Integrated Monitoring Report
2016 Season

March 2017

(Revised June 2017)

Mississippi Valley Conservation Authority

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Executive Summary

The goal of this integrated monitoring report is to present a snapshot of the monitoring that MVCA undertook during the 2016 season. It is meant to replace the individualized lake reports previously created for the Watershed Watch (WW) program. As such, the emphasis of the report is on lake monitoring but also includes water levels and flow, snow pack, and fish data. Each subwatershed within the Mississippi Valley will be on a five year rotation for this more in depth analysis, with the Clyde River subwatershed being in focus for 2016. We are hoping that this strategy will give readers a more holistic understanding of the watershed and potentially shed some light on the collected results. In addition to the focus on the Clyde, three lakes along the main stem of the Mississippi River and two auxiliary lakes were also sampled.

Along with the change in reporting format, a review of the Watershed Watch program in 2016 revealed opportunities to maximize the collection of data with current time and resources. Changes occurring from this review include a new lake rotation, removal of parameters, and adjustments to sampling protocol. We believe this will serve the program well moving forward.

The most significant factor affecting the lakes and streams in the summer of 2016 was the severe drought seen across the watershed. Water levels and flow were at historic lows for much of the summer. The lack of wind disturbance also influenced the dissolved oxygen levels of lakes, which can have drastic effects on the survival of many fish species. On top of the ecological issue, this disturbance can have social and economic repercussions when it alters the productivity of recreational and sport fisheries.

Overall, the lakes in the Clyde Subwatershed largely maintained their historic trends in Total Phosphorus, Secchi depth, and pH despite drought conditions. Only two exceedances of the Provincial Water Quality Objective for Total Phosphorus (20µg/L) occurred this year, likely caused by local effects such as a precipitation event shortly before sampling. The coldwater lakes, Palmerston and Canonto maintained summer thermal stratification, ensuring sufficient dissolved oxygen levels for native fish species.

As expected for a cool water system, coldwater fish species (Burbot and Rainbow Trout) were found in two of the Clyde tributaries. As the effects of climate change escalate, increasing water temperatures in our watershed are a concern. Moving forward, a focus of the stream monitoring program will be to observe changes in fish community composition, as this can be an indicator of changing thermal regimes. Fortunately, the high forest cover and low population density in the Clyde subwatershed provides many services to maintain the health of the water, including buffering the effects of a changing climate.

This report emphasizes the value of the monitoring conducted through MVCA's Water Management, Watershed Watch, and Stream Monitoring programs. It also highlights some gaps in these programs. While we have tried to address a few of these with revisions to the WW protocol, lack of baseline stream data still remains an issue. Focusing on these gaps will allow the MVCA to provide a better understanding of ecological trends to stakeholders, which will assist in future decision-making.

Introduction

The Watershed Watch (WW) program was initiated at the Mississippi Valley Conservation Authority (MVCA) in 1998 in partnership with the Mississippi Valley Lake Stewardship Network, with the goal to accumulate reliable environmental data on the plentiful and diverse lakes within the watershed. Despite various adjustments to the protocol throughout the years, the program has remained a fundamental part of MVCA's monitoring schedule and continues to provide valuable baseline data while promoting stewardship of these important features. A review of the program in 2016 highlighted some aspects of the program that required adjustment, including the lake rotation, parameters, and sampling protocol.

One of the major concerns with the former lake rotation was the amount of time between sampling events. With the previous rotation, each lake was sampled for one season every five years. Because of inter-annual environmental variation (for example a drought year) this was too long of a sampling gap to provide accurate water quality trends. To collect more frequent data, a new rotation was established that places more emphasis on the lakes near the main stem of the Mississippi River. We believe this change will allow MVCA to monitor more closely the trends of those lakes that are most indicative of the general health of the watershed.

Another notable change to the Watershed Watch protocol this year was the removal of chlorophyll *a* sampling. While chlorophyll *a* is a good indicator of lake trophic status because of its presence in phytoplankton, the sampling procedures required to calculate an accurate average annual concentration are too extensive for the purposes of the Watershed Watch program. More specifically, the literature recommends a minimum of 5 – 10 sampling events per year to achieve a reasonable confidence in the results reflecting the true nature of the lake, but current resources only allow for three visits to each lake in a sampling season. As such, this parameter provided very little useful data at a high cost and we determined it was best to remove it from the program. Changes have also been made to streamline the total phosphorus sampling and more detail on this can be found in the methodology section below.

As previously mentioned, the main goal of the Watershed Watch program is to collect reliable environmental data and monitor trends on the lakes of the Mississippi Valley watershed. However, it is worth noting that while in an ideal world we would have the resources to conduct extensive research on every lake each year, the reality is that this program is designed solely to collect *baseline* data and to monitor *general* trends. That is to say, we are collecting relatively simple data on parameters that are easily reproducible and that give a broad idea of changes in water quality. While the data can be used in conjunction with other data, it is insufficient on its own for any environmental impact studies that may need to be conducted on a lake due to development projects etc. Should stewards be interested in more detailed yearly assessments of their lake, we would recommend considering the Lake Partner Program (LPP) through the Dorset Environmental Science Centre. With willing volunteers from your lake association this program provides an excellent framework, as well as equipment, for reliable and detailed yearly data collection. It is also an excellent means to promote awareness and ownership of lake health.

Seasonal Conditions

Three types of water *quantity* monitoring occurred in the Clyde subwatershed in 2016; snow pack, water levels, and water flow. Figure 1 portrays the locations of the gauges used to collect level and flow data, the snow courses where snow pack is measured, and the locations of the Watershed Watch sites.

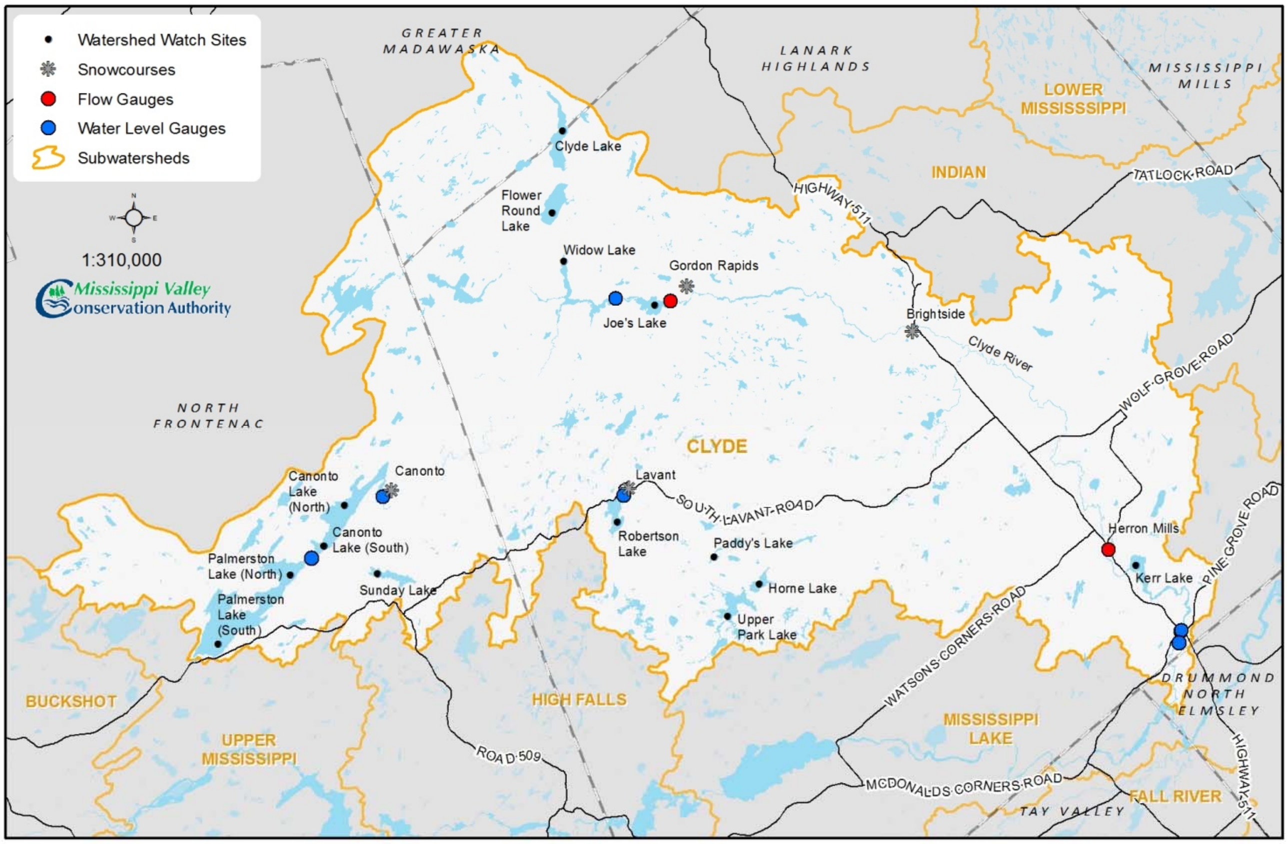


Figure 1: Various water quantity measuring sites in the Clyde subwatershed, plus Watershed Watch sites.

Snow Pack

Snow pack is measured at various spots around the watershed and provides information on the expected spring runoff for that year. This helps inform MVCA on potential runoff that assists in dam operations and flood forecasting for the entire watershed. Water management is critical in order to minimize flood damage, maintain flows and levels for fish and wildlife and meet the target levels for summer recreational activities. There are four snow courses used to determine spring runoff in the Clyde subwatershed; Canonto, Gordon Rapids, Brightside, and Lavant. The results for 2016 can be seen in Figure 2. The vertical bars represent snow pack level, and the horizontal lines represent historical averages for the associated snow course.

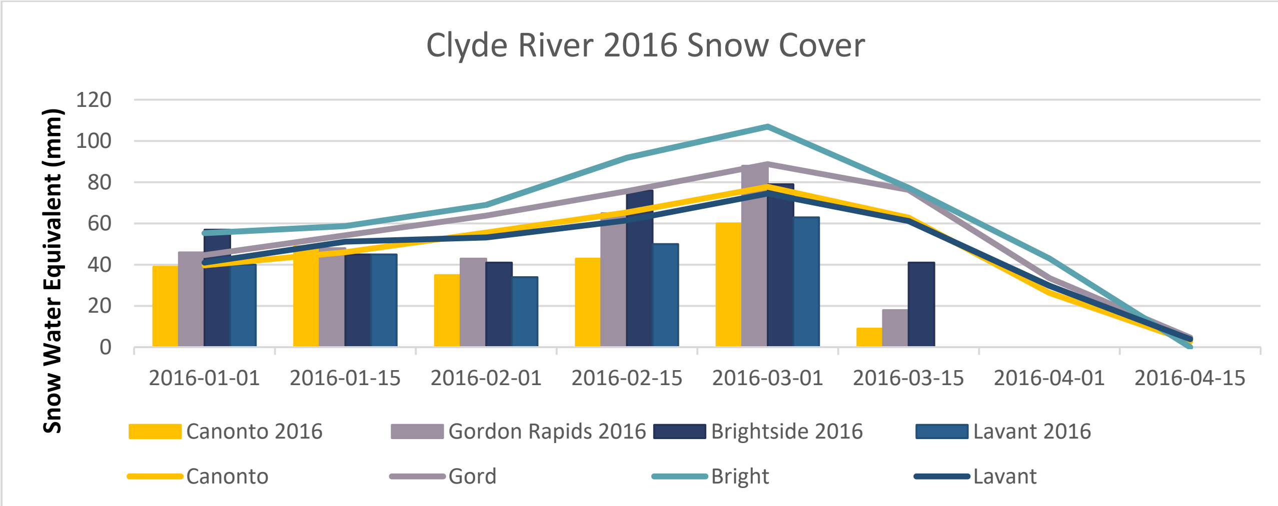


Figure 2: 2016 Snow pack levels vs. historical averages.

From January through to the beginning of March the watershed had near the historical average in snow water content. By the middle of March the majority of that snow had disappeared and runoff was evident in creeks and lakes. Long range forecasts indicated a warm and dry spring and a hot and dry summer. This information led to the decision to keep many headwater lakes at higher levels in preparation for low water levels.

Water Levels and Precipitation

Water levels are most often measured at gauges at the MVCA owned and/or operated dams around the watershed. Precipitation gauges are normally located with streamflow sites on tributaries and the main stem of the Mississippi River. For the purpose of this report we analyzed data at two locations: the most upstream site on the Clyde system (Palmerston Lake – level gauge at dam, precipitation gauge at Buckshot Creek), and the most downstream site (Lanark – level gauge at bridge, precipitation gauge at Herron Mills site). Figures 3a and 3b are the levels seen over the entire 2016 year.

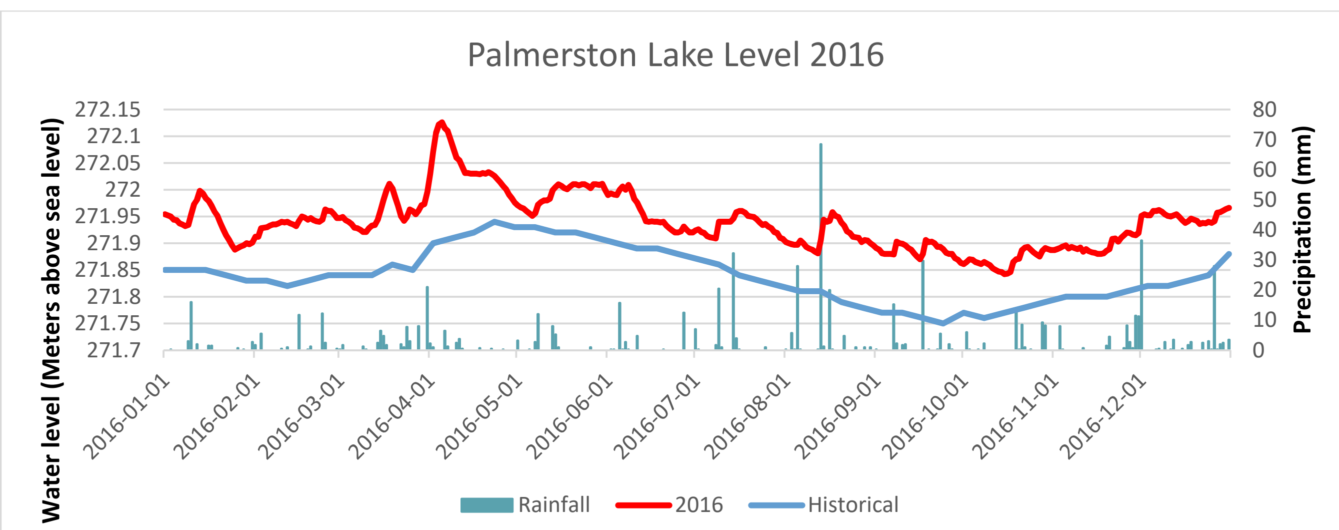


Figure 3a): Water levels and precipitation for 2016 at Palmerston Lake.

