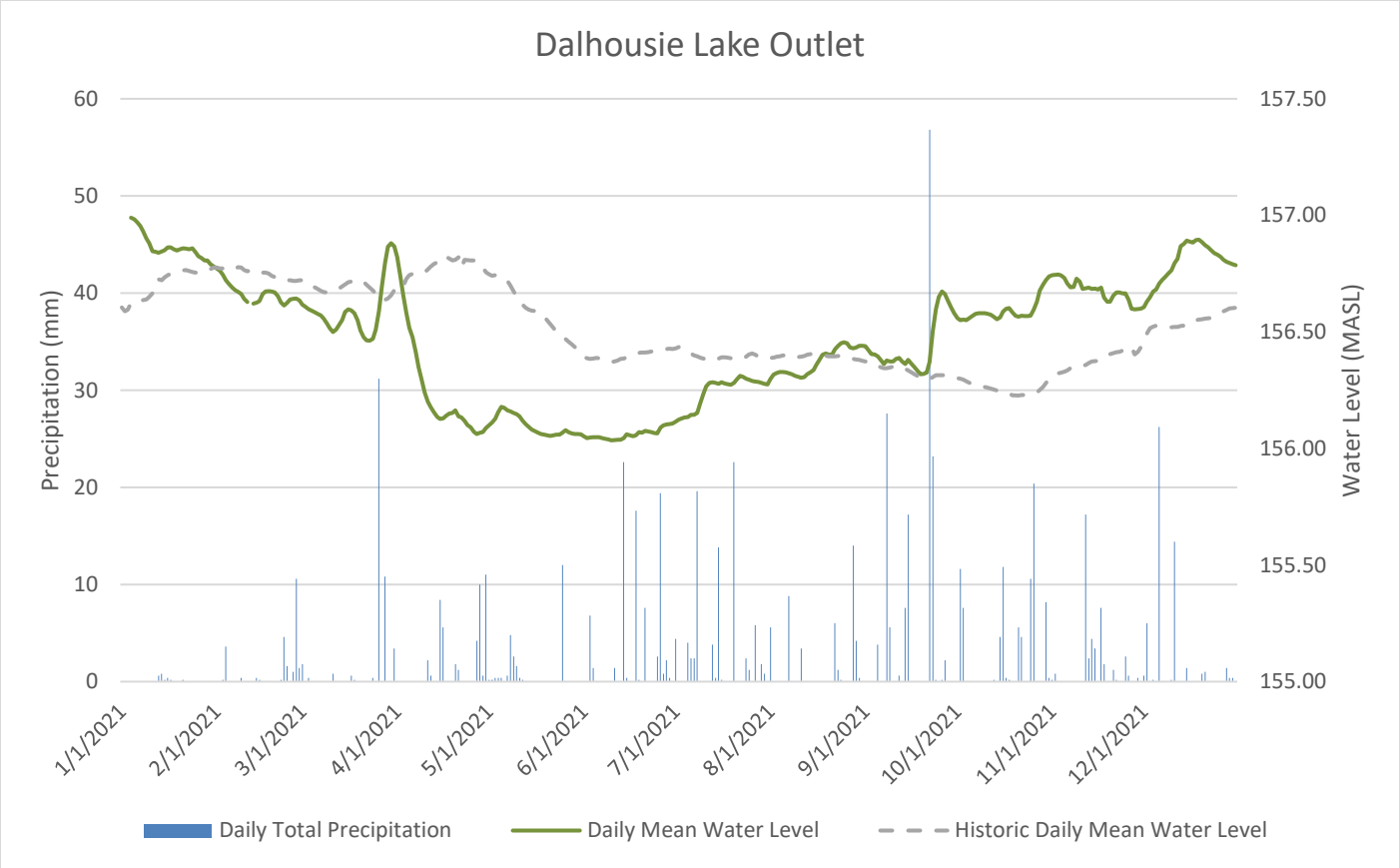


Figure 4c: 2021 and historic daily mean water levels (meters above sea level - MASL) at the Dalhousie Lake gauge compared to the 2021 daily total precipitation at the same gauge.

The gauge station at the outlet of Dalhousie Lake

Lake Monitoring Program

In 2021, the sampling focus was on the Mississippi Lakes subwatershed. Located in the central and east portion of the watershed, the Mississippi River flows from Snow Road to Carleton Place. The Mississippi Lakes subwatershed is 60 km long and has a watershed area of 488 km^2. Three lakes were sampled in the Mississippi Lakes subwatershed and one lake was sampled to represent the main Mississippi River, and three other lakes were sampled for a total of seven lakes sampled in 2021. Table 1 lists the lakes sampled by subwatershed in order from upstream to downstream. Figure 5 highlights the lake sites where sampling occurred in 2021.

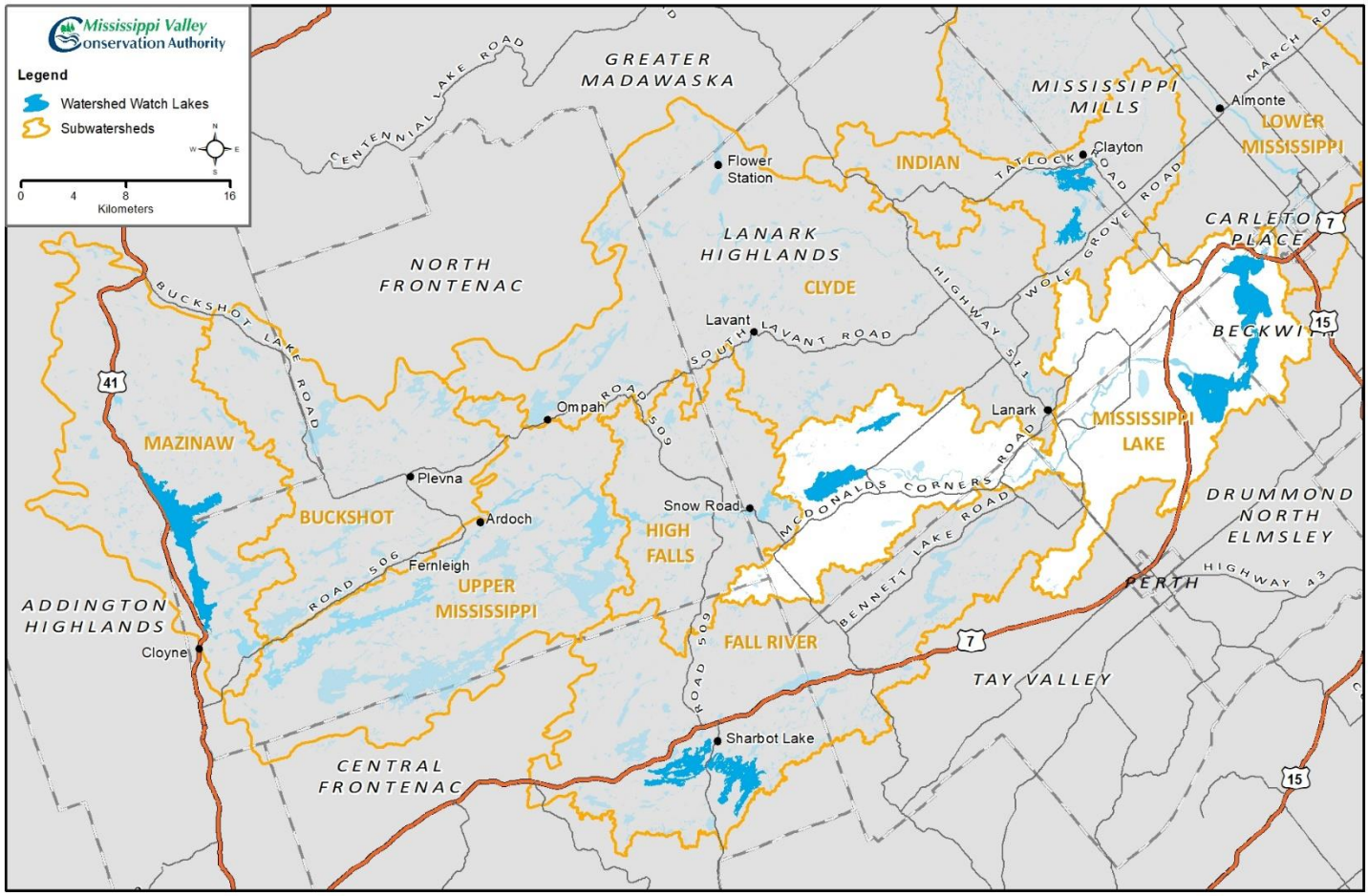


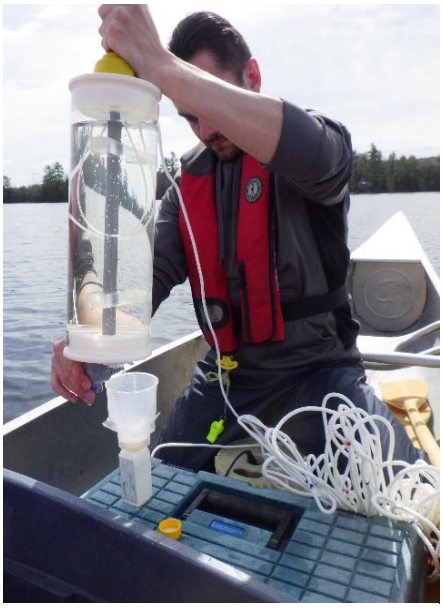
Figure 5: The lakes shown in darker blue are the 7 lakes monitored in 2021. The Mississippi Lakes subwatershed is shown in white.

Table 1: Lakes sampled in 2021.