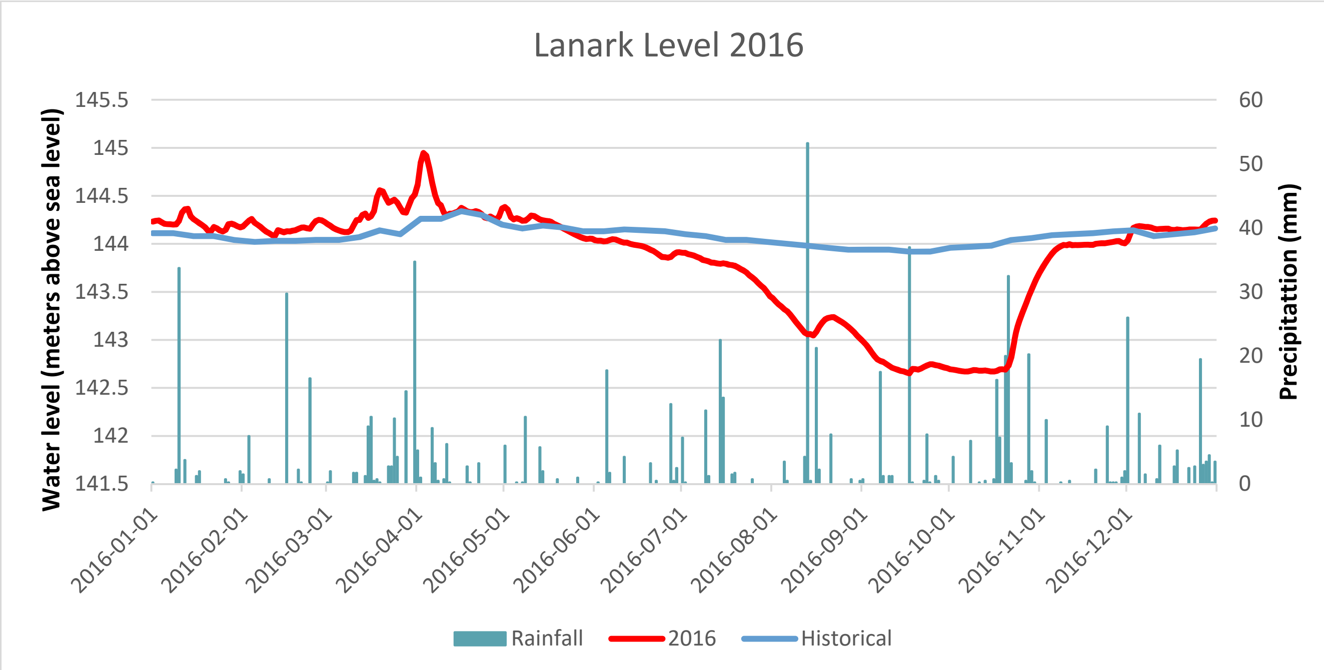


Figure 3b): Water levels and precipitation for 2016 at Lanark.

Palmerston Lake dam.

A few things should be noted on the above graphs. Despite the severe drought conditions over the summer, Palmerston Lake levels remained above average over the year. Palmerston Lake is one of the headwater lakes of the Clyde River and has a dam at the outlet. At the start of the summer, the long range forecast was for hot and dry conditions. Water levels in many of the lakes, including Palmerston and Canonto, were maintained at the top end of the summer target range for as long as conditions would allow. As can be seen by the graph, levels on Palmerston Lake were typically 10 cm above the historic normal for the lake which allowed some flows to be maintained out of this lake throughout the summer.

In contrast, the levels at the Lanark Bridge were below average for the majority of the summer and fall. Located at the downstream end of the Clyde River, the water must pass through many features before reaching Lanark. With the extremely dry conditions of 2016, much of the water was used up or evaporated before having the chance to reach this dam. That being said, water levels at this location were even lower than expected as a result of the drought and conditions observed in other areas of the watershed. Investigations did not uncover any satisfactory answers. The system returned to what would be considered normal (for the existing drought conditions) around October 1st with no significant precipitation events driving that response.

Also found in these graphs are daily precipitation levels. Note that the majority of the precipitation events in 2016 were less than 10 mm; an insufficient amount to provide any significant recharge to the system. However, with the occasional large rain event (eg. >60mm on Aug 13), we see an associated increase in water level.

Finally, another factor affecting water levels around the watershed was the number days of over 30°C temperatures throughout the summer. This contributes to greater evaporation and likely drier soil moisture conditions.

Flow

There are two stream flow gauges in the Clyde subwatershed; Gordon Rapids (upstream in the Clyde; just down from Joe's Lake), and Herron Mills (downstream on the Clyde; upstream of Kerr Lake). The data collected by these gauges is another piece of the puzzle used to assist with water management decisions. Flows for these two gauges can be seen below (Figures 4a and 4b).

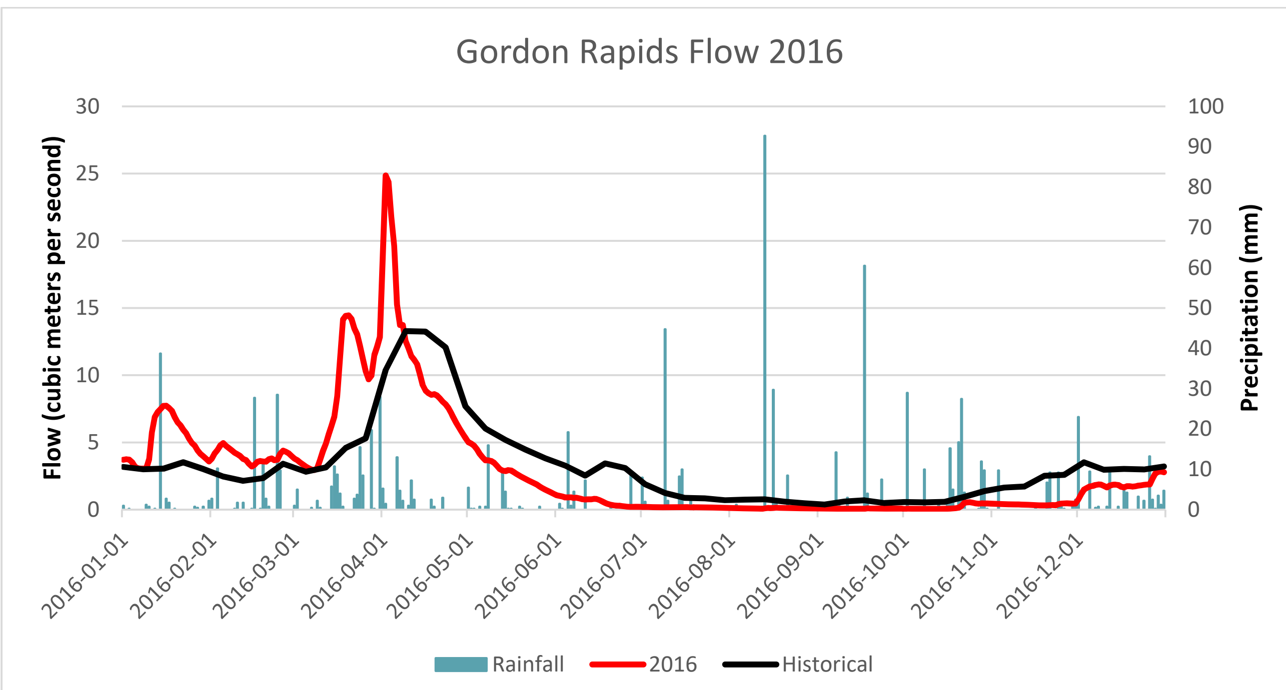


Figure 4a): Water flows and precipitation at Gordon Rapids.

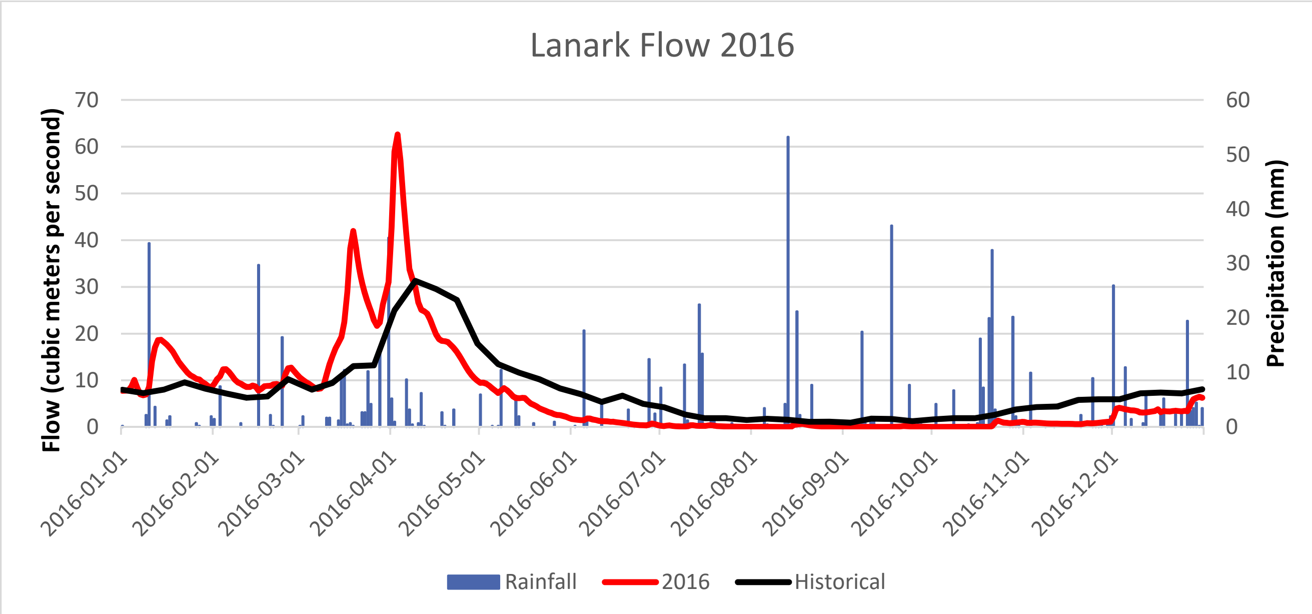


Figure 4b): Water flows and precipitation at the Lanark stream gauge.

Stream gauge on the Clyde River.

The large increase in flow around April is a normal occurrence and is representative of the runoff associated with the spring freshet.

After the freshet, levels dropped very quickly below the historical average and remained there until September. While the general shape of these graphs is normal for stream flow, the absolute values are below average.

Similar to the water level graphs, we notice in Figures 4a and 4b that there is very little response in flow with most precipitation events. This may be a result of the incredibly low soil moisture content throughout the watershed in 2016. The extreme drought conditions (caused largely by minimal snow pack runoff and little precipitation) caused a decrease in the soil moisture content. So, any rain that did fall was largely absorbed by the soil rather than running off into streams causing an increase in flow. This lack of response to precipitation is another indication of the extremely dry conditions that had accumulated over the summer and was a contributing factor to the eventual declaration of Level III Drought status for a large part of the summer.

Indicators and Methodology

The Watershed Watch program tests for numerous water quality parameters. These parameters are selected for their relative simplicity of collection, reproducibility, and ability to contribute to trophic status determination. Most of the indicators (Secchi depth, pH, D.O., temperature, calcium) can be determined on site using a handheld probe or other simple equipment. Total phosphorus is the only parameter that requires the collection of a water sample and shipping of the sample to a lab for analysis.

Total Phosphorus (TP)

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 we tend to see adverse effects such as algae blooms. It can be found in many man-made products such as soaps, detergents, fertilizers and septic waste. Total phosphorus is measured in micrograms per litre (μg/L).

As part of the Watershed Watch program, two types of total phosphorus levels are measured at each sampling location: euphotic zone phosphorus and bottom phosphorus. The euphotic zone is defined as twice the Secchi depth and is the depth to which light can reach and influence plant growth. Sampling this zone involves a mixing bottle method which collects water from throughout the whole euphotic depth. This provides an indication of phosphorus levels available to plant life in the lake.

The bottom phosphorus sample is collected at approximately 1 meter off the bottom of the lake, at sites that have a depth greater than the euphotic zone, using a device called a Kremmerer Bottle. The bottle is sent down to the appropriate depth with both ends open, then a weight on the rope is dropped, causing both ends to close and 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 1 below. It should be noted that while these numbers provide an idea of a lake's 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 within years, so it is important to look at larger trends rather than one or two exceptional years.

Table 1: Interpreting Total Phosphorus Results

Total Phosphorus Level	Lake Trophic Status
0 – 10 μg/L	Oligotrophic – unenriched, few nutrients
10 – 20 μg/L	Mesotrophic – moderately enriched, some nutrients
>20 μg/L	Eutrophic – enriched, higher levels of nutrients

Source: Water Management, Policies and Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy. MOE. 1994.

The Provincial Water Quality Objective (PWQO) for phosphorus in lakes is 20 ug/L. The goal is to maintain phosphorus below this level to help ensure aquatic health and maintain the recreational value of our lakes.

2016 Protocol Changes to TP

A few notable changes were made to the total phosphorus sampling protocol this year.

First, we began filtering the samples through an 80 µm mesh filter before filling the sample bottles. This protocol has been in practice by the Lake Partner Program and by other conservation authorities for numerous years now with favourable results. The primary goal is to reduce the number of artificially high TP results caused by zooplankton in the sample. These microscopic planktonic organisms contain exceptionally high levels of phosphorus compared to lake water, so when they occasionally get picked up in a sample, results are not indicative of the true total phosphorus of the water. Filtering helps to prevent this. Furthermore, by following the same guidelines as the LPP and other CAs, we can more confidently compare results between these programs.

The second small change to the TP protocol made was not collecting a bottom sample if the euphotic zone was greater than the depth at the sampling point. This was to avoid duplicate results, because in these conditions the euphotic zone sample would include water from the bottom of the lake.

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. As the disc is lowered, the point at which you can no longer see the disc is noted as well as the point at which it reappears when it is brought back up. The average of these two numbers is your Secchi depth. The greater your Secchi depth, the clearer your lake is. As previously mentioned, the Secchi depth also helps determine the euphotic zone (the depth through which light is able to penetrate). Two times the Secchi depth equals the depth of the euphotic zone.

Secchi depth can be influenced by the concentration of algae in the water. Usually, 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.

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

Source: Water Management, Policies and Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy. MOE. 1994.

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, while 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.

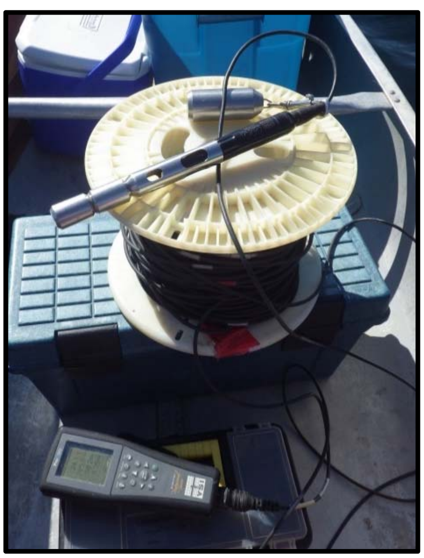
Calcium

Calcium in lakes is a measure of the levels of Ca^{2+}, Mg^{2+} and 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 various ways but is usually done either as the concentration of free calcium ions (Ca^{2+}) (mg/L) or, because most hard water ions stem from calcium carbonate, as calcium hardness as $CaCO_3$ (mg/L). For this program, we measure Calcium Hardness (in mg/L as $CaCO_3$) in the field then the result is multiplied by 0.4 to determine the concentration of Ca^{2+} freely available in the water. Ca^{2+} 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, as a component in the cell walls of aquatic plants, or eventually deposited into the sediment of the lake. Because of its importance in shell/body coverings, calcium has been shown to change zooplankton (small planktonic invertebrates) communities, which are an important food source for many baitfish species, and is also the limiting factor in the occurrence of Zebra Mussels.

Dissolved Oxygen (D.O.)

Adequate dissolved oxygen levels are critical to good water quality and are 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) biomass produced in the lake.



Pro ODO (Optical Dissolved Oxygen Probe).

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. Lakes that stratify during the summer are characterized by a warm epilimnion separated from a cold hypolimnion by a layer of water where temperature rapidly declines with depth, known as the metalimnion or thermocline. D.O. is at its lowest during the late summer and early fall as water in the hypolimnion cannot recharge its oxygen concentrations since it is isolated from the atmosphere by the epilimnion and thermocline. This can result in low dissolved oxygen in the hypolimnion which may have detrimental effects on aquatic species that regularly inhabit this part of the lake.

Phytoplankton production also plays a role in the concentration of dissolved oxygen. When phytoplankton die and settle to the lake bottom, they are decomposed by bacteria. This bacteria consumes large amounts of oxygen, reducing the concentrations available for fish and other organisms living in the hypolimnion.

Dissolved Oxygen is measured using an Optical Dissolved Oxygen Probe. This instrument, pictured above, is lowered through the water at one meter increments, where it takes both temperature and D.O. readings. This creates a dissolved oxygen profile where we can see the changes in temperature and D.O. as the depth increases. Table 3 shows the optimal temperature/D.O. combinations for cold, cool, and warm water fish habitat.

Table 3: Optimal Conditions for Different Fish Habitat

	Dissolved Oxygen	**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.

2016 Lakes

As previously mentioned, the lake rotation underwent some changes in 2016. In order to allow greater monitoring effort on the main Mississippi River line, lakes directly along the river are now being sampled every two years, those in the main subwatersheds feeding into the river will be sampled every three years, and the remaining lakes will be visited either every five or eight years. This new rotation will allow more data for those lakes that are more indicative of the health of the watershed, who also have higher pressures associated with a larger shoreline population, while maintaining at least the same number of sampling events for the majority of the remaining lakes. Only small headwater lakes with minimal development activity located away from the main Mississippi branches have decreased from every five years to every eight years for sampling. This will allow us to keep monitoring for any extreme changes, while opening up resources for higher traffic lakes. See Appendix A for the full updated rotation.

In 2016, focus was on the Clyde River subwatershed. The Clyde River is a cool water system with headwater lakes that include Palmerston Lake and Canonto Lake in North Frontenac, and Flower Round Lake and Joe's Lake in Lanark Highlands. From there the river moves southwest, passing through Kerr Lake, finally meeting the Mississippi River just south of the town of Lanark. Also included in the sampling rotation were Robertson and Sunday lakes.

There are a number of dams along this system that MVCA manages. An MVCA owned and operated dam can be found just downstream of Widow Lake, and one in the town of Lanark. Furthermore, two Ministry of Natural Resources and Forestry (MNRF) owned but MVCA operated dams stand at the outlet of both Palmerston and Canonto Lakes.

In total, three lakes along the main Mississippi line, seven in the Clyde subwatershed and two auxiliary lakes in other subwatersheds made for a total of twelves lakes sampled in 2016. The main Mississippi lakes were Mazinaw, the headwater lake at the top (west end) of the watershed; Crotch Lake, an important offline reservoir feature; and Dalhousie Lake, an online lake about halfway along the Mississippi River. Table 4 lists the lakes sampled in 2016, along with their subwatershed.

Table 4: Lakes Sampled in 2016 and Associated Subwatershed

Mississippi Main Stem	**Clyde Subwatershed**	**Auxiliary Lakes**
Mazinaw Lake (*Mazinaw*)	Canonto Lake	Ardoch Lake (*Upper Mississippi*)
Dalhousie Lake (*High Falls*)	Palmerston Lake	White Lake (*Fall River*)
Crotch Lake (*Upper Mississippi*)	Flower Round Lake	
	Joe's Lake	
	Kerr Lake	
	Robertson Lake	
	Sunday Lake	

Watershed Watch Results

The following pages are the Watershed Watch results for 2016, organized by water flow from the top of each watershed to the bottom starting with the main Mississippi branch lakes, then the Clyde River subwatershed lakes, and lastly the auxiliary lakes.

Most lakes followed their previous year's trends with only two samples uncharacteristically exceeding 20 ug/L of total phosphorus. This occurred in the south basin of Crotch Lake on the main Mississippi branch, and on Flower Round Lake in the head waters of the Clyde River subwatershed. Both these exceedances are thought to be due to the influence of runoff from a recent rain event prior to sample collection.

Appendix B contains the dissolved oxygen and temperature profile values for 2016 for each lake in alphabetical order and all seem to be within reasonable ranges for the time of year they were taken.

Appendix C contains the results of our invasive species sampling program which is undertaken annually in partnership with the Ontario Federation of Anglers and Hunters. A positive result was found for Spiny Waterflea in Crotch Lake and a suspect result was found for Zebra Mussels in Silver Lake. All other lakes came back negative.

Robertson Lake

Main Mississippi Line Lakes

Mazinaw Lake

Table 5: North Basin (Campbell's Bay)

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
6/3/2016	12:30:00	4.5	4 (#1), 8 (#2)	5 (#1), 5 (#2)	8.14	16
7/19/2016	12:30:00	5.75	3	5	7.99	n/a
9/1/2016	12:40:00	4.2	4	4	8.01	n/a

Table 6: South Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
6/3/2016	11:30:00	5.5	36	20 (#1), 21(#2)	8.32	8
7/16/2016	11:16:00	5.25	2	4	8.28	n/a
9/1/2016	11:40:00	3.8	5	4	8.02	n/a

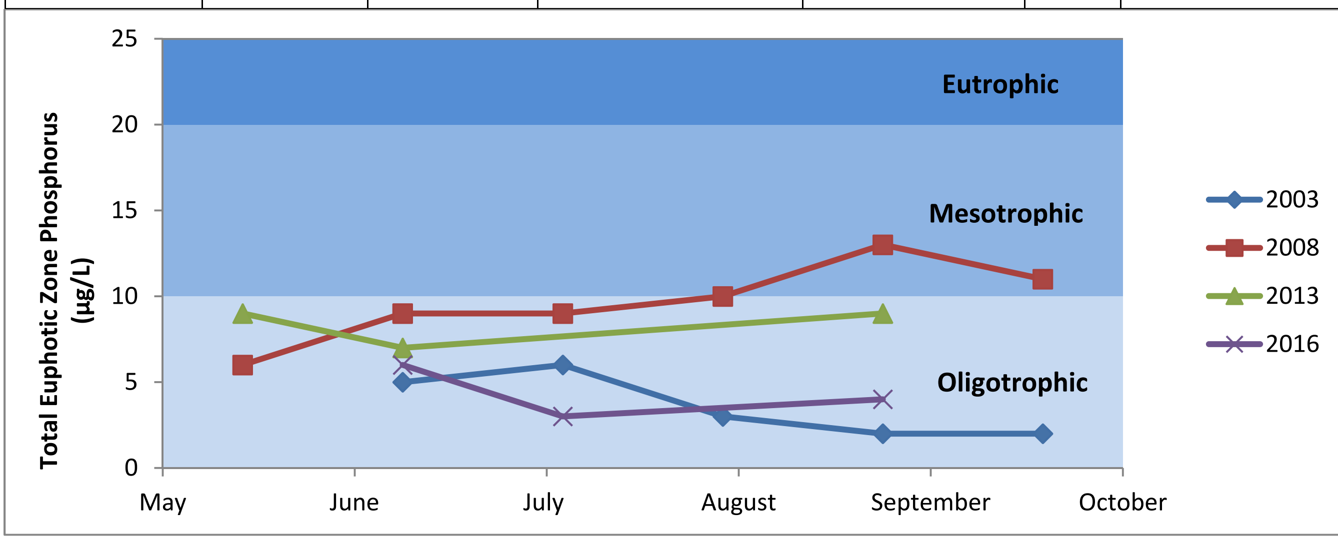
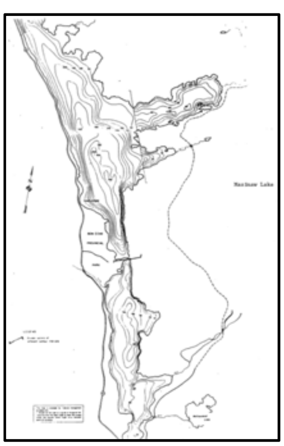


Figure 5: Mazinaw Lake North Basin Euphotic Zone Total Phosphorus Values.



Mazinaw is the largest and deepest Lake in the Mississippi Valley watershed with a maximum depth of over 140 meters. It is located at the western edge of the watershed and features Bon Echo Provincial Park. Due to its depth, it is no surprise that Mazinaw Lake is a coldwater lake that consistently shows an oligotrophic status in both the North and South basins. Results in 2016 maintain this trend.

Sampling events for Mazinaw will now occur on a two year rotation to account for its critical position within the watershed; should any drastic changes to water quality arise in the lake, the whole Mississippi Valley watershed could be affected.

Invasive species sampling for zebra mussels and spiny water flea has returned negative results.

Crotch Lake

Table 7: North Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/26/2016	12:00:00	4.5	5	8	8.43	24
7/13/2016	12:50:00	5.25	6	11	8.27	n/a
9/2/2016	11:40:00	3.75	7	12	8.12	n/a

Table 8: South Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/26/2016	11:00:00	5	9	12	8.67	16
7/13/2016	10:45:00	4.75	5	6	8.25	n/a
9/2/2016	10:45:00	3.5	42	22	8.18	n/a

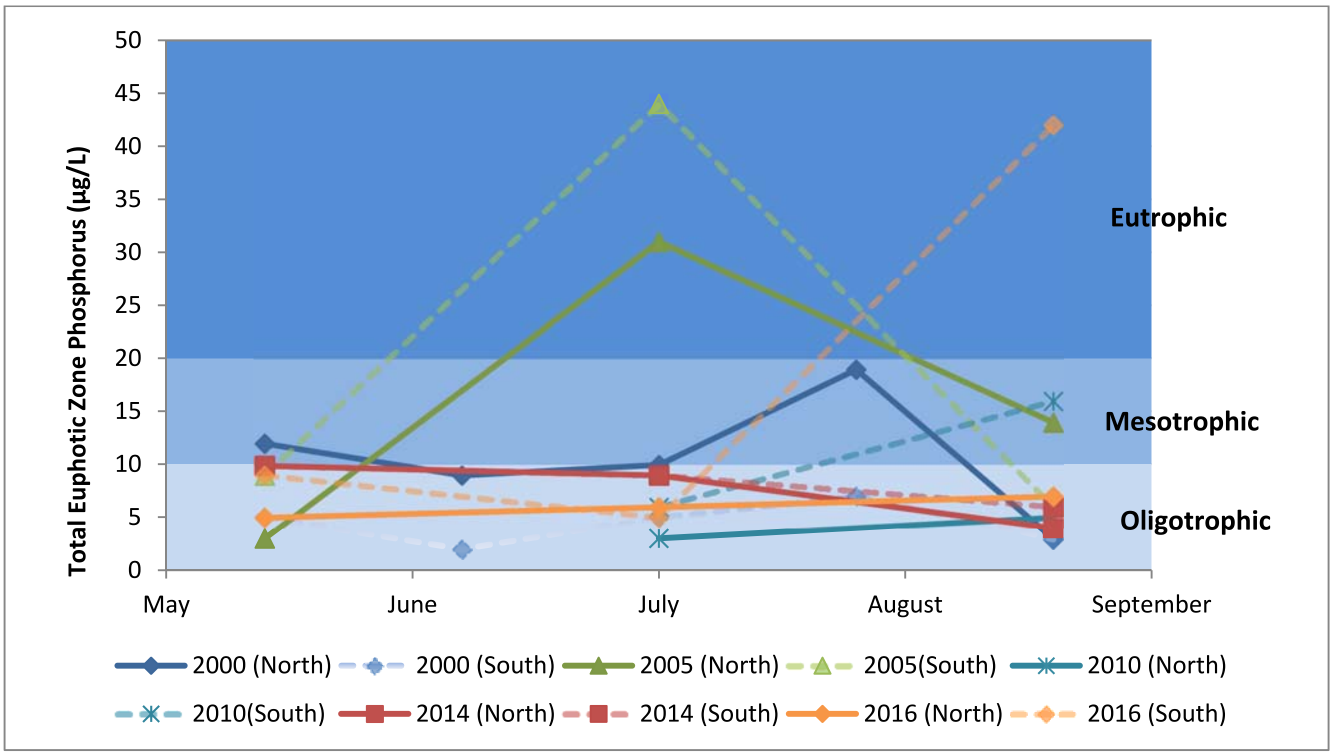


Figure 6: Crotch Lake North and South Basin Euphotic Zone Total Phosphorus Values.