Mississippi Main Stem	Mississippi Lakes Subwatershed	Other Subwatersheds
Mazinaw Lake	Dalhousie Lake*	Fall River: Sharbot Lake
	Patterson Lake	Indian River: Clayton Lake
	Mississippi Lakes*	Indian River: Taylor Lake

*These lakes are also part of the main Mississippi River.

Results Summary



Filtering a bottom sample

Overall, the lakes sampled in 2021 were consistent with historic trends for Total Phosphorus (TP) levels, Secchi depth and trophic status. The lakes will continue to be sampled as part of the regular rotation to further support the establishment of a long-term data set characterizing the condition of watershed lakes.

To help interpret and display the results of the lake monitoring program, a box and whisker plot has been used. This type of chart is used to highlight the middle 50% of the data set. In other words, 50% of all data points lie within the box and the additional 50% is shown by the lines (whiskers) extending from the top and bottom of the box, 25% respectively. The median value of the data set is shown with a line indicating the middle of the data set. Outliers are any data points that fall outside of the reach of the box and whisker area. This type of graph shows if any results are considered outliers from the data set as dots above/below the whiskers. As seen in the examples below (Figure 6 and 7). MVCA has chosen to use Box and Whisker plots in order to help interpret the TP results seen in 2021 against the full data set for each of the sampling locations. If a result is between the minimum and maximum values, it would tend to indicate that the value was a part of the natural variance in the lake. When a TP result is determined to be beyond the minimum or maximum values, it is classified an outlier, indicating that the result could be attributed to sampling error or contamination. The lakes will continue to be monitored as part of the regular sampling rotation which enhances the robustness of MVCA's long-term data set and improves understanding of yearly results.

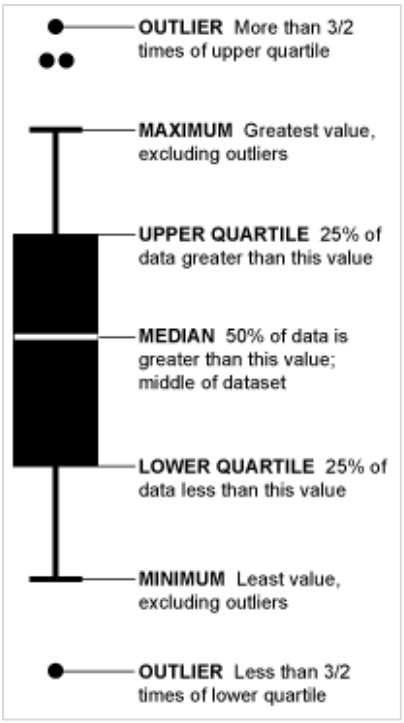


Figure 6: How to interpret a Box and Whisker Plot.

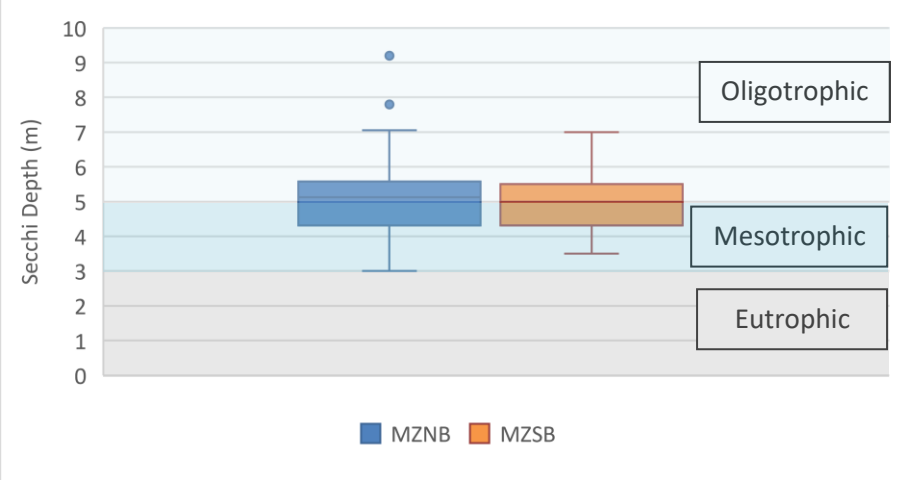


Figure 7: An example of a box and whisker plot from Mazinaw Lake's 2019 Secchi depth results compared to trophic statuses.

Lake Monitoring Indicators and Methodology

The Lake Monitoring Program tests for six water quality parameters. These parameters are selected for their relative simplicity of collection, reproducibility, and ability to determine trophic status. These parameters are further described below.

Calcium

Calcium in lakes is a measure of the levels of calcium (Ca^{2+}), magnesium (Mg^{2+}) and bicarbonate (HCO_3^-) ions in the water. Higher levels of these ions classify the water as 'hard' water, and lower levels 'soft' water. This can be measured in various ways but is usually done either as the concentration of free calcium ions (Ca^{2+}) (mg/L) or, calcium hardness because most hard water ions stem from calcium carbonate ($CaCO_3$ in mg/L). For this program, MVCA measures calcium hardness in the field, the result is then multiplied by 0.4 to determine the concentration of calcium freely available in the water. Calcium in freshwater usually falls within the range of 4 to 100 mg/L.

Calcium enters a lake largely through the mineral weathering of rocks (especially marbles and limestones). It is then either used by aquatic organisms for bones or shells or as a component in the cell walls of aquatic plants, and eventually deposits into the sediment of the lake. Because of its importance in shell/body coverings, calcium has been shown to influence zooplankton (small planktonic invertebrates) communities, which are an important food source for many baitfish species. Higher calcium levels are also required for zebra mussels to thrive.

Calcium sampling only occurs as part of the spring sampling protocol.

Secchi Depth

Secchi depth is a measure of water clarity and is collected using a Secchi disc. The Secchi disc is a black and white disc that is lowered into the water on the shady side of the boat to the point where it can no longer be seen. The greater the Secchi depth, the clearer the lake is. The Secchi depth also helps determine the euphotic zone (the depth of water through which light is able to penetrate). Secchi depth can be influenced by the concentration of algae or the presence of other suspended materials in the water. The presence of zebra mussels can also influence Secchi depth as they filter the water and feed on the algae and zooplankton, making the water clearer and possibly increasing Secchi depths. Often a decrease in Secchi depth occurs in unison with an increase in phosphorus. The following guideline shown in Table 2 is used to determine your lake's nutrient status according to Secchi depth.

Secchi disc

Table 2: Interpreting Secchi disc results.

Secchi Depth	Lake Nutrient Status
≥ 5 meters	Oligotrophic – unenriched, few nutrients
3.0 – 4.9 meters	Mesotrophic – moderately enriched, some nutrients
< 3.0 meters	Eutrophic – enriched, higher levels of nutrients

Total Phosphorus

Phosphorus is an essential nutrient for all living organisms as it plays a role in numerous aspects of biological metabolism. It is also the limiting nutrient in biological activity and therefore when phosphorus levels get too high there tend to be adverse effects such as algae blooms. Phosphorus can be found naturally in the environment, as well as in many man-made products such as soaps, detergents, fertilizers and septic waste. Total phosphorus (TP) is measured in micrograms per liter (µg/L).

Kemmerer Bottle

As part of the Lake Monitoring program, two types of total phosphorus levels are measured at each sampling location: euphotic zone phosphorus (TPA) and bottom phosphorus (TPB). All TP samples are filtered through an 80-micron mesh to remove zooplankton which could skew results. The euphotic zone is defined as twice the Secchi depth and is the depth to which light can reach and influence plant growth.

The bottom phosphorus sample is collected at sites that have a depth greater than the euphotic zone, using a device called a Kemmerer Bottle. The bottle is sent down to the appropriate depth, approximately 1 meter off the bottom of the lake, with both ends open. A weight on the rope is then dropped, causing both ends to close when the weight hits the bottle, sealing the sample water in the bottle, providing a discrete volume of water from the appropriate depth.

Total phosphorus levels provide an accepted standard to characterize a lake's trophic status following the general guidelines seen in Table 3. It should be noted that while these numbers provide an idea of a lake's current trophic status, lakes naturally progress over time from oligotrophic to eutrophic, so an 'ideal' trophic status does not exist. Furthermore, natural variation can cause a great deal of change from year to year and even within years, so it is important to look at larger trends rather than one or two exceptional years.

Table 3: Interpreting total phosphorus results.

Total Phosphorus Level	Lake Trophic Status
≤ 10 µg/L	Oligotrophic – unenriched, few nutrients
10.1 – 19.9 µg/L	Mesotrophic – moderately enriched, some nutrients
≥ 20 µg/L	Eutrophic – enriched, higher levels of nutrients

The Provincial Water Quality Objective (PWQO) for phosphorus in lakes is 20 µg/L (*Water Management, Policies and Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy. MOE. 1994*). The goal is to keep phosphorus below this level in order to maintain aquatic health and the recreational value of watershed lakes.

pH

The pH scale is a logarithmic measure of the concentration of hydrogen ions in solution. It is a measure of the acidity of a solution and ranges from 0 to 14. A pH of 7 is considered neutral, values above 7 are basic, and values below 7 are acidic. The logarithmic scale means that a change from pH 7 to pH 8 is a ten-fold decrease in the concentration of hydrogen ions in solution.

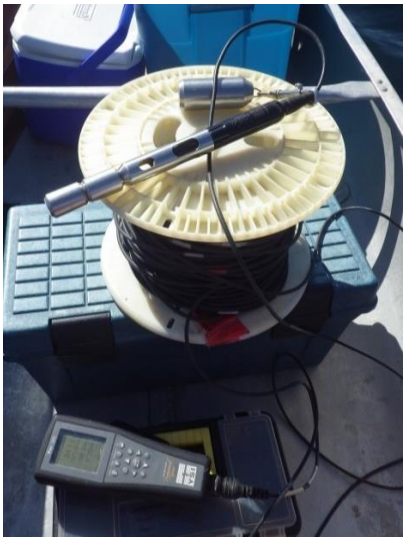
The acidity of a water body affects all chemical reactions within the water. Even small changes in pH can have a large influence on the solubility of some nutrients, including phosphorus, which in turn can influence plant growth. The PWQO

for pH in lakes is 6.5 – 8.5, which ensures optimal conditions for most aquatic species.