On average, Crotch Lake produces total phosphorus values suggesting Oligotrophic status. Three exceedances of the PWQO for total phosphorus have occurred on Crotch lake; July of 2005 in both the North (44 µg/L) and South (31 µg/L) basins, and in September 2016 in the South basin (42 µg/L). On the day of the 2016 September sampling (Sept 2), water on Crotch Lake was 0.7 m below the historical average. This low level may have affected total phosphorus readings, potentially producing the high value we see in Figure 6.

The 2016 sampling of Crotch Lake revealed the continued presence of the spiny waterflea, which has been present since 2012.

Dalhousie Lake

Table 9: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/17/2016	11:00:00	5	7	17	8.6	24
7/6/2016	8:47:00	7.25	13	67	8.46	n/a
9/29/2016	9:00:00	3	7	462	8.13	n/a

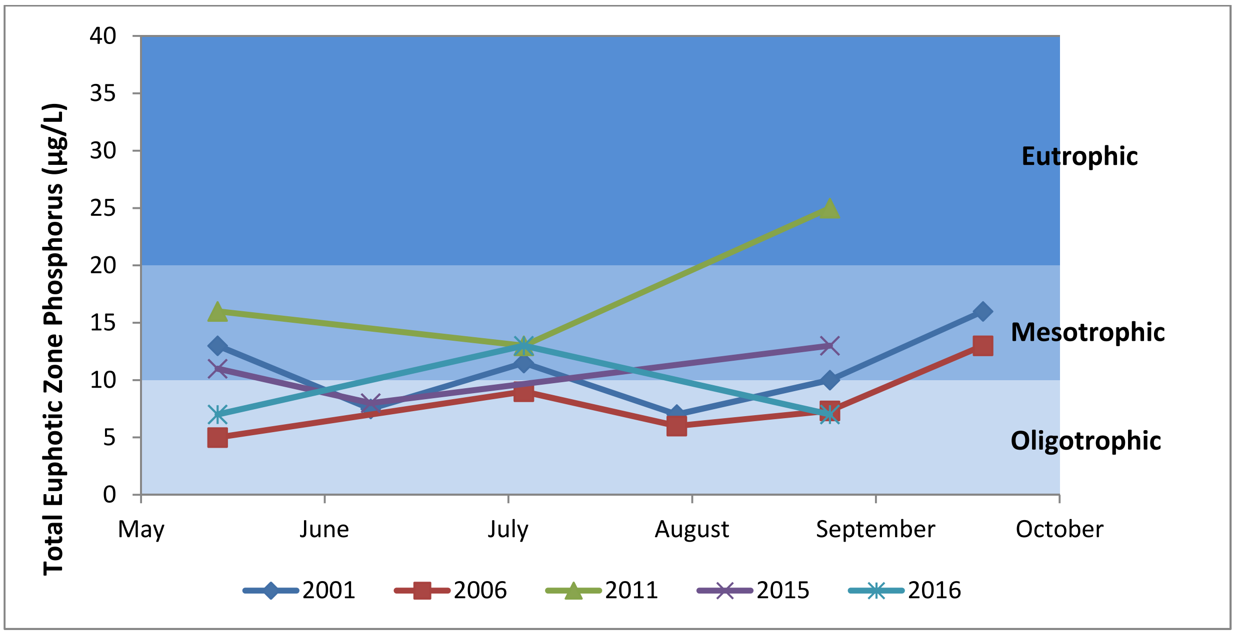


Figure 7: Dalhousie Lake Euphotic Zone Total Phosphorus Values.

The total phosphorus values for Dalhousie lake consistently place it in the Oligotrophic to Mesotrophic range, with one exception during the September sampling of 2011 (25 µg/L).

As seen in Table 9, the total phosphorus results for the bottom sample in 2016 were 17, 67, and 462 µg/L for May, July, and September sampling respectively. The extremely anomalous value of 462 µg/L is likely due to sampling error as a value this high is unlikely. The sediment at the bottom of any lake is much higher in phosphorus than the lake water itself. Therefore, contamination of the sample with even small amounts of sediment can cause huge spikes in the results. Despite careful sampling protocols, this is a distinct possibility while taking a bottom sample just one meter off the bottom of the lake bed.

Dalhousie Lake tested negative for two invasive species, zebra mussels and spiny waterfleas. This is in keeping with results from 2010, 2011, 2012 and 2014. In fact, zebra mussels have not been identified in the lake since 2008.

Clyde River Subwatershed

Palmerston Lake

Table 10: North Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/10/2016	10:30:00	6.8	9	8	8.33	32
7/18/2016	10:20:00	6.75	3	8	8.45	n/a
9/15/2016	10:30:00	7	3	5	8.45	n/a

Table 11: South Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/10/2016	11:15:00	6.5	5	4	8.19	40
7/18/2016	11:51:00	6.75	7	10	8.44	n/a
9/15/2016	11:20:00	7	3	5	8.56	n/a

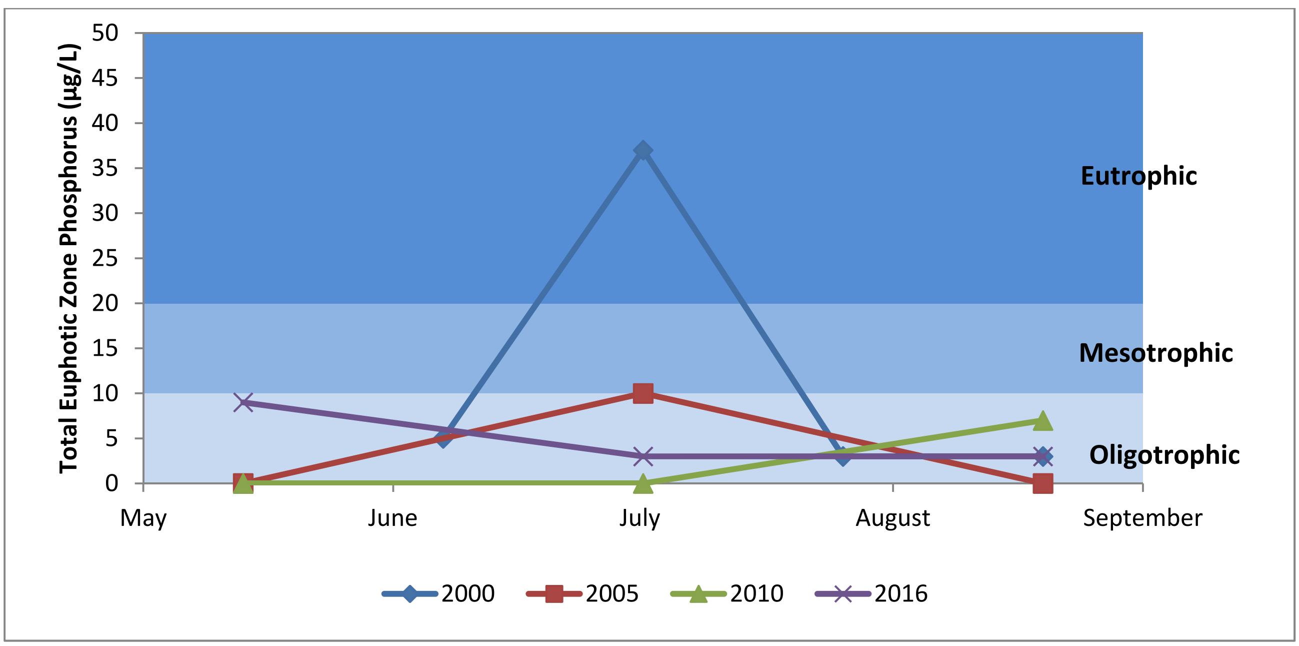


Figure 8: Palmerston Lake North Basin Euphotic Zone Total Phosphorus Values.

Palmerston Lake is the most upstream lake in the Clyde subwatershed and is directly upstream of Canonto Lake. It is a large cold water lake whose water levels are controlled by a dam at its outlet.

Total Phosphorus values almost exclusively place Palmerston Lake in the oligotrophic range. Two exceptions to this have occurred. On July 18th 2000, in both the North and South basin, TP increased to 37µg/L. Similarly, in September 2010, TP values in the South Basin increased to 14µg/L. It is possible that these spikes were an effect caused by increased runoff following a rain storm event. According to

Environment Canada's Historical Weather Data, the Palmerston Lake area received heavy rain a few days prior to both the July 2000 and the September 2010 sampling dates (approximately 32mm and 11mm, respectively). As rain hits the ground during a storm event the water flows with gravity into the nearest basin (in this case, Palmerston Lake). As it passes over the soil it collects phosphorus from all the organic matter present on the ground. When this water, high in phosphorus, filters into the lake it briefly increases the total phosphorus levels of the lake. Levels return to normal once the TP has been used up by aquatic organisms or flushed downstream.

Testing for invasive species was conducted and the results came back negative for both zebra mussels and spiny water flea.

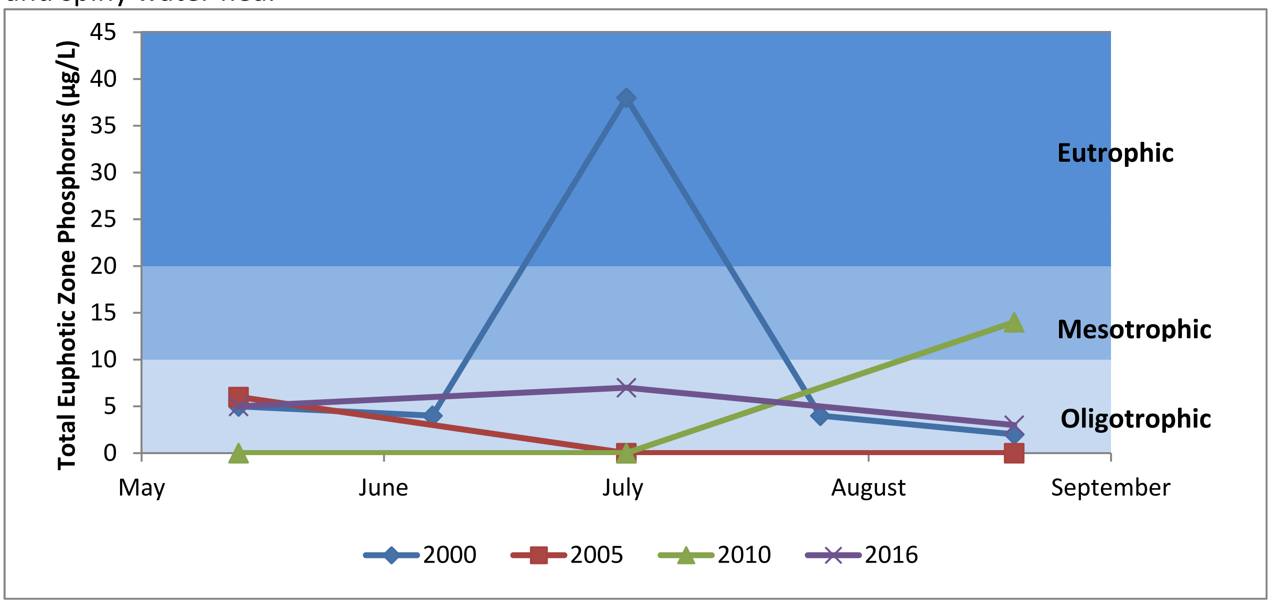
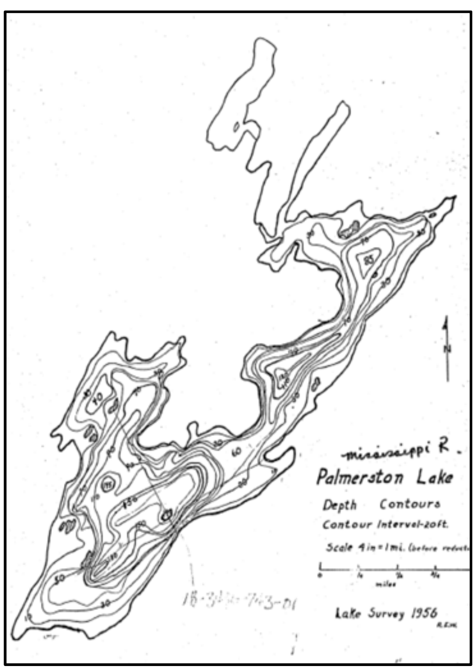


Figure 9: Palmerston Lake South Basin Euphotic Zone Total Phosphorus Values.



Canonto Lake

Table 12: North Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/20/2016	11:00:00	9.25	5	6	8.58	n/a
7/11/2016	10:00:00	6.25	3	18	8.48	40
9/19/2016	10:30:00	6	5	9	8.58	n/a

Table 13: South Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/20/2016	10:30:00	8.5	3	11	8.66	n/a
7/11/2016	10:25:00	6.25	2	7	8.55	40
9/19/2016	10:15:00	6.6	5	19	8.5	n/a

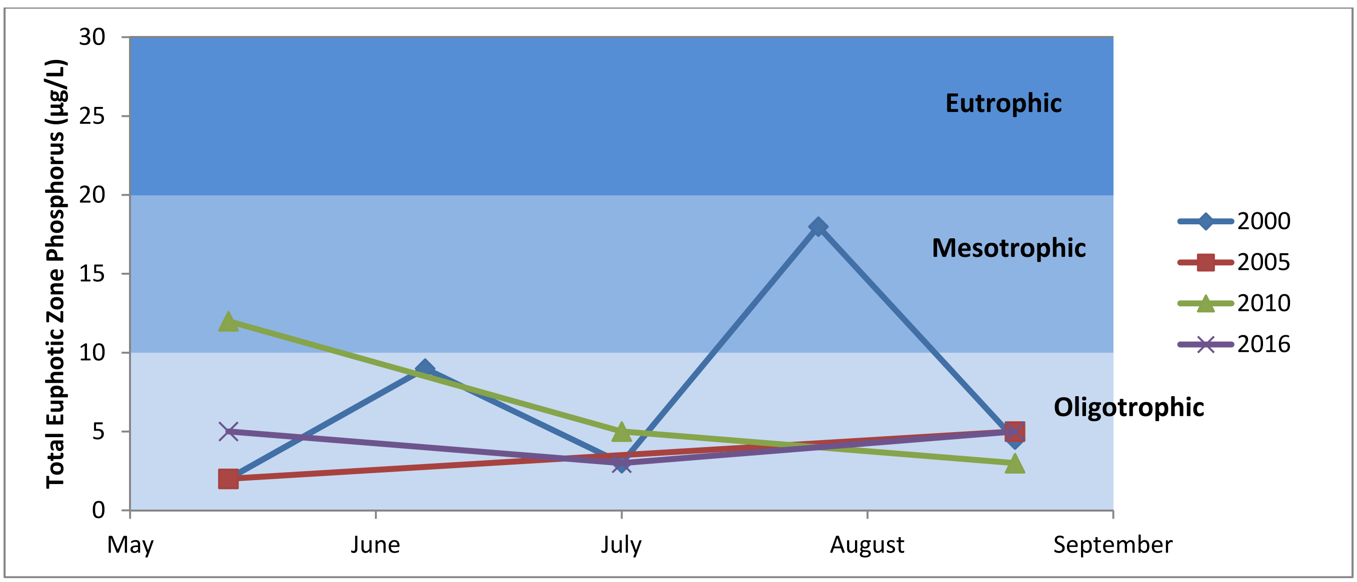


Figure 10: Canonto Lake North Basin Euphotic Zone Total Phosphorus Values.

Canonto is a cold water lake at the top of the Clyde subwatershed. It is fairly consistently found to be oligotrophic; unenriched with few nutrients. Two sampling points lie in the mesotrophic range: May 2010 (12 µg/L) and August 2000 (18 µg/L). Its position as a headwater lake at the top of the subwatershed means that anything that affects the health of the lake will affect the features downstream as well.

The high calcium concentration and high pH of Canonto Lake are ideal conditions for the proliferation of zebra mussels. Zebra mussels were found in Canonto Lake in 2014, however samples from 2015 and 2016 did not find zebra mussels. This should continue to be monitored. Always clean boating and fishing equipment when moving from one body of water to another.

Sunday Lake

Table 14: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/18/2016	10:30:00	5.5	8	17	8.55	32
6/29/2016	11:03:00	4.75	6	44	8.74	n/a
9/9/2016	10:30:00	5	7	22	8.54	n/a

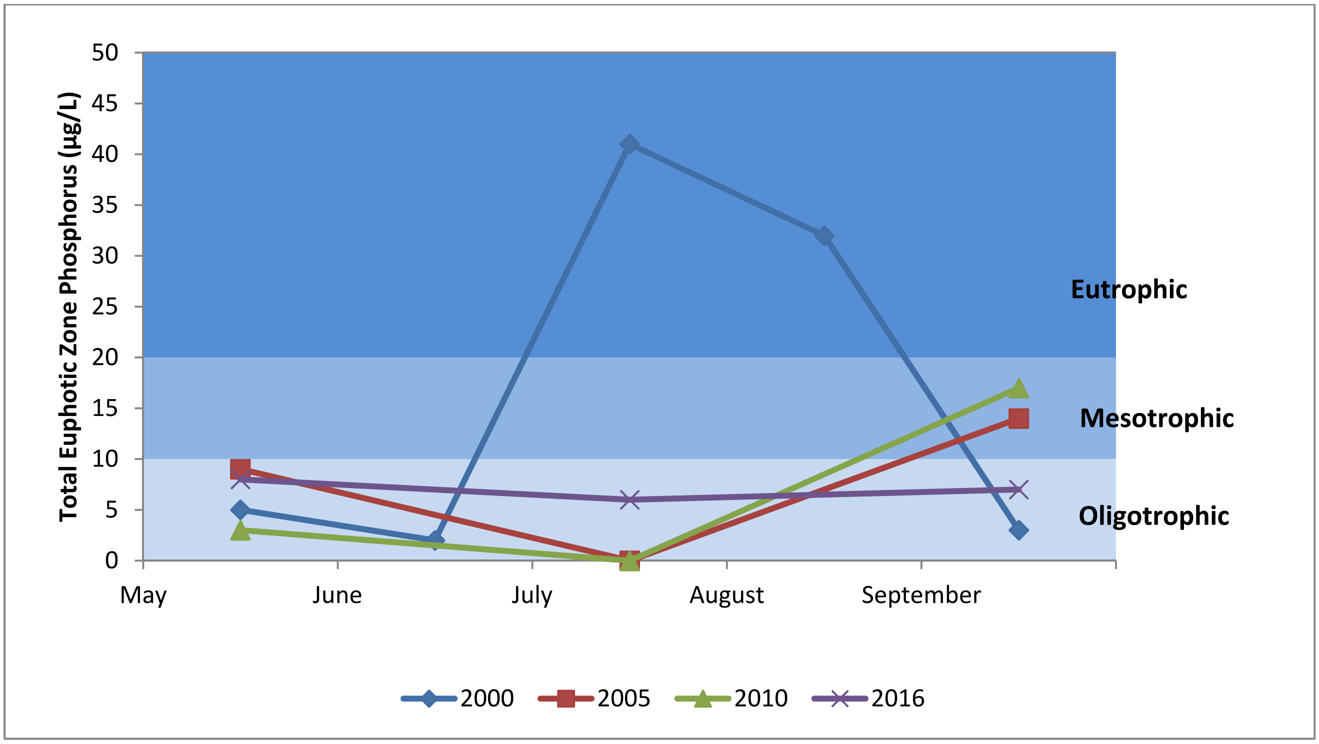
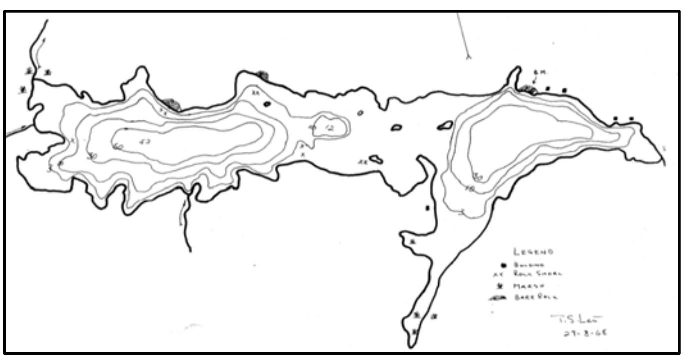


Figure 11: Sunday Lake Euphotic Zone Total Phosphorus Values.



Sunday Lake is another headwaters Lake of the Clyde Subwatershed, located in its northwest corner. Its waters flow into the South Branch of the Clyde, along with those of Palmerston and Canonto Lakes before flowing northeast to reach the main branch of the Clyde River at Widow Lake.

The TP values for Sunday Lake have been consistently in the oligotrophic range (0 – 10 µg/L), except for two values in the mesotrophic range during the September samples of 2005 and 2010 (14 and 17 µg/L), and two values in the eutrophic range in July and August, 2000 (41 and 32 µg/L, respectively).

The 2013 invasive species sampling results indicate that zebra mussels were present in the lake. The 2016 sampling results indicate no invasive species present. This will continue to be monitored.

Robertson Lake

Table 15: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/30/2016	11:00:00	8.5	9	54	8.74	40
7/4/2016	10:25:00	8.25	6	110	8.84	n/a
9/6/2016	10:46:00	8.1	6	177	8.57	n/a

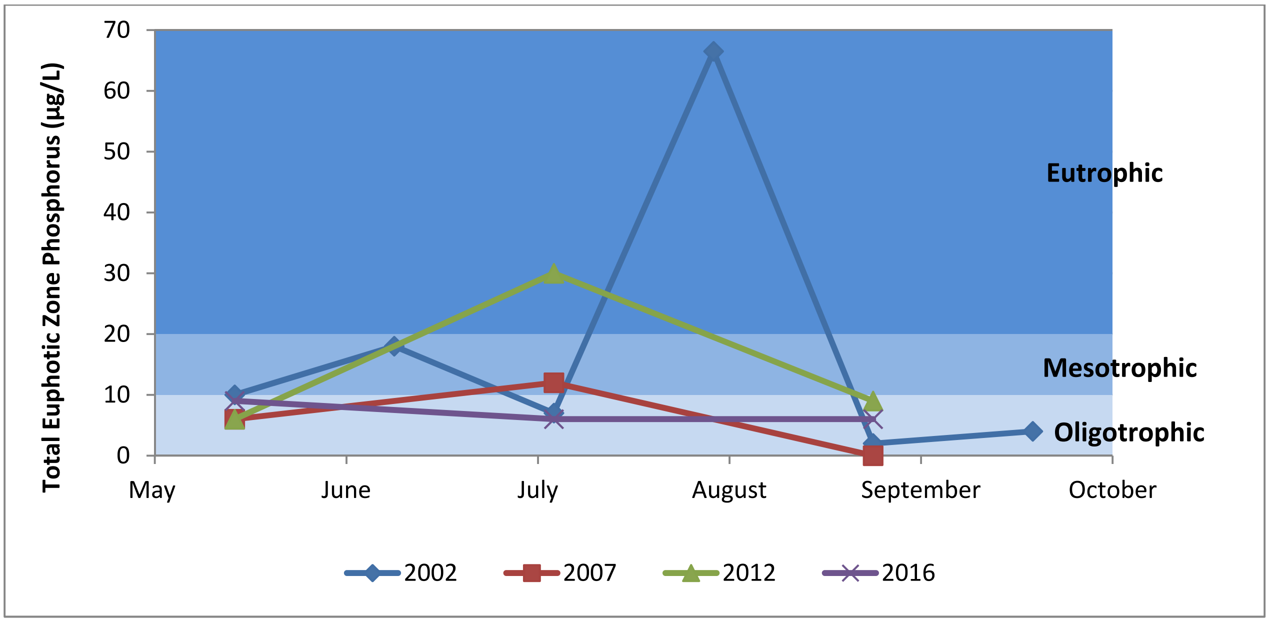
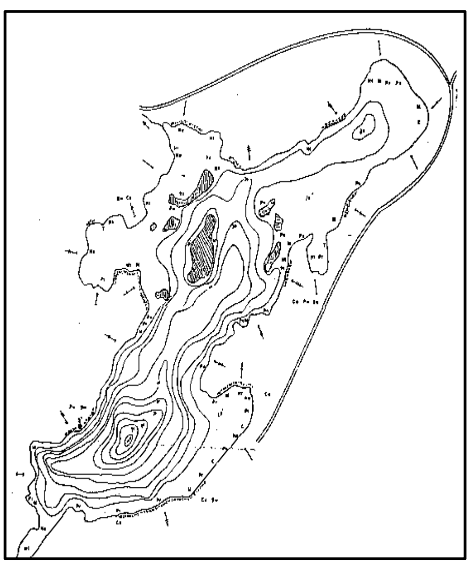


Figure 12: Robertson Lake Euphotic Zone Total Phosphorus Values.



Robertson Lake is a headwaters lake of the Clyde River subwatershed. Seen in Figure 12, the extreme TP value in August 2002 (66.5 µg/L) is likely due to sample contamination as it appears out of trend with the other years of data.

Also of interest in Robertson Lake are the high clarity values (Secchi disc measurements > 8 m) and the high bottom sample total phosphorus values. In 2009, zebra mussels were found to be present in Robertson Lake. Zebra mussels have the ability to filter large amounts of water (approx. 1 L/day) for the purpose of feeding on phytoplankton. Because of phytoplankton's negative effect on water clarity, the presence of this filtering organism often greatly increases the clarity of a lake upon invasion. This may be what we are seeing here however the lake has been sampled for zebra mussels and spiny waterflea in 2012, 2014 and 2016 all of which have retuned negative results. It is still prudent to consider the impacts of this filter feeder and remain diligent in preventing and tracking the spread of invaders.

Flower Round Lake

Table 16: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/31/2016	10:45:00	5	9	13	8.83	32
7/7/2016	10:40:00	5.5	12	69	8.47	n/a
8/31/2016	10:56:00	4.4	40	64	8.52	n/a

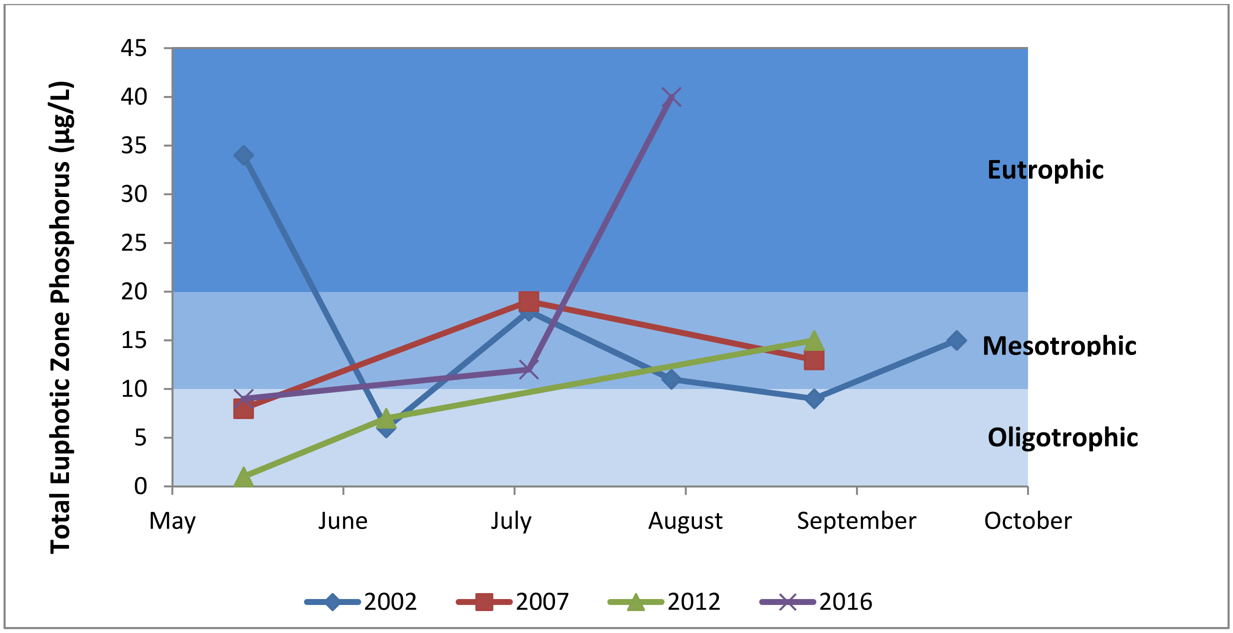
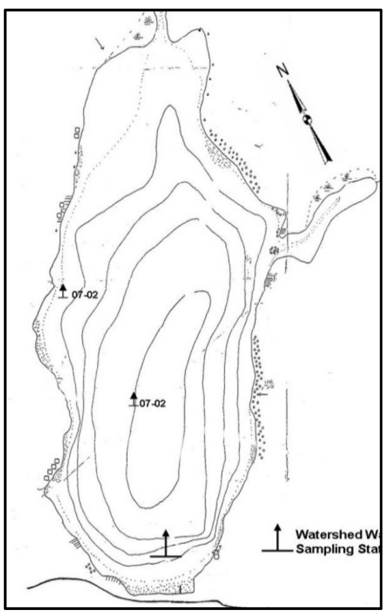


Figure 13: Flower Round Lake Euphotic Zone Total Phosphorus Values.