Dissolved Oxygen and Water Temperature

Dissolved oxygen (D.O.) is essential to all aquatic life, including fish, invertebrates and bacteria. Many factors can influence dissolved oxygen concentrations in a lake, but two key factors are lake stratification (water temperature) and the amount of phytoplankton (microscopic algae) produced in the lake.

Lake stratification is the separation of the lake into three layers: the epilimnion (top layer), metalimnion (middle layer) and the hypolimnion (bottom layer). Stratification is caused by changes in water temperature with depth, and occurs from late spring to early fall.



Optical Dissolved Oxygen Probe

Deeper water D.O. is at its lowest during the late summer and early fall. This is when the water in the hypolimnion cannot recharge its oxygen concentrations because it is isolated from the atmosphere by the epilimnion and the thermocline (the steep temperature gradient between the warm sunlight epilimnion water and the cooler hypolimnion water below). Also, during the fall the phytoplankton that have been active during the summer months begin to die and settle to the bottom of the lake. The bacteria that decompose the phytoplankton consume large amounts of dissolved oxygen, further depleting stores in the hypolimnion. The low levels of D.O. in the bottom depths of a lake decrease the amount of critical habitat available for cool water fish species to thrive as they can also be stressed by the warmer temperatures in the oxygen rich epilimnion.

Dissolved oxygen and water temperature are measured using an Optical Dissolved Oxygen Probe. This instrument, pictured above, is lowered through the water at one-meter intervals, where it takes both water temperature and D.O. readings. This creates a dissolved oxygen profile where changes in temperature and D.O. can be recorded as depth increases. Table 4 shows the optimal temperature/D.O. combinations for cold, cool, and warm water fish habitat. Results from the D.O. and water temperature profiles for each of the 2020 lake monitoring sites are available in Appendix A.

Table 4: Optimal conditions for different fish habitat.

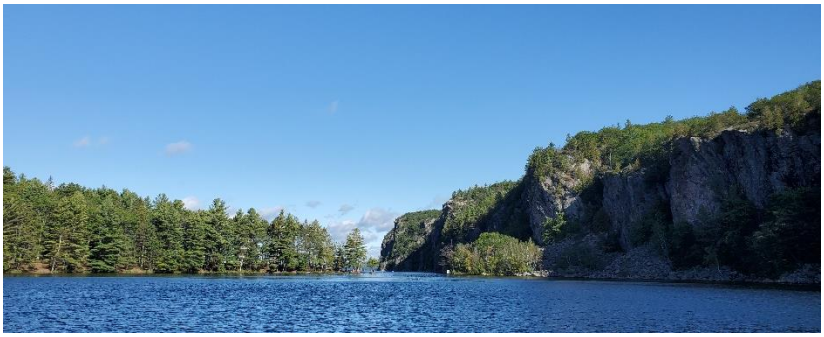
	Dissolved Oxygen		Water Temperature
Cold Optimal	>6 mg/L	AND	<10 °C
Cool Optimal	>4 mg/L	AND	<15.5 °C
Warm Optimal	>4 mg/L	AND	<25 °C

Source: Coker, G.A., Portt, C.B., & Minns, C.K.(2001). Morphological and Ecological Characteristics of Canadian Freshwater Fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2554.

Main Mississippi River

Mazinaw Lake

Mazinaw Lake is a large and deep lake on the western edge of the Mississippi Valley watershed. A large section of the lake is part of Bon Echo Provincial Park. It has a maximum depth of 145 meters (m), making it the seventh deepest lake in Ontario and the deepest lake in the Mississippi Valley watershed. It also features a picturesque rock wall standing over 100 m tall on the eastern side of the lake.



Based on Secchi depth results in 2021 (Table 5, Figure 8) the lake maintains its oligotrophic status. However, three of the euphotic zone total phosphorus results were above the 10 µg/L threshold putting them in the mesotrophic classification. There was also a high total phosphorus reading in the July sample of the south basin, but given the lake's history of having low nutrient concentrations this value is likely an outlier in the dataset. Mazinaw Lake is sampled every two years and this enhanced effort will help us put this year's results into the context of the long-term lake status.

Mazinaw Lake maintains optimal and critical cold-water fish habitat throughout the ice-free season into the fall. The water temperature and dissolved oxygen profiles from the 2021 sampling events are available in Appendix A.

Table 5: 2020 sampling summary for Mazinaw Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
North Basin	May 19, 2021	5.5	< 2	2	16
North Basin	July 19, 2021	5	12	10	
North Basin	Sept 26, 2021	4.5	11	9	
South Basin	May 19, 2021	3.75	5	2	16
South Basin	July 19, 2021	5	29	10	
South Basin	Sept 26, 2021	4.5	15	6	

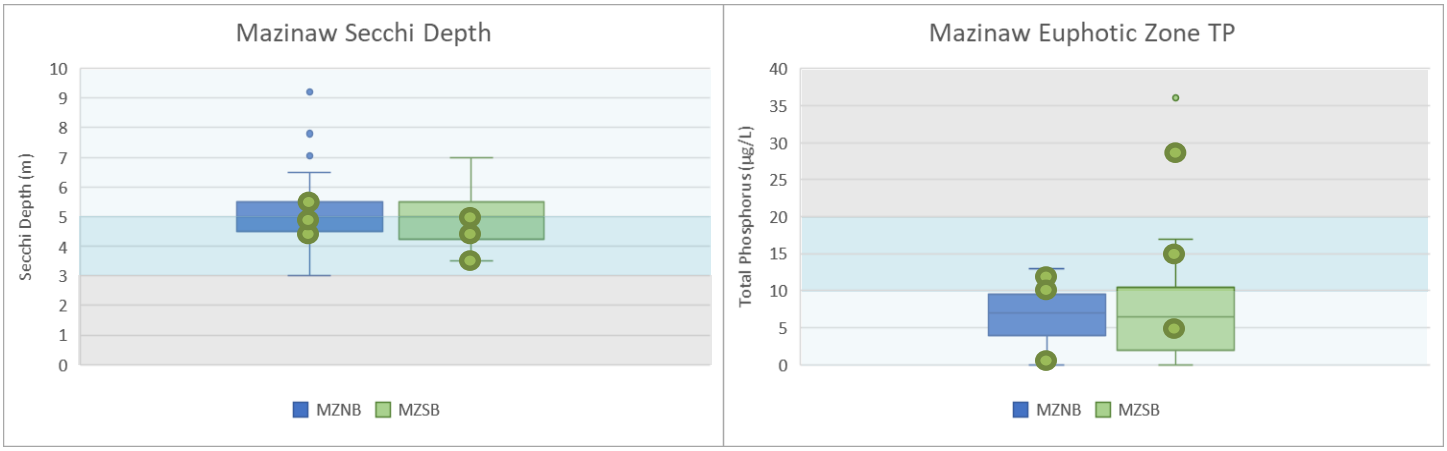


Figure 8: Secchi Depth and Euphotic Zone Total Phosphorus results from seven sampling years for both basins of Mazinaw Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours.

Mississippi Lakes Subwatershed

Dalhousie Lake

Dalhousie Lake is the last main river lake before the Clyde and Fall Rivers join the Mississippi River near Lanark and is located at the transition between the Canadian Shield and the St. Lawrence lowlands geologic zones. It is a wide and shallow lake with the deepest area at 11 meters, located in the western portion of the lake. The lake provides warm water habitat to northern pike, small and large mouth bass, walleye and other fish species.

A summary of the 2021 sampling results are shown in Table 6 and are compared to past years results in Figure 9. Dalhousie Lake has maintained a mesotrophic status throughout the eight ice-free seasons that it has been sampled by MVCA. The 2021 sample results further support this classification.

In 2021 Dalhousie Lake experienced very low (< 2 mg/L) levels of dissolved oxygen at depths below 8 m during both the July and September sampling events (Appendix A). At certain times of year Dalhousie Lake can have a high flushing rate due to the seasonal flows. However, during the summer months when river flows are reduced, the mixing and flushing of the bottom lake water may also be reduced. As seen in Table 6, bottom sample total phosphorus results for Dalhousie Lake in 2021 are very high. Sampling from 2017-2020 found that high bottom total phosphorus values also occurred. It is possible that these high TP values are linked to a chemical process that releases dissolved phosphorus from the sediment back into the water column under low dissolved oxygen conditions. As a large main river lake, Dalhousie will continue to be monitored frequently to track the lake's condition, in particular the high total phosphorus in the bottom waters.