Located near Flower Station in the Lanark Highlands, Flower Round Lake is one of the first lakes along the Clyde River. As such, the waterbody should see minimal pollution from upstream, which gives it a unique characteristic as the 'starting point' of the Clyde River water quality.

As seen in Figure 13, Flower Round Lake generally falls within the Oligotrophic to Mesotrophic range according to total phosphorus values. Two exceptions to this include the May sample of 2002 (34 µg/L) and the August sample of 2016 (40 µg/L).

Flower Round Lake tested negative for zebra mussels and spiny waterfleas. This is in keeping with results from 2007, 2008 and 2013. In fact, zebra mussels have not been identified in the lake since 2006.

Joe's Lake

Table 17: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/18/2016	14:30:00	2.75	19	n/a	8.83	24
7/5/2016	10:10:00	3.5	9	n/a	8.35	n/a
9/23/2016	9:30:00	2.75	14	n/a	8.02	n/a

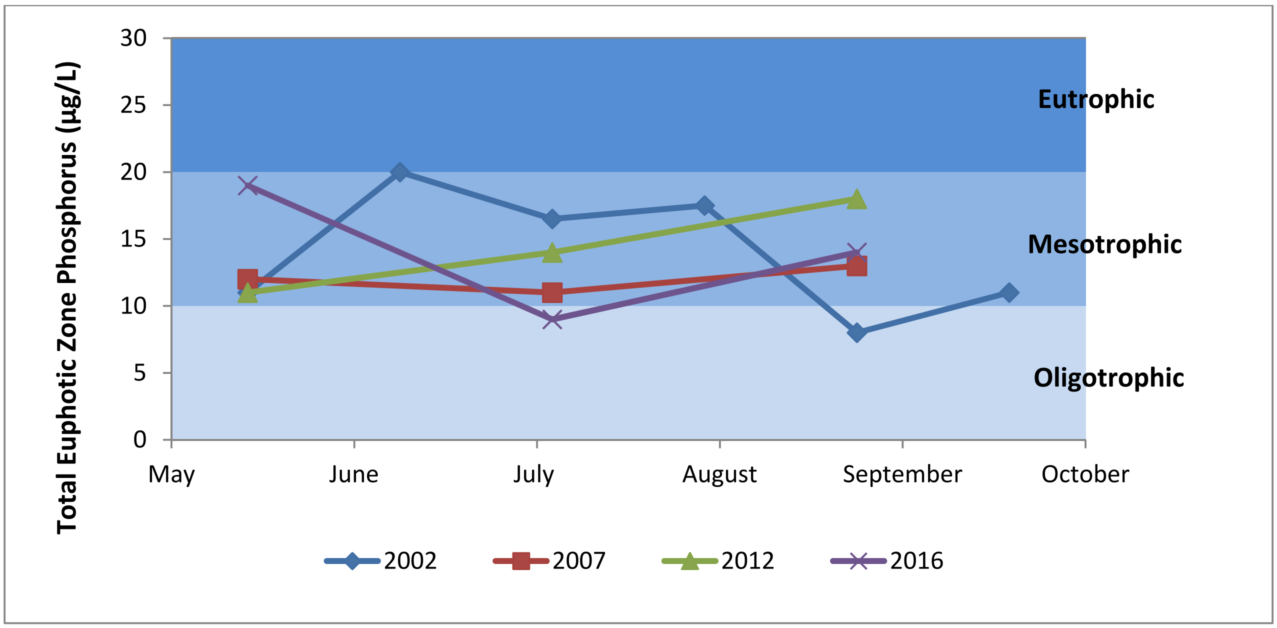
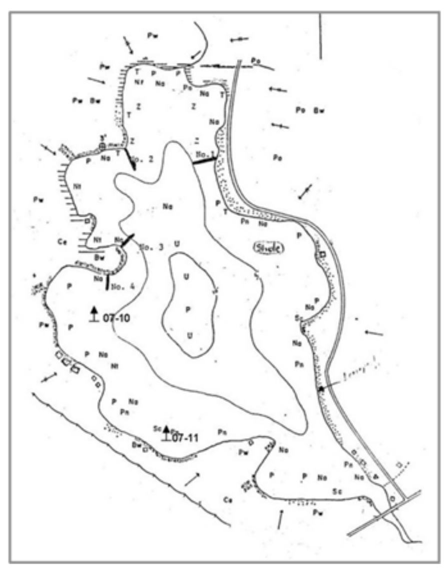


Figure 14: Joe's Lake Euphotic Zone Total Phosphorus Values.

Joe's Lake is a small shallow lake just downstream of Flower Round, separated only by Widow Lake where water enters from the South Branch of the Clyde River.



As seen in Figure 14 Total Phosphorus data for Joe's Lake is similar to results from Flower Round Lake and shows fairly consistent values between 2002 and 2016. Results fall almost exclusively in the mesotrophic range of 10 – 20 µg/L.

Testing for invasive species was conducted and the results came back negative for both zebra mussels and spiny water flea.

Kerr Lake

Table 18: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/16/2016	10:00:00	2.5	11		8.43	40
7/8/2016	9:30:00	2.5	12		8.45	n/a
No data for September sampling. Lake was inaccessible due to extreme low water levels.						

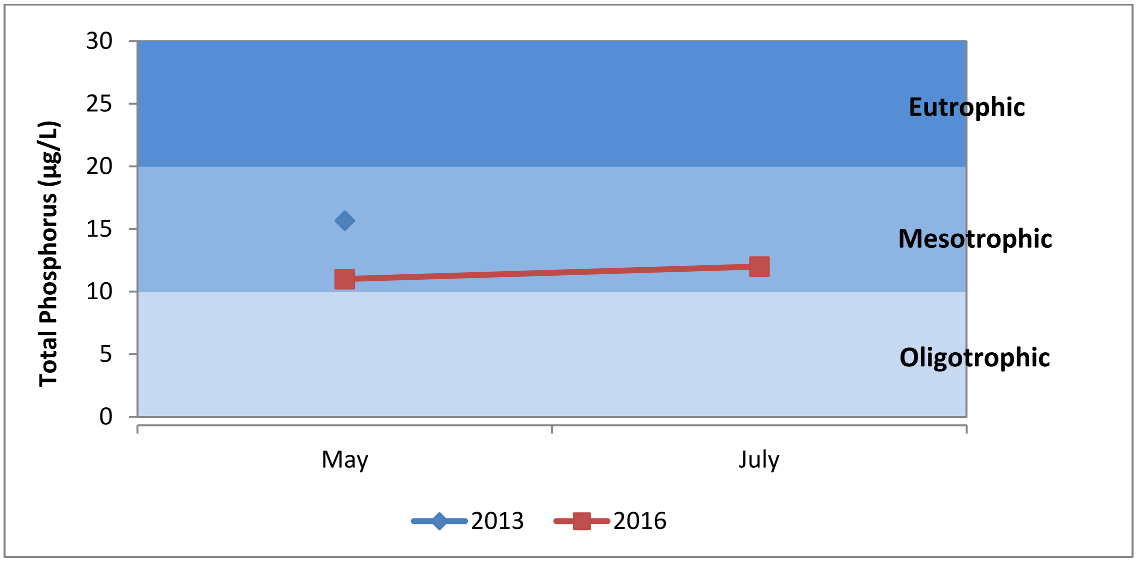


Figure 15: Kerr Lake Euphotic Zone Total Phosphorus Values.

In September of 2016, levels in the Clyde River just upstream of Kerr Lake were low enough to prevent access to the lake for sampling (see image to the left). This is why there are only two sampling points for 2016. While the volume of data for Kerr Lake is noticeably low, the sampling events collected so far show a mesotrophic status. This is to be expected in this very shallow, warm water lake.

In direct contrast to Flower Round, Kerr Lake is the waterbody furthest downstream in the Clyde River system. As such, Kerr Lake data could play an important role in drawing attention to any negative conditions occurring upstream. Monitoring should continue in order to further establish current conditions and observe any trends in the future.

Invasive species sampling for zebra mussels and spiny water flea has returned negative results.

Auxiliary Lakes

Ardoch Lake

Table 19: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
5/24/2016	11:00:00	6.5	9	32	8.85	40
6/30/2016	11:05:00	5	8	14	9.05	n/a
9/12/2016	10:40:00	5.1	6	20	8.51	n/a

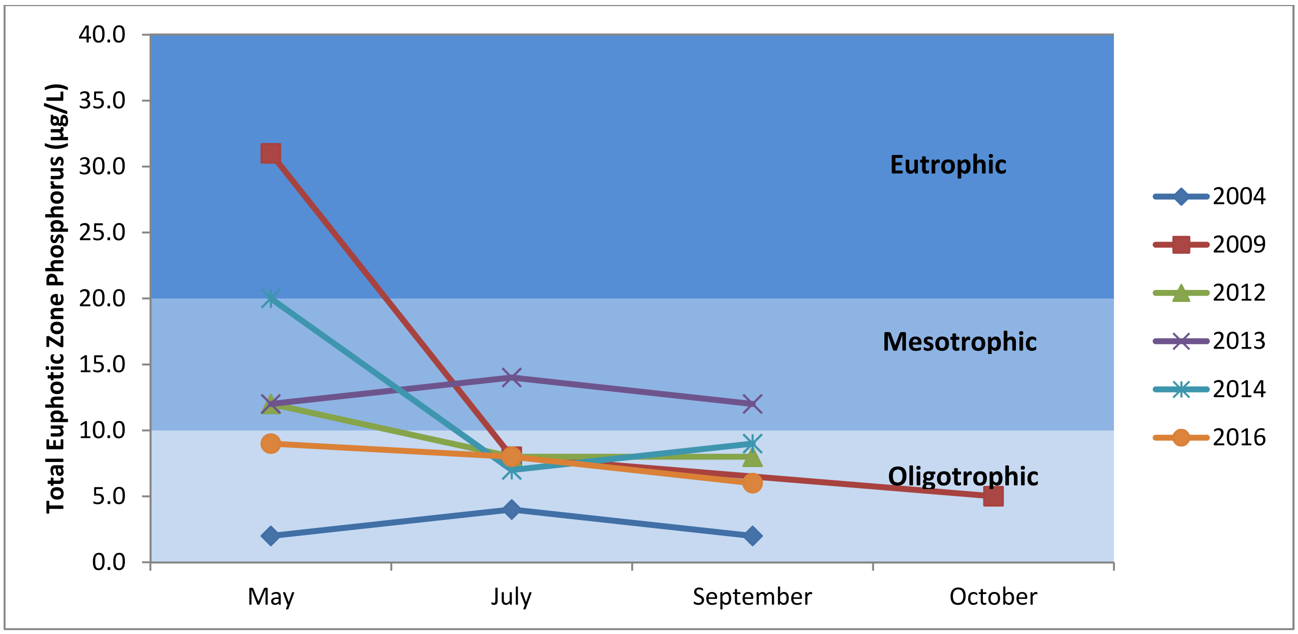
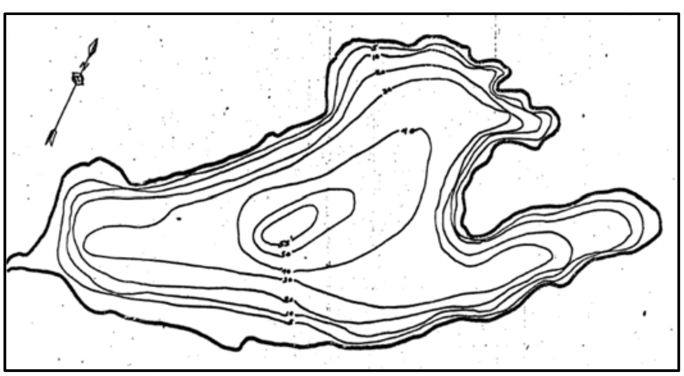


Figure 16: Ardoch Lake Euphotic Zone Total Phosphorus Values.



The graph above shows Total Phosphorus data over the three sampling months for each year Ardoch Lake was sampled. We can see that on average TP levels stay within the oligotrophic and mesotrophic ranges, 2016 included. Two exceedances of the PWQO of 20 µg/L have occurred historically; both during the May sample, once in 2009 (31 µg/L) and again in 2014 (20 µg/L). Because it is a headwaters lake, Ardoch is very sensitive to runoff effects. It is possible that in 2009 and 2014, higher snow melt flushed into the lake, bringing with it phosphorus from the landscape, and causing a spike in the spring phosphorus levels. In both years, TP was back down to average levels by the July sample.

The 2009 invasive species sampling indicated the presence of zebra mussels. The 2012-2016 invasive species sampling results continue to indicate that no zebra mussels or other invasive species are present in the lake.

White Lake

Table 20: Main Basin

Date	Time	Secchi Depth (m)	Total P – Euphotic Zone (ug/L)	Total P – Bottom Sample (ug/L)	pH	Calcium (Ca^{2+}) (mg/L)
6/1/2016	11:00:00	3.75	9	14	8.92	40
7/15/2016	10:30:00	4.5	6	5	8.7	n/a
9/14/2016	12:00:00	4	6	67	8.58	n/a

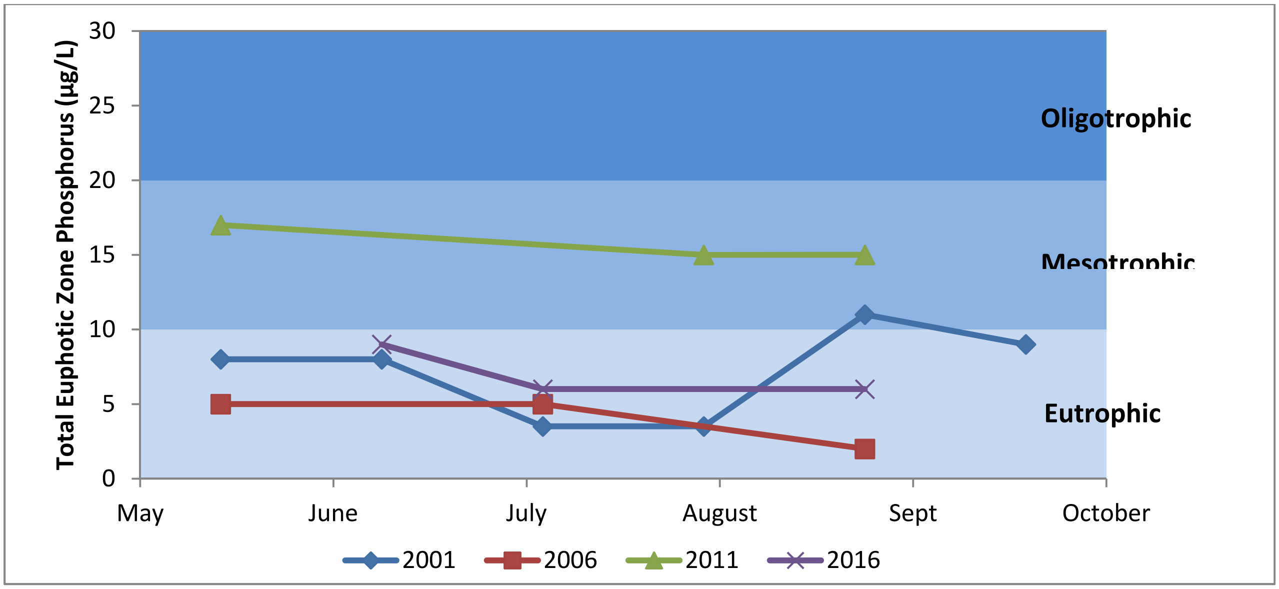
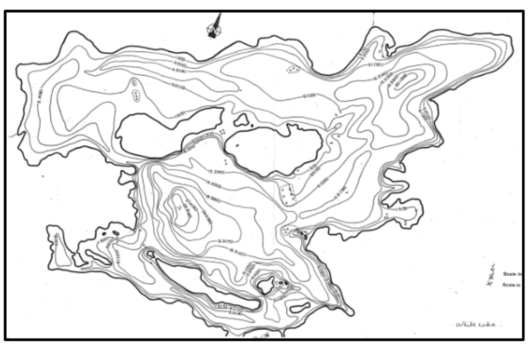


Figure 17: White Lake Euphotic Zone Total Phosphorus Values.