The water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table 6: 2021 sampling summary for Dalhousie Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
Main Basin	May 5, 2021	6	5	4	32
Main Basin	July 5, 2021	4.5	11	43	
Main Basin	Sept 17, 2021	6.25	30	43	

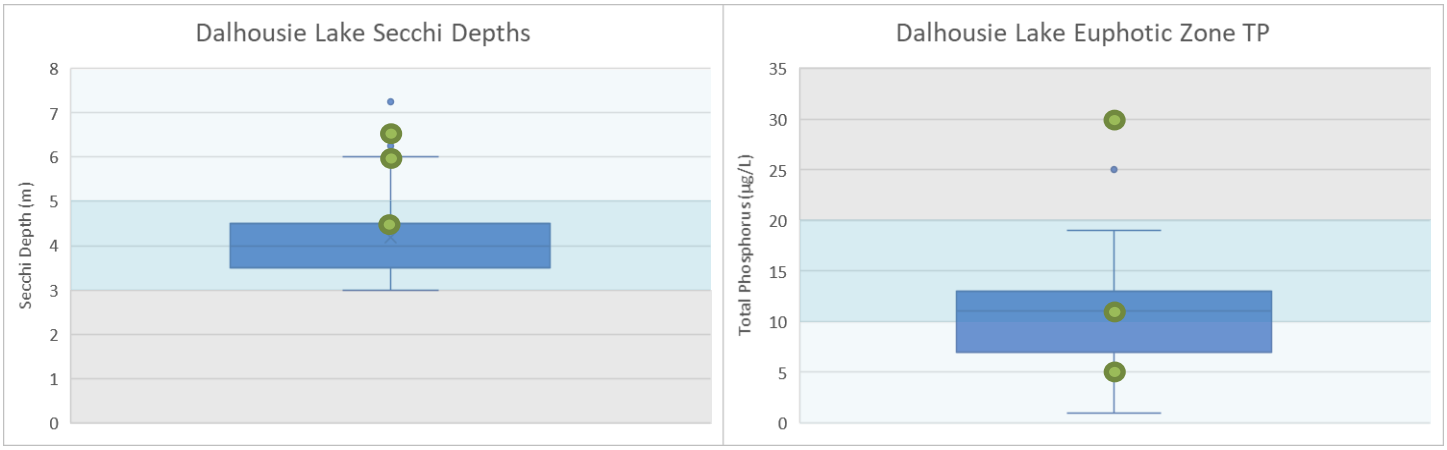


Figure 9: Secchi Depth and Euphotic Zone Total Phosphorus results from eight sampling years for the main basin of Dalhousie Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours.

Patterson Lake

Patterson Lake is 16 m deep and is known to support warm-water fish such as northern pike, yellow perch, small and largemouth bass, and walleye.

The Secchi depth and total phosphorus results from the 2021 season are shown in Table 7 and results are compared to past years in Figure 10. Figure 10 shows the 2021 sample values (green points) fall on the low nutrient side of the normal distribution of sampling data for the lake.

Based on the data collected in 2021 the lake is classified as mesotrophic, this is in line with historical values for Patterson Lake.

The water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table7: 2021 sampling summary for Patterson Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
Main Basin	May 13, 2021	4.5	5	15	48
Main Basin	July 6, 2021	5	16	62	
Main Basin	Sept 14, 2021	4.5	11	92	

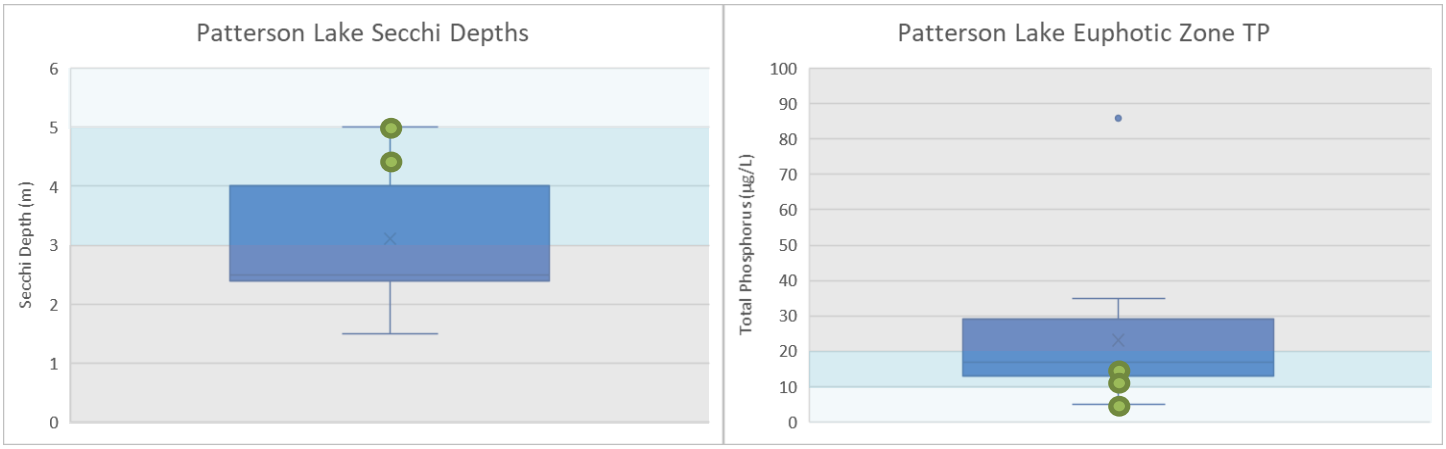


Figure 10: Secchi Depth and Euphotic Zone Total Phosphorus results from four sampling years for the main basin of Patterson Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours.

Mississippi Lake

Mississippi Lake is a large and shallow warm water lake in Lanark County. It is the most downstream lake on the main stem of the Mississippi River system and its outlet is at the town of Carleton Place. It has a maximum depth of 10 meters. MVCA has now monitored it through 17 ice-free seasons. A summary of the results from the 2021 survey are presented in Table 8.

Figure 11 illustrates how this year's results for Secchi depth and euphotic zone total phosphorus samples compare with the overall data set for each of the four sampling locations on the lake. The overall historical trend for both Secchi depth results and TP show the lake is predominantly within the mesotrophic classification and the 2021 results further support this classification. While the July total phosphorus results were slightly above the 20 µg/L threshold for eutrophic classification, they are still within the typical range for the lake.

Water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table 8: 2021 sampling summary for Mississippi Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	Calcium (Ca2+) (mg/L)
Inlet (MLI)	May 6, 2021	4	5	7	48
Inlet	July 9, 2021	3.75	27	31	
Inlet	Sept 21, 2021	5	19	42	
Burnt Island (MLB)	May 6, 2021	5	6	6	
Burnt Island	July 9, 2021	5	24	23	
Burnt Island	Sept 21, 2021	-	24	-	
Pretties Island (MLP)	May 6, 2021	5.5	15	9	48
Pretties Island	July 9, 2021	5.5	23	-	
Pretties Island	Sept 21, 2021	5	15	-	
Outlet (MLO)	May 6, 2021	2	-	-	
Outlet	July 9, 2021	2	19	-	
Outlet	Sept 21, 2021	3	25	-	

*Total Phosphorus samples are only taken from 1 m off the bottom of the lake if the euphotic zone does not extend to the bottom.

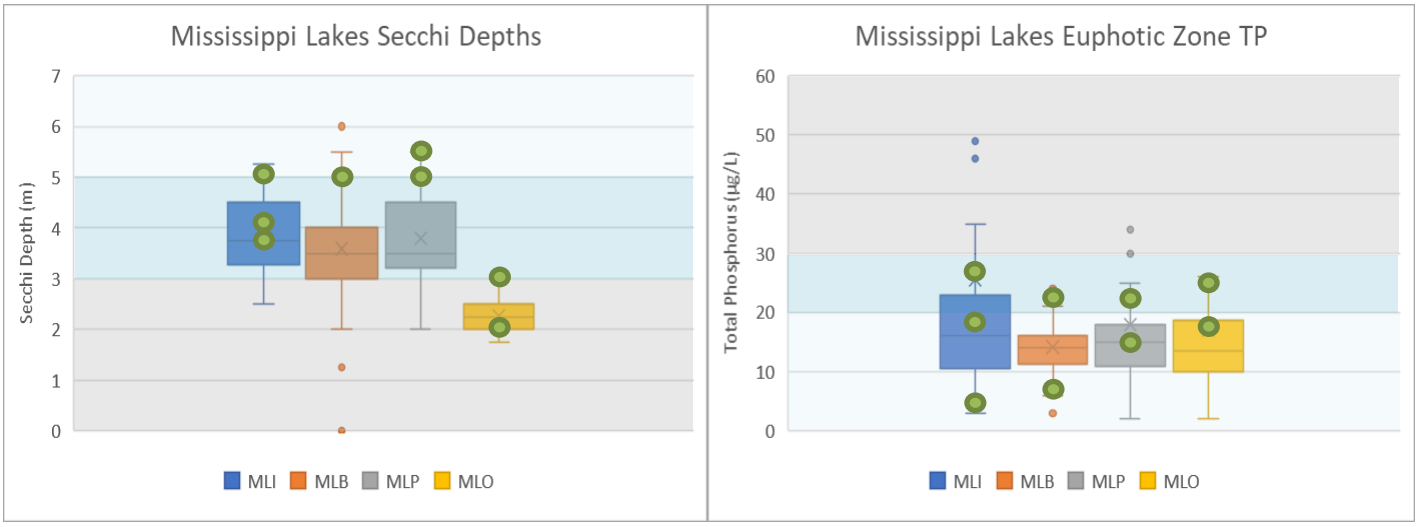


Figure 11: Secchi Depth and Euphotic Zone Total Phosphorus results from 17 sampling years for all four sites. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours. Note: the maximum Secchi depth possible at the outlet site (MLO) is limited by the water depth (3 m) and by a thick bed of aquatic plants inhabiting the area.

Fall River Subwatershed

Sharbot Lake

Sharbot Lake is predominately a deep cold-water lake (30 m) on the west side of Highway 38 (West Basin). To the east of Highway 38 the lake is shallower and warmer, but also contains a 30 m deep basin (East Basin). The lake is known to support sport fish species such as lake trout, cisco, northern pike, small and large mouth bass and walleye.

Data from the 2021 sampling events can be found in Table 9 and Figure 12. As can be seen in the box and whisker plots, both Secchi depth and TP values are close to the majority of results collected in previous years. This year there was a single unusually high total phosphorus reading (Main West Basin, July 16, 59 µg/L) but as that is out of character for the lake and the rest of the samples collected on that day, it is likely due to a sampling error rather than an indicator of nutrient enrichment. Based on the Secchi depth and surface water total phosphorus results in 2021 (Table 9, Figure 12) the lake maintains a meso-oligotrophic status.

The water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table 9: 2021 sampling summary for Sharbot Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
North West Basin	May 18, 2021	4	5	8	
North West Basin	July 16, 2021	6	11	14	
North West Basin	Sept 30, 2021	5	9	21	
Main West Basin	May 18, 2021	4	8	5	
Main West Basin	July 16, 2021	6.5	59	27	
Main West Basin	Sept 30, 2021	5	16	26	
South West Basin	May 18, 2021	4	7	8	40
South West Basin	July 16, 2021	6.5	22	19	
South West Basin	Sept 30, 2021	5	11	22	
East Basin	May 18, 2021	5	4	3	40
East Basin	July 16, 2021	5.5	17	25	
East Basin	Sept 30, 2021	4	9	26	

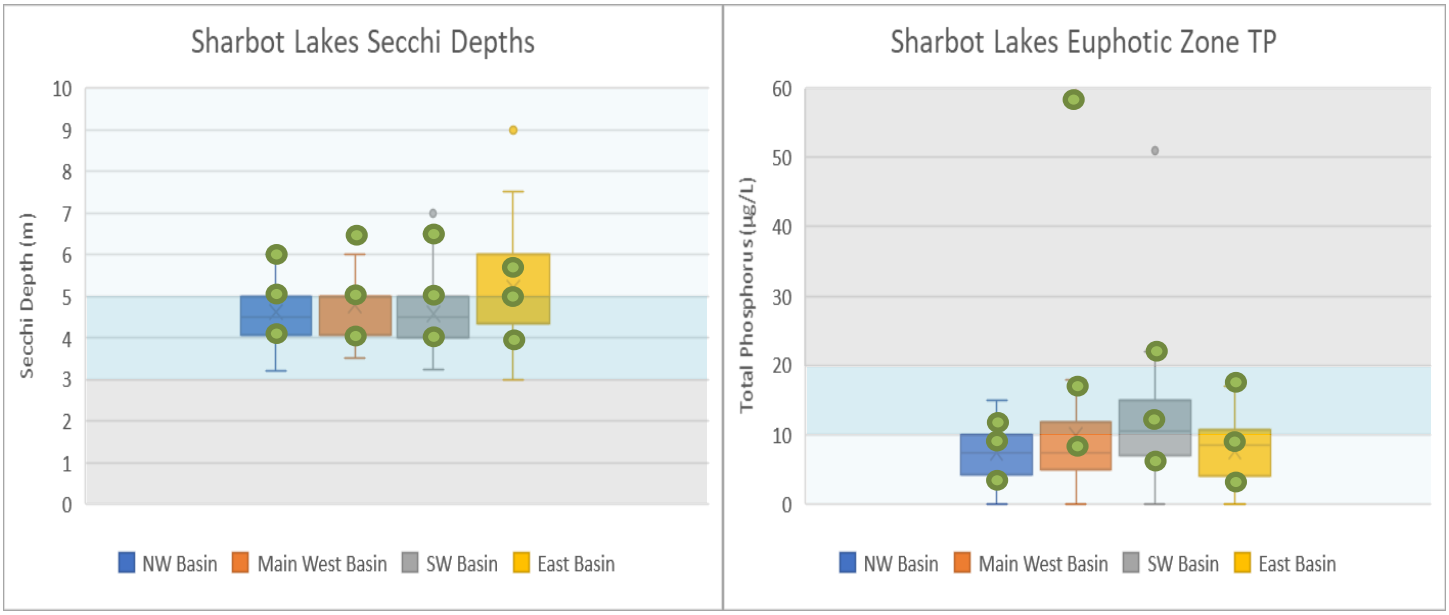


Figure 12: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for Sharbot Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours.

Indian River Subwatershed

Clayton Lake

Clayton Lake is a warm water lake in Lanark Highlands and Mississippi Mills that flows into the Indian River at the village of Clayton. It has a maximum depth of 10 meters. Clayton and Taylor Lakes are unique in the MVCA jurisdiction due to their large shoreline wetland ecosystem which has been classified as a Provincially Significant Wetland.

The results from the 2021 season are shown in Table 10 and are compared to past years results in Figure 13. Based on Secchi depths and average euphotic zone total phosphorus results from five sampling seasons the lake is classified as mesotrophic.

The water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table 10: 2021 sampling summary for Clayton Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
Main Basin	May 7, 2021	5.5	5	-	56
Main Basin	July 15, 2021	4.5	21	19	
Main Basin	Sept 10, 2021	4.5	10	-	

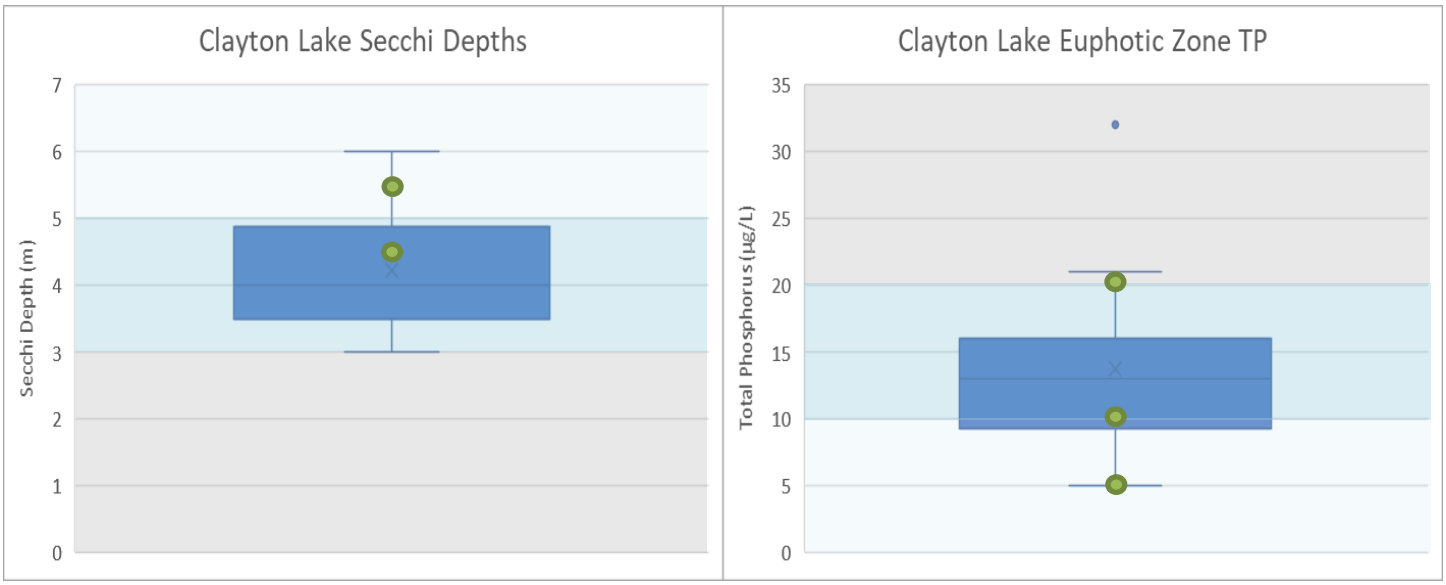


Figure 13: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin of Clayton Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours.

Taylor Lake

Taylor Lake is a small shallow warm water lake in Lanark Highlands that flows into Clayton Lake from the south. It has a maximum depth of 3 meters. Clayton and Taylor Lakes are unique in the MVCA jurisdiction due to their large shoreline wetland ecosystem which has been classified as a Provincially Significant Wetland.

The results from the 2021 season are shown in Table 11 and are compared to past years results in Figure 14. Based on Secchi depths and average euphotic zone total phosphorus results from five sampling seasons the lake is classified as mesotrophic.

The water temperature and dissolved oxygen profile data from the 2021 sampling events are available in Appendix A.

Table 11: 2021 sampling summary for Taylor Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	Calcium (Ca2+) (mg/L)
Main Basin	May 7, 2021	2	6	-	48
Main Basin	July 15, 2021	3	19	-	
Main Basin	Sept 10, 2021	2.5	21	-	

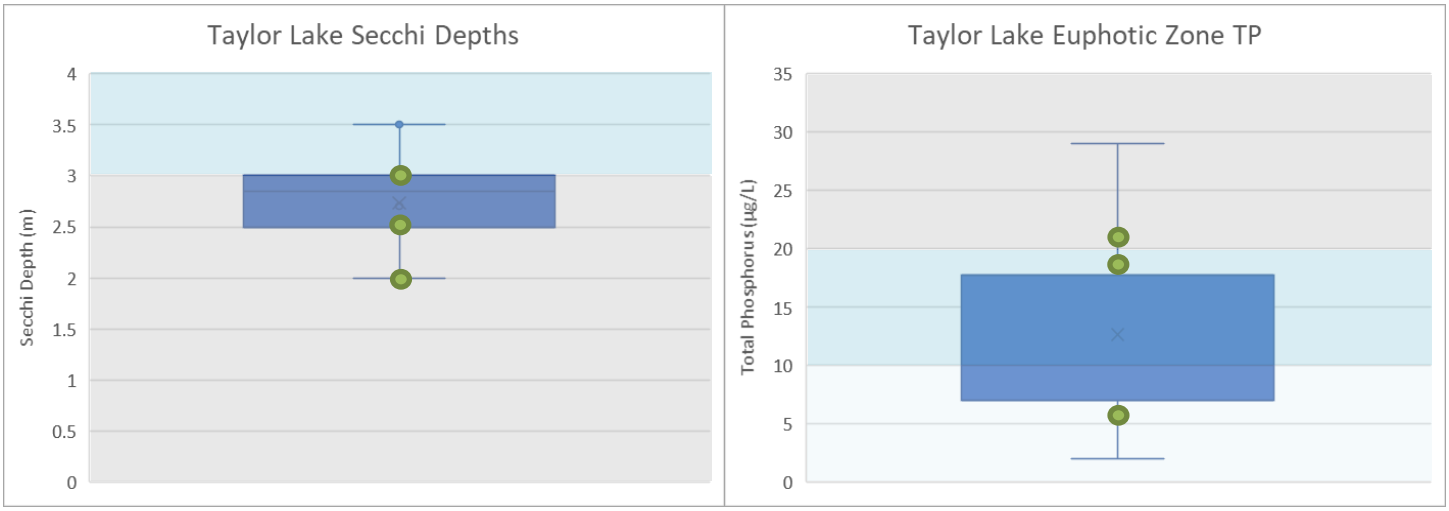


Figure 14: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin of Taylor Lake. The 2021 results are shown with a green dot, and the trophic level classifications are shown with the blue to grey background colours. Note: the maximum Secchi depth possible in Taylor Lake is limited by the water depth (3 m).