White Lake is a headwaters lake in the Fall River subwatershed. Its main features include an MNRF Fish Culture Station where fish are artificially bred in order to release for sport fishing and conservation throughout Ontario. In 2016, a highlight of sampling was witnessing the presence of a Bald Eagle nest, complete with Eagle and eaglet, on one of the islands.

As seen in Figure 17, the TP values for White Lake place it consistently in the oligotrophic range. The main exception was in 2011 when the values for all three sampling months were within the mesotrophic range (10 – 20 µg/L). High calcium and pH values leave this lake susceptible to zebra mussel invasion. This would be highly detrimental to the fish hatchery so visits to this lake are closely monitored by the MNRF. Fishing is also strictly prohibited on White Lake.

White Lake tested negative for zebra mussels and spiny waterfleas. This is in keeping with results from 2006, 2007, 2008 and 2011.

Biotic Data

Fish Sampling

Fish data collection and analysis has not historically been a focus at MVCA. Our main use of the data is to get an idea of community composition and to monitor for cold water species sightings. Cold water species in the Mississippi Valley Watershed include: Sculpins, Trout, Burbot and the Spottail Shiner. These species are useful in biological monitoring as they have very specific water temperature requirements for their survival. Therefore their presence in a stream or lake can provide clues to certain characteristics of that waterbody.

In 2016, cold water species were found in two of the streams sampled: Easton's Creek (Burbot) and Clyde River (Rainbow Trout). The fish in the remaining streams were largely cool or cool/warm water species. Figure 18 shows the locations and thermal classification of the sampling sites.

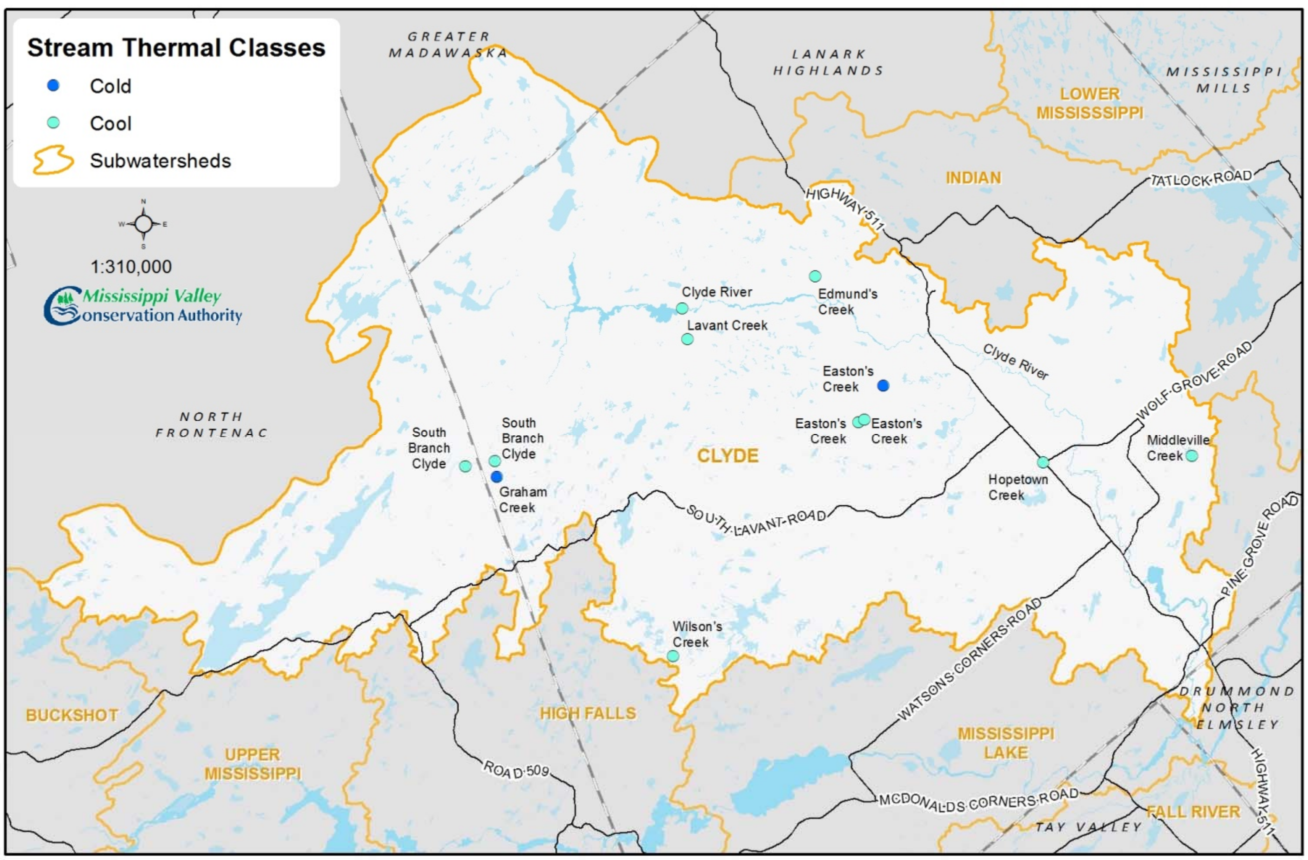


Figure 18: Thermal classification of sampled stream sites, according to fish species present.

Moving forward, the goal of the stream monitoring program will be to return to many of these sites to monitor any change in the fish community composition. Lack of any cold water species or other shifts in composition may indicate changes in the thermal regime of the stream.

Benthic Sampling

MVCA conducted sampling for benthic macro invertebrates at 13 sites in 2016 using the Ontario Benthic Biomonitoring Network protocols as seen in Figure 19. The processing of these samples is done in our lab over the winter and into the following summer so at the time of publishing this report we do not have an analysis of the results to share. Results will be discussed in the upcoming Watershed Report Card.

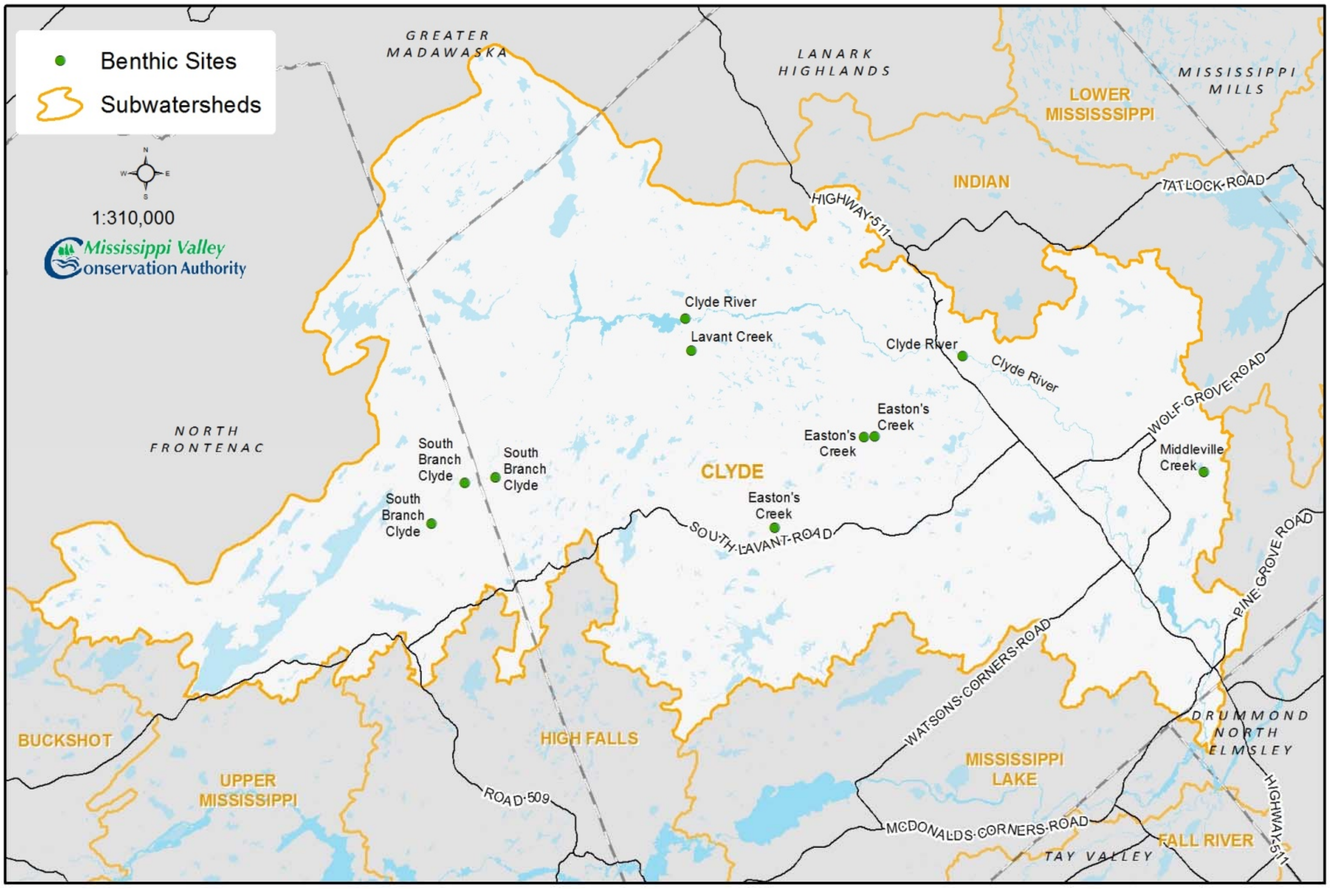


Figure 19: Benthic biomonitoring sites sampled in 2016.

Appendix A – Updated Sampling Rotation

2016 - Clyde	2017 – Fall River, Mazinaw	2018 – Upper Miss, Indian	2019 - Clyde
Mazinaw	Mazinaw	Kashwakamak	Mazinaw
Crotch	Crotch	Mississippi	Crotch
Dalhousie	Dalhousie	Mosque	Dalhousie
Canonto	Sharbot	Big Gull	Canonto
Flower Round	Bennett	Clayton	Flower Round
Joes	Silver	Taylor	Joes
Kerr	Buckshot	Ardoch	Kerr
Palmerston	Mackavoy	Malcolm	Palmerston
Robertson	Kishkebus	Pine	Robertson
Sunday	Marble	McCausland	Sunday
White	Shabomeka	Fawn	Clyde
Ardoch			Widow

2020 – Buckshot, High Falls	2021 – Lower Miss, Miss lake	2022 – Fall River, Mazinaw	2023 – Upper Miss, Indian
Kashwakamak	Mazinaw	Kashwakamak	Mazinaw
Mississippi	Crotch	Mississippi	Crotch
Sharbot	Dalhousie	Canonto	Dalhousie
Bennett	Mosque	Flower Round	Sharbot
Silver	Big Gull	Joes	Bennett
Buckshot	Clayton	Kerr	Silver
Grindstone	Taylor	Palmerston	Buckshot
Mississagagon	White	Mackavoy	Ardoch
Shawenegog	Patterson	Kishkebus	Malcolm
Sand	Constance	Marble	Pine
Miller	Horne	Shabomeka	Clear
Blue		Black	

2024 – Clyde	2025 – Buckshot, High Falls	2026 – Lower Miss, Miss lake	2027 – Fall River, Mazinaw
Kashwakamak	Mazinaw	Kashwakamak	Mazinaw
Mississippi	Crotch	Mississippi	Crotch
Mosque	Dalhousie	Sharbot	Dalhousie
Big Gull	Canonto	Bennett	Mosque
Clayton	Flower Round	Silver	Big Gull
Taylor	Joes	Buckshot	Clayton
Robertson	Kerr	White	Taylor
Sunday	Palmerston	Patterson	Mackavoy
Clyde	Grindstone	Constance	Kishkebus
Widow	Mississagagon	McCausland	Marble
Paddy	Shawenegog	Fawn	Shabomeka
Upper Park	Sand		
	Miller		

2028 – Upper Miss, Indian	2029 – Clyde	2030 – Buckshot, High Falls	2031 – Lower Miss, Miss lake
Kashwakamak	Mazinaw	Kashwakamak	Mazinaw
Mississippi	Crotch	Mississippi	Crotch
Canonto	Dalhousie	Mosque	Dalhousie
Flower Round	Sharbot	Big Gull	Canonto
Joes	Bennett	Clayton	Flower Round
Kerr	Silver	Taylor	Joes
Palmerston	Buckshot	Grindstone	Kerr
Ardoch	Robertson	Mississagagon	Palmerston
Malcolm	Sunday	Shawenegog	White
Pine	Clyde	Sand	Patterson
Blue	Widow	Miller	Constance
	Horne	Black	Clear