Stream Monitoring Program

Summary

While the lake monitoring program focusses efforts on particular subwatershed(s) each year on a rotational basis, stream sampling is also conducted at select additional sites throughout the Mississippi River watershed to help expand MVCA's knowledge of these smaller systems. Due to the Covid-19 pandemic only temperature monitoring data was collected from our streams in 2021. Figure 15 illustrates the locations of these sites across the Mississippi River watershed and Table 12 summarizes the stream site thermal results for 2021.

Brook Trout

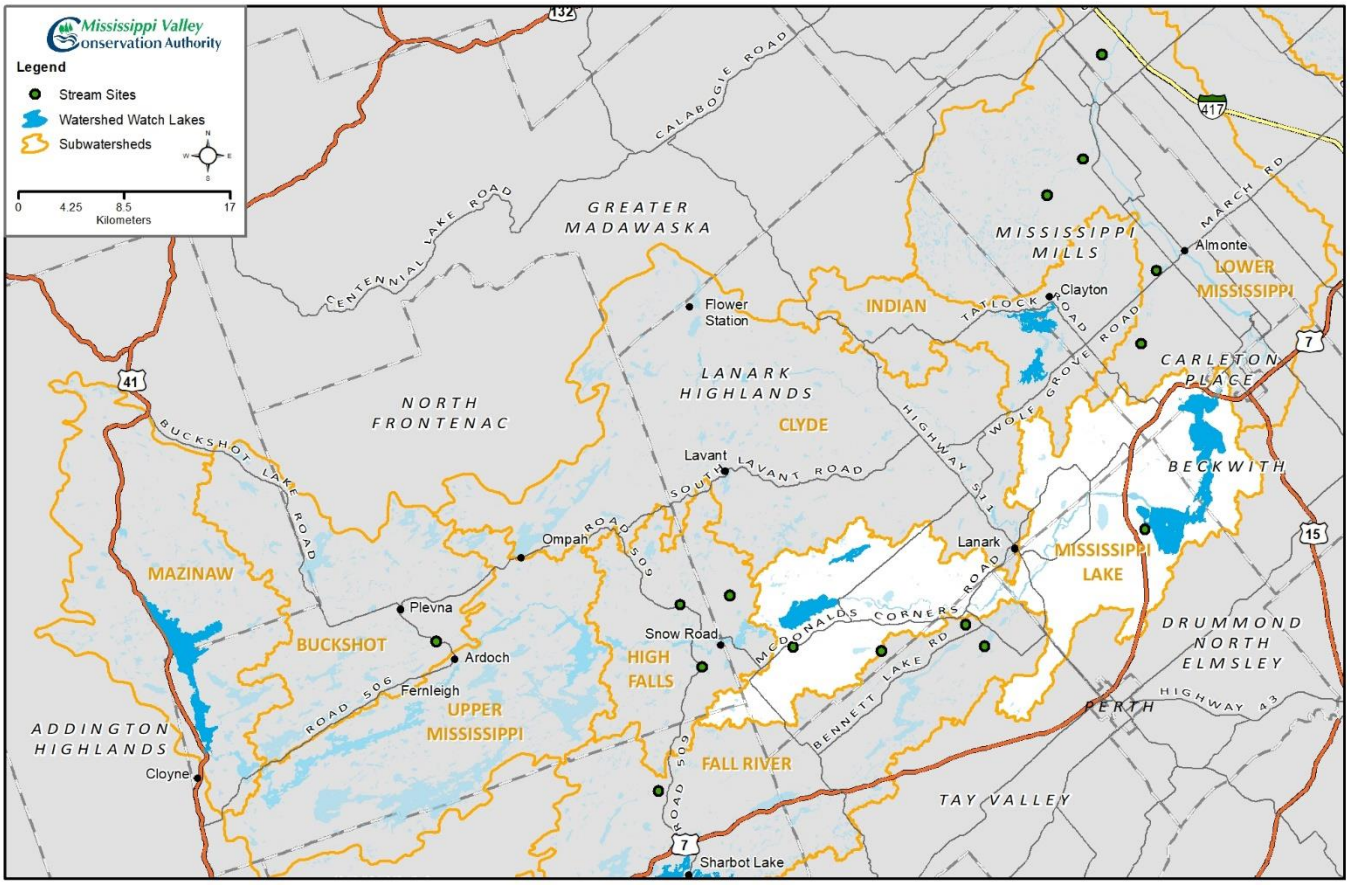


Figure 15: 2021 stream sampling site locations.

Temperature Monitoring

Many factors can influence fluctuations in stream temperature, including springs, tributaries, precipitation runoff, discharge pipes, and stream shading from riparian vegetation. The natural year to year variations of water temperatures can be influenced by many factors, (duration and frequency of rain events, flow rates from springs, changes in stream shading, etc.) and can have many impacts on the stress levels and success rates of the cold to cool water fish species that are found in the creek. Water temperature is used along with the maximum air temperature (using the revised Stoneman and Jones method by Cindy Chu *et al, 2009*) to classify a watercourse as either cold, cold-cool, cool, cool-warm, or warm water. Refer to Table 12 for a summary of the thermal classification results from the 2021 season.

Deploying a temperature logger

Temperature loggers were launched at 15 stream sites in the Mississippi River watershed to investigate thermal habitat availability and to continue monitoring known cold to cool water streams for potential variations due to changes in annual climate. As discussed further in the Water Quantity Summary, the 2021 season started with a less prominent melt coupled with below average rainfall in April and May. This resulted in MVCA issuing a Level 1 Low Water Condition Statement on June 9th which was in place until July 19th. Rainfall in June and July were above average and alleviated the spring drought conditions. While August had significant hot dry weather, flows and levels sustained normal conditions for the time of year.

Due to the frequency of rain events in July, most of the data used for classifying the 2021 results came from the August readings. Analysis of the temperature logger data indicates that the July rain events helped keep loggers submerged and the majority of the sites maintained past thermal classification ranges. There is a need for continued monitoring at stations prone to fluctuate between categories to determine if the observed thermal fluctuations are an ongoing trend or a temporary condition due to the hot dry conditions experienced in the last few summers.

Water temperature in Paul's Creek has now been monitored for four consecutive ice-free seasons. In 2017 the creek was classified as cool, however in 2018 the system was classified as a cool-warm system and has stayed within that range since then. Bolton Creek had a similar warming between a cool-warm classification in 2017 and a warm classification in 2018. In 2019 and 2020 Bolton Creek has remained classified as warm. Cold water fish are still found in both systems indicating that there are sufficient cool water refuges near the study sites to maintain these populations.

Mosquito Creek has been monitored for four years now and while it did range into the cold-cool category in 2019 is has predominantly been classified as a cool water system in 2018, 2020 and 2021.

Burbot, a cold-water fish, continues to be caught in Bolton Creek however analysis of the data from the temperature loggers have classified that reach as warm water habitat since 2018. This fish species may have a tolerance for late season warm water and/or it may find cooler refuge downstream of where we place the logger.

Lastly, in contrast to the observed warming discussed above, Long Sault Creek became cooler after 2017 it has remained within a cool water classification since then.

Table 12: A summary of the Mississippi River watershed stream sites sampled in 2021 with their thermal classification results. *Note, it may take many years of classification analysis to account for annual weather influences.

Subwatershed	Stream Name	2021 Thermal Classification	Number of Years Monitored	Thermal Trend Direction*
Buckshot Creek	Swamp Creek	Cool-Warm	1	-
Fall River	Bolton Creek: Hunter Side Rd	Warm	5	Warmed then Stable
Fall River	Bolton Creek: Burkes Settlement Rd	n/a	1	-
Fall River	Limekiln Creek	Cool-Warm	2	Warmed
High Falls	Antoine Creek	Cool	2	Stable
High Falls	Mosquito Creek	Cool	4	Stable
Lower Mississippi	Cartwrights Creek	Cool-Warm	2	Warmed
Lower Mississippi	Indian Creek: Sugar Bush Rd	Warm	1	-
Lower Mississippi	Indian Creek: Pakenham 9th Conc.	Cool-Warm	1	-
Lower Mississippi	Wolfe Grove Creek: Ramsay 8	Cool-Warm	3	Cooled then Stable
Lower Mississippi	Wolfe Grove Creek: Rae Rd	Cool-Warm	2	Cooler
Mississippi Lakes	Black Creek	n/a	3	Stable
Mississippi Lakes	Long Sault Creek	Cold-Cool	6	Cooler
Mississippi Lakes	McIntyre Creek	Warm	2	Warmed
Mississippi Lakes	Paul's Creek	Cool-Warm	6	Warmed then Stable

Rainbow Trout

Shoreline Stewardship

MVCA's Tree Planting Programs

Shoreline tree planting is an effective way to protect water quality, combat erosion, clean the water, and create healthy habitat for fish, birds, pollinators and other wildlife.

MVCA administers a small-scale shoreline planting program where MVCA staff conduct a site visit then work with the property owners to design a shoreline planting plan that will suit their property's needs. MVCA then orders, delivers and installs the plants according to the agreed upon plan. In 2021, this program resulted in 951 trees and shrubs being planted across 10 properties.

For the past three years, MVCA has been working with a select number of lake associations on a rotational basis to pilot a free tree event, where property owners are offered up to 15 shoreline plants per property. In 2021, MVCA partnered with the Sharbot Lake Association and the Dalhousie Lake Association to distribute 951 plants to 73 properties. Due to the continued success of this program within the lake community, MVCA will be working with Mazinaw Lake, Silver Lake, and the Bennett Lake and Fagan Lake Associations in 2022.

Lake Planning

2021 Activity Summary

MVCA has a mandated role to address natural hazard issues, such as flooding and erosion in the review of planning applications under the Planning Act. Additionally, in an advisory role, applications are reviewed within the context of Natural Heritage values such as wetlands, wildlife and fish habitat; as well as water quality and quantity. MVCA also administers Ontario Regulation 153/06. The purpose of this regulation is to prevent loss of life and property due to flooding and erosion, and to conserve and enhance natural resources. In MVCA regulated areas (floodplains, shorelines and wetlands), permission is required from MVCA for development, interference with wetlands, and alterations to shorelines and watercourses.

In 2021, MVCA planning and regulations staff reviewed 46 permit applications on the lakes monitored in 2021. This represents 13% of the total permits issued in 2021.

Having reliable information about the health of a lake is essential for providing appropriate and effective recommendations on development applications. The monitoring information is often used in the review of planning applications and may assist in developing mitigation recommendations so impacts of development are minimized.

Monitoring of our lakes also informs shoreline residents, both seasonal and permanent, of the lake health which encourages them to become stewards of their lake by taking an active role in restoring and enhancing their shoreline. Stewardship initiatives that protect and enhance water quality include temporarily storing water (eg. rain barrels), directing runoff away from the lake (e.g. installing properly working eavestroughs), creating or enhancing surfaces to allow more water to infiltrate rather than run off along the surface (e.g. rain gardens), and planting trees and shrubs along the shoreline.

Appendix A: Water Temperature and Dissolved Oxygen Profile Details

The results from the 2021 temperature and dissolved oxygen profiles from all the lake sampling events are presented below in alphabetical order. For the lakes with appropriate cool to cold water conditions, a colour code has been applied to the table representing optimal cold-water habitat conditions (in blue) and the fringe vital conditions for survival (in pink) as defined in Table A-1. Some of the warm water lakes may be shown to have these conditions periodically but they do not last throughout the season and thus they only support a warm water fishery.

Table A-2 summarizes the thermal classifications for the lakes sampled in 2021. Some of the cold-water lakes may no longer support certain cold-water fish species (such as lake trout) due to historical stocking activities or water level management efforts.

Table A-1: Optimal and vital habitat conditions for cold water fish species such as Lake Trout.

	Optimal Habitat for Cold Water Fisheries (Trout) = DO > 6 mg/L at < 10°C
	Vital Habitat for Cold Water Fisheries (Trout) = DO > 4 mg/L at < 15.5°C

Table A-2: List of cold water and warm water lakes monitored in 2021.

Cold Water Lakes	**Warm Water Lakes**
Mazinaw Lake	Dalhousie Lake
Sharbot Lake (west)	Sharbot lake (east)
	Mississippi Lake
	Patterson
	Clayton Lake
	Taylor Lake

Clayton Lake

Main Basin

	5/7/2021		7/15/2021		9/10/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.6	11.37	24.8	9.40	20.0	8.93
1	10.6	11.37	24.8	9.47	20.0	8.88
2	10.5	11.29	24.8	9.51	19.9	8.86
3	10.4	11.20	24.4	9.41	19.8	8.89
4	10.4	11.22	22.3	8.87	19.7	8.86
5	10.4	11.05	21.2	7.66		
6			19.1	1.89		
7			16.1	0.65		

Dalhousie Lake

Main Basin

	5/5/2021		7/5/2021		9/17/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.2	11.34	24.1	8.15	20.6	8.76
1	10.1	11.33	24.0	8.15	20.2	8.74
2	10.1	11.31	23.9	8.15	20.2	8.70
3	10.0	11.30	23.7	8.18	20.2	8.66
4	9.9	11.26	23.3	8.13	20.1	8.61
5	9.8	11.24	22.7	7.71	20.1	8.45
6	9.8	11.20	20.3	6.55	20.0	8.35
7	9.7	11.22	17.3	4.88	19.7	7.02
8	9.7	11.21	13.7	3.16	19.2	5.07
9	9.5	11.15	10.7	1.02	14.8	0.59
10	9.3	10.77	10.4	0.81	13.0	0.57
11	8.9	10.00	10.3	0.62		
12			10.1	0.53		
13			10.1	0.49		
14			10.1	0.50		

Mazinaw Lake

Campbell's Bay

	5/19/2021		7/19/2021		9/26/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	17.0	10.03	24.9	8.61	17.9	9.60
1	16.1	10.12	24.8	8.62	17.9	9.56
2	14.5	10.31	24.6	8.65	17.9	9.52
3	12.2	10.57	23.2	8.73	17.9	9.48
4	9.1	10.80	22.7	8.71	17.9	9.45
5	7.2	10.83	22.1	8.47	17.9	9.43
6	6.8	10.81	20.1	8.63	17.9	9.04
7	6.5	10.81	18.9	8.67	17.9	9.37
8	6.3	10.76	13.8	9.53	17.9	98.40
9	5.9	10.76	11.6	9.95	17.9	9.30
10	5.7	10.76	9.6	10.24	16.5	9.11
11	5.6	10.74	7.8	10.45	13.0	9.23
12	5.5	10.70	7.1	10.58	10.0	9.58
13	5.3	10.67			8.7	9.84
14	5.2	10.68			6.8	10.20
15	5.2	10.68			6.4	10.46
16	5.2	10.64				
17	5.1	10.62				
18	5.1	10.58				

South Basin

	5/19/2021		7/19/2021		9/26/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	18.1	9.84	24.0	8.80	18.0	9.50
1	17.1	9.93	23.9	8.84	18.0	9.47
2	15.7	10.27	23.8	8.84	18.0	9.44
3	12.1	10.84	23.1	8.76	18.0	9.43
4	9.5	11.02	21.6	8.71	18.0	9.42
5	9.0	11.01	20.7	8.77	18.0	9.40
6	8.4	11.00	18.7	8.93	18.0	9.39
7	8.1	10.92	15.0	9.54	18.0	9.37
8	7.8	10.83	11.3	10.15	18.0	9.34
9	7.3	10.78	8.7	10.34	12.9	9.39
10	7.0	10.75	8.3	10.31	9.6	9.42
11	7.0	10.74	7.7	10.33	8.5	9.51
12	6.8	10.70	7.3	10.39	7.9	9.47
13	6.7	10.67	7.2	10.18	7.6	9.46
14	6.6	10.62	7.0	10.18	7.4	9.50
15	6.4	10.58	6.9	10.24	7.2	9.49
16	6.2	10.57	6.9	10.23	7.1	9.47
17	6.0	10.58	6.7	10.16	7.0	9.45
18	6.0	10.58	6.7	10.14	6.9	9.47
19	5.9	10.51	6.6	10.17	6.8	9.45
20	5.8	10.50	6.6	10.16	6.7	9.46
21	5.8	10.48	6.6	10.17	6.6	9.52
22	5.7	10.48	6.5	10.26	6.6	9.51
23	5.7	10.44	6.4	10.31	6.4	9.51
24	5.6	10.43	6.3	10.26	6.4	9.51
25	5.6	10.42	6.2	10.25	6.3	9.49
26	5.6	10.40	6.2	10.18	6.2	9.51
27	5.6	10.37	6.0	10.12	6.2	9.50
28	5.5	10.38	5.9	10.12	6.1	9.52
29	5.5	10.36	5.9	10.11	6.1	9.51
30	5.5	10.34	5.9	10.09	6.1	9.53
31	5.5	10.31	5.9	10.00	6.1	9.56
32	5.5	10.30	5.9	10.10	6.1	9.58
33	5.5	10.28	4.9	10.10	6.0	9.57
34	5.5	10.25	5.9	10.16	6.0	9.56
35	5.5	10.22	5.9	10.15	5.9	9.50
36	5.5	10.20	6.0	10.02	5.8	9.47
37	5.5	10.19	5.9	10.05	5.8	9.42

38	5.5	10.17	5.8	10.08	5.8	9.41
39	5.5	10.15	5.8	10.07	5.7	9.40
40	5.5	10.13	5.8	10.07	5.7	9.38
41	5.5	10.11	6.8	10.06	5.7	9.35
42	5.5	10.11	5.8	10.06	5.7	9.34
43	5.4	10.10	5.7	10.07	5.7	9.32
44	5.4	10.08	5.7	10.04	5.7	9.32
45	5.4	10.08	5.7	10.01	5.7	9.30
46	5.4	10.07	5.7	10.00	5.7	0.84
47	5.4	10.06	5.7	9.98	5.7	0.72
48	5.4	10.04	5.7	9.96		
49	5.4	10.02	5.7	9.93		

Mississippi Lake

Inlet

	5/6/2021		7/9/2021		9/21/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.6	11.46	21.7	8.18	20.2	9.08
1	10.6	11.47	21.7	8.11	20.3	9.02
2	10.6	11.46	21.7	8.02	20.3	9.00
3	10.6	11.45	21.6	7.83	20.2	8.99
4	10.6	11.44	21.4	7.53	20.2	8.98
5	10.5	11.47	20.6	5.98	20.2	8.81
6	10.5	11.46	14.3	1.51	19.7	7.95
7	10.5	11.45	12.5	0.91	17.3	1.68
8	10.5	11.47	11.2	0.67	13.7	0.63
9	10.5	11.52	10.9	0.64	12.1	0.60

Burnt Island

	5/6/2021		7/9/2021		9/21/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.5	12.19	21.6	8.68	n/a	n/a
1	10.4	12.20	21.7	8.57		
2	10.4	12.18	21.7	8.50		
3	10.3	12.20	21.7	8.50		
4	10.3	12.19	21.8	8.46		
5	10.3	12.18	21.8	8.46		
6	10.3	12.15	21.7	8.55		
7	10.1	12.18	21.6	8.57		
8	10.2	12.13	21.6	8.55		
9	10.1	11.99				

Pretties Island

	5/6/2021		7/9/2021		9/21/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.5	12.14	21.8	8.51	19.9	9.02
1	10.2	12.14	21.9	8.47	19.9	8.97
2	10.0	12.12	21.9	8.44	20.0	8.96
3	10.0	12.07	21.9	8.40	20.0	8.92
4	10.0	12.05	21.8	8.32	20.0	8.91
5	9.9	12.01	21.7	8.25		
6	9.9	11.94				

Outlet

	5/6/2021		7/9/2021		9/21/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.1	12.63	20.0	8.76	19.9	9.84
1	10.0	12.65	20.0	8.73	19.9	9.83
2	9.9	12.68	20.0	8.73	19.9	9.81

Patterson Lake

Main Basin

	5/13/2021		7/6/2021		9/14/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	12.3	11.01	24.2	9.42	19.9	9.16
1	12.1	11.02	24.1	9.45	19.9	9.12
2	12.0	11.03	23.9	9.46	19.9	9.10
3	11.7	11.02	23.8	9.45	19.9	9.08
4	10.8	10.98	23.8	9.40	19.9	9.03
5	10.2	10.80	20.4	9.36	19.8	9.00
6	9.9	10.48	14.9	9.50	19.8	8.95
7	9.1	9.45	11.0	6.89	14.3	4.32
8	7.7	7.61	9.4	5.00	11.0	1.96
9	6.0	4.57	7.9	1.62	9.1	0.87
10	5.7	4.25	7.0	0.77	7.8	0.69
11	5.5	3.72	6.3	0.58	6.8	0.59
12	5.3	3.40	6.0	0.50	6.5	0.55
13	5.2	3.12	5.9	0.48	6.3	0.54
14	5.1	3.02	5.8	0.46	6.2	0.53
15	5.1	3.02	5.8	0.46		
16	5.0	2.97				
17	4.9	2.89				

Sharbot Lake

Main East

	5/18/2021		7/16/2021		9/30/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	17.2	10.20	24.4	8.81	17.7	10.26
1	16.6	10.20	24.3	8.83	17.7	10.24
2	14.3	10.66	24.0	8.85	17.7	10.20
3	14.3	10.66	23.9	8.84	17.7	10.18
4	12.4	10.97	23.8	8.82	17.7	10.15
5	11.2	10.83	22.2	8.60	17.7	10.13
6	10.5	10.76	20.0	8.36	17.7	10.11
7	9.8	10.55	15.0	9.35	17.7	10.09
8	9.2	10.42	11.7	9.66	17.7	10.07
9	8.8	10.33	10.3	9.33	15.6	7.63
10	8.6	10.28	9.4	9.02	10.9	7.73
11	8.3	10.16	8.9	8.85	9.6	7.62
12	7.9	10.03	8.4	8.66	8.8	7.25
13	7.6	9.92	8.0	8.55	8.0	6.73
14	7.5	9.91	7.6	8.42	7.6	6.72
15	7.2	9.78	7.2	8.14	7.1	6.60
16	6.9	9.67	6.9	8.04	6.9	6.25
17	6.7	9.64	6.6	8.05	6.4	6.04
18	6.4	9.43	6.5	8.05	6.3	5.57
19	6.2	9.38	6.3	7.97	6.2	5.51
20	6.0	9.26	6.2	7.80	6.0	5.00
21	6.0	9.18	6.1	7.62	6.0	3.68
22	5.9	9.16	6.1	7.23	6.0	2.46
23	5.8	9.13	6.0	7.21	6.0	1.64
24	5.8	9.06	6.0	7.09		
25	5.7	9.04	6.0	7.07		
26	5.7	8.98	5.9	6.95		
27	5.6	8.88	5.8	6.17		
28	5.5	8.65				
29	5.5	8.59				
30	5.5	8.42				
31	5.4	8.04				

Main West

	5/18/2021		7/16/2021		9/30/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	17.2	10.20	24.4	8.81	17.7	10.26
1	16.6	10.20	24.3	8.83	17.7	10.24
2	14.3	10.66	24.0	8.85	17.7	10.20
3	14.3	10.66	23.9	8.84	17.7	10.18
4	12.4	10.97	23.8	8.82	17.7	10.15
5	11.2	10.83	22.2	8.60	17.7	10.13
6	10.5	10.76	20.0	8.36	17.7	10.11
7	9.8	10.55	15.0	9.35	17.7	10.09
8	9.2	10.42	11.7	9.66	17.7	10.07
9	8.8	10.33	10.3	9.33	15.6	7.63
10	8.6	10.28	9.4	9.02	10.9	7.73
11	8.3	10.16	8.9	8.85	9.6	7.62
12	7.9	10.03	8.4	8.66	8.8	7.25
13	7.6	9.92	8.0	8.55	8.0	6.73
14	7.5	9.91	7.6	8.42	7.6	6.72
15	7.2	9.78	7.2	8.14	7.1	6.60
16	6.9	9.67	6.9	8.04	6.9	6.25
17	6.7	9.64	6.6	8.05	6.4	6.04
18	6.4	9.43	6.5	8.05	6.3	5.57
19	6.2	9.38	6.3	7.97	6.2	5.51
20	6.0	9.26	6.2	7.80	6.0	5.00
21	6.0	9.18	6.1	7.62	6.0	3.68
22	5.9	9.16	6.1	7.23	6.0	2.46
23	5.8	9.13	6.0	7.21	6.0	1.64
24	5.8	9.06	6.0	7.09		
25	5.7	9.04	6.0	7.07		
26	5.7	8.98	5.9	6.95		
27	5.6	8.88	5.8	6.17		
28	5.5	8.65				
29	5.5	8.59				
30	5.5	8.42				
31	5.4	8.04				

North West

	5/18/2021		7/16/2021		9/30/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	16.4	10.32	24.6	8.77	17.8	10.09
1	15.9	10.39	24.1	8.83	17.8	10.06
2	14.3	10.68	23.7	8.88	17.8	10.02
3	13.9	10.79	23.6	8.84	17.8	10.00
4	12.7	10.91	22.8	8.81	17.8	9.98
5	11.4	10.91	22.4	8.68	17.8	9.96
6	10.6	10.81	20.3	8.31	17.8	9.95
7	9.5	10.51	14.6	9.46	17.8	9.91
8	9.0	10.44	11.1	9.76	17.7	9.87
9	8.5	10.24	10.0	9.44	13.7	7.53
10	8.1	10.15	9.3	9.01	11.3	7.52
11	8.0	10.05	8.8	8.73	10.0	7.34
12	7.9	10.00	8.4	8.56	9.1	6.90
13	7.4	9.78	8.0	8.21	8.3	6.00
14	7.1	9.58	7.6	7.75	7.9	5.39
15	6.9	9.50	7.4	7.68	7.6	4.94
16	6.8	9.42	7.3	7.30	7.5	4.65
17	6.8	9.31	7.2	7.13	7.4	4.35
18	6.8	9.28	7.2	7.14	7.4	4.17
19	6.7	9.22	7.1	6.99	7.3	3.80
20	6.6	9.15	7.1	6.82	7.2	3.51
21	6.6	9.10	7.1	6.60	7.2	3.39
22	6.6	9.06	7.1	6.54	7.2	3.27
23	6.6	9.03	7.1	6.51	7.2	3.30
24	6.6	9.01	7.0	6.47	7.2	3.28
25	6.6	8.99	7.0	6.13	7.2	3.23
26	6.6	8.97	7.0	5.51	7.2	0.99
27	6.6	8.94				
28	6.5	8.92				
29	6.5	8.90				
30	6.5	8.85				

South West

	5/18/2021		7/16/2021		9/30/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	16.0	10.20	25.0	8.85	17.8	9.71
1	15.8	10.22	24.4	8.85	17.8	9.70
2	14.6	10.52	24.2	8.89	17.7	9.66
3	13.1	10.74	24.0	8.89	17.7	9.65
4	11.4	10.72	22.6	8.70	17.7	9.64
5	10.4	10.50	21.6	8.40	17.7	9.61
6	9.8	10.23	19.4	8.13	17.7	9.58
7	9.5	10.11	15.0	8.13	17.7	9.58
8	9.4	9.90	11.9	7.05	17.2	6.23
9	9.1	9.56	10.7	4.73	13.5	0.85
10	8.9	9.05	10.0	2.63	11.9	0.74
11	8.7	7.60	9.6	1.79	11.0	0.68

Taylor Lake

Main Basin

	5/7/2021		7/15/2021		9/10/2021	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	11.5	11.89	25.5	9.72	19.9	9.62
1	11.4	11.89	25.5	9.74	19.9	9.62
2	11.3	11.90	25.4	9.80	19.8	9.67
3			24.3	9.38		