2 year rotation	3 year rotation	5 year rotation	8 year rotation
Kashwakamak	Canonto	Ardoch	McCausland
Mississippi	Flower Round	Malcolm	Fawn
Mazinaw	Joes	Pine	Blue
Crotch	Kerr	Grindstone	Horne
Dalhousie	Palmerston	Mississagagon	Black
	Sharbot	Shawenegog	Clear
	Bennett	Sand	Paddy
	Silver	Miller	Upper Park
	Buckshot	White	
	Mosque	Patterson	
	Big Gull	Constance	
	Clayton	Mackavoy	
	Taylor	Kishkebus	
		Marble	
		Shabomeka	
		Robertson	
		Sunday	
		Clyde	
		Widow	

Appendix B: Dissolved Oxygen and Temperature Profiles by Lake

Ardoch Lake

	May 24/2016		June 30/2016		Sept 12/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	18.6	10.7	23.6	9.39	22.4	9.03
1	18.1	10.62	23.5	9.42	22.5	8.98
2	17.7	10.88	23.5	9.36	22.5	8.94
3	16.9	11.02	23.4	9.28	22.5	8.91
4	15.1	11.67	23.3	9.34	22.4	8.88
5	14.3	11.71	21.1	10.64	22.4	8.8
6	12.6	12.47	16.3	12.98	22.2	8.63
7	10.7	13.83	13.2	13.34	20.6	10.2
8	7.8	13.72	10.3	13.14	15.4	11.58
9	6.8	12.75	8.6	12.27	11.6	9.71
10	6.2	11.43	7.7	11.33	9.7	7.27
11	5.8	9.45	7.1	10.24	8.7	5.2
12	5.5	5.85	6.8	9.1	8.2	2.36
13	5.3	3.25	6.3	3.45	7.9	0.44
14	5.2	2.11	6	0.88	7.6	-0.03

Canonto Lake

North Basin

	May 20/ 2016		July 11/2016		Sept 19/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	14.9	10.64	23.5	8.97	20.9	9.24
1	14.4	10.77	23.4	8.98	21	9.24
2	13.9	10.8	22.9	9.05	20.9	9.21
3	13.6	10.8	22.8	9.06	20.9	9.16
4	13.2	10.83	22.7	9.04	20.9	9.1
5	12.7	10.87	22.6	8.98	20.9	9.07
6	12.3	10.95	20.6	10.82	20.9	9.03
7	11.4	11.13	16.7	12.18	20.4	8.8
8	9.8	11.14	12.6	12.16	20	8.76
9	8	11.22	10.4	12.13	15.6	10.39
10	6.9	10.45	8.6	11.56	12.5	10.34
11	6.2	10.07	7.9	10.7	10.4	8.31
12	5.9	9.71	7.3	9.91	9.1	6.03
13	5.6	4.26	7	8.94	8.3	2.84
14					7.6	2.38
15					7	1.2

16					6.7	0.3
17					6.3	0.03

South Basin

	May 20/2016		July 11/2016		Sept 19/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	14.4	10.95	22.8	9.05	21.4	9.22
1	14	11.01	22.8	9.02	21.1	9.23
2	13.6	11.05	22.8	8.97	21	9.22
3	13.2	11.04	22.8	8.95	20.9	9.22
4	12.9	11.06	22.8	8.96	20.9	9.18
5	12.7	11.07	22.7	8.94	20.9	9.13
6	12.4	11.08	18.9	12.09	20.9	9.07
7	11.2	11.43	15.4	12.7	20.8	8.93
8	9.9	11.77	13.3	12.8	20.1	9.49
9	7.4	11.93	10.8	12.72	15.8	12.2
10	6	11.02	8.6	11.95	11.2	11.4
11	5.4	10.24	7.5	11.4	9.2	9.16
12	5.1	9.71	6.8	10.6	8	7.04
13	4.8	8.82	6.2	8.91	7.1	5.6
14	4.6	7.82	5.8	7.26	6.6	3.66
15	4.5	6.92	5.2	4.84	6.1	1.51
16	4.4	6.53	5.1	3.06	5.9	0.43
17	4.4	6.43	5	2.1	5.8	0.07
18			4.9	1.27	5.6	-0.06
19			4.8	1.15	5.5	-0.15
20			4.8	0.73	5.4	-0.2
21			4.7	0	5.3	-0.22
22					5.3	-0.23

Crotch Lake

North Basin

	May 26/2016		July 13/2016		Sept 2/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp °C	D.O. (mg/L)
0.1	19.1	10.03	24.8	8.83	21.8	8.96
1	19	10.07	24.4	8.91	22.1	8.88
2	18.6	10.1	24.3	8.91	22.1	8.85
3	16.6	10.28	24.1	8.89	22.2	8.8
4	15.2	10.26	24	8.87	22.2	8.77
5	15	10.23	23.9	8.83	22.2	8.72
6	13.4	10.11	21.7	8.14	22.1	8.56
7	12.6	9.97	19	7.39	18.4	4.53
8	11.9	9.82	15.4	6.83	14.3	3.69
9	11.2	9.73	12.9	6.23	12.1	2.64
10	10.1	9.61	11.2	5.94	10.8	2.3
11	9.3	9.4	9.9	5.77	10.2	2.06
12	8.8	9.31	9.4	5.68	9.5	1.73
13	8.5	9.2	9.2	5.67	8.9	1.27
14	8.3	9.08	8.8	5.06	8.7	1.05
15	8.2	9.04	8.6	5.08	8.5	0.62
16	7.8	8.89	8.4	4.9	8.4	0.33
17	7.6	8.71	8.3	4.82	8.3	0.08
18	7.4	8.44	8.2	4.51		
19	7.2	8.22	7.9	2.65		
20	7.1	7.92				

South Basin

	May 26/2016		July 13/2016		Sept 2/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp °C	D.O. (mg/L)
0.1	18.8	10.63	24.4	8.78	22.2	8.97
1	18.5	10.73	24.3	8.8	22.3	8.94
2	16.4	11.36	24.2	8.79	22.3	8.91
3	15	11.31	24	8.76	22.3	8.87
4	14.1	11.27	23.8	8.75	22.3	8.84
5	13.2	11.34	23.2	8.67	22.3	8.79
6	12.3	11.13	19.2	8.66	22.3	8.72
7	11.6	10.64	15.8	7.94	16.8	6.09
8	11.2	10.59	12.7	7.38	13.5	5.3
9	10.8	10.33	12.5	7.38	11	4.85
10	9.6	9.88	10.3	6.86	9.8	4.26

11	8.7	9.66	9.5	6.84	9.2	3.74
12	8.2	9.72	9.1	6.63	8.9	3.54
13	7.8	9.77	8.8	6.55	8.7	3.35
14	7.5	9.64	8.5	6.18	8.4	3.12
15	7.3	9.46	8.3	5.91	8.1	2.73
16	7.2	9.3	8	5.62	7.9	2.14
17	7.1	9.21	7.9	5.64	7.7	1.26
18	7.1	9.11	7.8	5.66	7.8	2.14
19	7.1	9.1	7.7	5.19	7.7	1.4
20	7	8.97	7.6	5.11	7.7	1.11
21	7	8.85	7.6	4.64	7.6	0.95
22	7	8.82			7.6	0.71
23	6.9	8.56			7.5	0.62
24	6.9	8.28			7.5	0.54
25	6.8	8.12			7.4	0.35
26	6.8	7.37				

Dalhousie Lake

	May 17/2016		July 6/2016		Sept 29/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	13.8	10.54	23.1	8.98	18.9	8.85
1	13.7	10.49	23.2	8.95	18.9	8.82
2	13.3	10.47	23.2	8.91	18.9	8.79
3	13.3	10.41	22.8	8.79	19	8.74
4	13.2	10.32	22.5	8.6	19	8.71
5	13.2	10.27	22.2	8.38	19	8.69
6	13.1	10.24	21.6	7.69	19	8.65
7	13.1	10.22	17.1	5.27	19	8.62
8	13	10.11	14.7	3.12	18.9	8.56
9	12.9	10.04	13.6	1.44	18.5	8.25
10	11.5	8.82	12.7	0.22	15.8	0.45
11	11.1	8.64	12.1	-0.09	13.4	0.11
12	10.5	8.19	11.5	-0.21	12.8	0.02
13	10.1	7.56	11.2	-0.23	11.9	-0.05
14	9.8	7.14	11	-0.24		
15	9.3	6.56	10.6	-0.25		
16	8.8	5.94	10.4	-0.27		
17	8.6	5.5				

Flower Round Lake

	May 31/2016		July 7/2016		August 31/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	22.50	9.23	25.6	8.94	23.6	8.89
1	22.60	9.19	25.2	9.03	23.7	8.87
2	22.60	9.13	25.1	9.04	23.6	8.83
3	20.30	10.04	24.2	8.94	23.6	8.77
4	16.40	10.70	23.5	8.95	23.5	8.74
5	14.20	10.34	20.5	8.78	23.5	8.59
6	12.30	10.02	16.2	8.88	21.4	6.83
7	10.10	8.34	13.9	8.64	16	0.55
8	8.80	6.12	10.1	3.8	12.4	0.27
9	7.70	3.73	8.3	-0.05	10.3	-0.02
10	7.40	3.48	7.6	-0.14	9.4	-0.12
11	6.90	2.11	7.3	-0.19	8.5	-0.19
12	6.60	0.93	7.1	-0.22	8.1	-0.21

Joe's Lake

	May 18/2016		July 5/2016		Sept 23/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	15.1	10.41	24.1	9.6	20.3	8.52
1	14.5	10.36	23.8	9.57	20.4	8.38
2	13.9	10.29	23.4	9.29	20.5	8.31
3	13.3	10.03	23	8.43	20.6	8.27
4	12.6	9.5			20.4	5.18

Kerr Lake

	May 16/2016		July 8/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	13.6	9.88	25.2	9.68
1	14	9.75	25.2	9.62
2	14.1	9.68	25.2	9.58
3	14.1	9.57	23.1	10.15
4	14.1	9.45	19.6	2.98
5	14.1	9.33		

Mazinaw Lake

North Basin

	June 3/2016		July 19/2016		Sept 1/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	20	9.72	23.3	8.92	22.5	9.11
1	19.9	9.73	23.3	8.89	22.9	9.05
2	19.8	9.72	23.2	8.88	22.9	9.04
3	19.5	9.77	23.2	8.85	23	9
4	17.1	10.12	23.1	8.84	23	8.97
5	15.1	10.59	22.8	8.79	23	8.94
6	12.6	11.03	22.3	8.93	23	8.91
7	10.7	11.25	18.8	9.5	22.5	8.85
8	8.8	11.24	14.2	10.04	20.7	8.96
9	8.1	11.19	13.2	10.12	14.1	9.45
10	7.8	11.15	10.4	10.27	11.1	9.69
11	7.6	11.1	9.3	10.3	9.4	9.82
12	7.2	11.05	8.6	10.36	9.2	9.8
13	6.9	11.03	8.3	10.39	8.5	9.78
14	6.9	10.98	7.1	10.52	7.8	9.85
15	6.8	10.95	6.1	10.64	7.1	9.92
16					6.7	9.98

South Basin

	June 3/2016		July 16/2016		Sept 1/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	21.4	9.24	23.1	8.96	22.8	9.0
1	21	9.34	23.4	8.88	23.0	9.0
2	20.8	9.35	23.3	8.87	23.0	8.9
3	19.4	9.72	23.3	8.83	23.0	8.9
4	17.1	10.4	23.1	8.8	23.0	8.9
5	14.6	10.87	23.1	8.75	23.0	8.9
6	13.2	11.15	20.2	9.49	22.9	8.8
7	11.5	11.05	16	9.7	20.5	8.9
8	9.8	10.95	13	9.67	13.8	9.1
9	8.8	10.87	9.7	9.87	11.4	9.1
10	9	10.91	8.6	9.84	9.4	9.0
11	8	10.8	8.1	9.79	8.6	8.8
12	7.6	10.78	7.7	9.65	8.0	8.9
13	7.8	10.77	7.4	9.6	7.8	8.8
14	7	10.7	7.3	9.62	7.5	8.8
15	6.8	10.65	7.1	9.69	7.3	8.8

16	6.6	10.64	6.9	9.69	7.1	8.7
17	6.5	10.61	6.9	9.64	7.0	8.7
18	6.3	10.56	6.8	9.61	6.9	8.8
19	6.1	10.56	6.7	9.6	6.7	8.9
20	5.9	10.51	6.6	9.6	6.6	8.9
21	5.8	10.51	6.5	9.56	6.5	8.9
22	5.8	10.55	6.4	9.55	6.4	8.9
23	6.1	10.63	6.3	9.53	6.3	8.8
24	6.7	10.71	6.3	9.54	6.2	8.8
25	5.7	10.4	6.2	9.54	6.1	8.8
26	5.6	10.42	6.1	9.51	6.1	8.9
27	5.6	10.39	6.2	9.46	6.0	8.9
28	5.4	10.27	6.1	9.47	5.9	8.8
29	5.4	10.22	6.1	9.5	5.9	8.8
30	5.2	10.19	5.8	9.5	5.8	8.9
31	5.2	10.16	5.6	9.47	5.8	8.8
32	5.2	10.12	5.6	9.45	5.6	8.8
33	5.2	10.09	5.6	9.46	5.6	8.8
34	5.2	10.06	5.6	9.47	5.6	8.7
35	5.2	10.03	5.6	9.46	5.5	8.7
36	5.1	10.02	5.6	9.48	5.4	8.7
37	5.1	9.99	5.7	9.53	5.8	8.6
38	5.1	9.96	5.7	9.53	5.7	8.6
39	5.1	9.93	5.6	9.49	5.6	8.6
40	5.1	9.9	5.5	9.47	5.5	8.6
41	5.1	9.88	5.5	9.46	5.5	8.6
42	5.1	9.86	5.4	9.38	5.5	8.5
43	5.1	9.83	5.4	9.38	5.5	8.5
44	5.1	9.79	5.4	9.37	5.4	8.5
45	5.1	9.75	5.4	9.35	5.4	8.4
46	5.1	9.45	5.4	9.37	5.3	8.4
47	5.1	9.74	5.4	9.38	5.3	8.4
48	5.1	9.77	5.4	9.34	5.3	8.4
49			5.4	9.29	5.3	8.3
50			5.4	9.24	5.3	8.3

Palmerston Lake

North Basin

	May 10/2016		July 18/2016		Sept 15/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.1	11.81	24.1	8.8	21.2	9.33
1	9.8	11.91	23.8	8.84	21.3	9.3
2	9.6	11.95	23.7	8.83	21.4	9.25
3	9.5	11.94	23.6	8.83	21.4	9.22
4	9.4	11.93	23.6	8.8	21.4	9.18
5	9.3	11.89	23.5	8.79	21.4	9.12
6	9.2	11.89	23.4	8.78	21.4	9.09
7	9.2	11.85	23.4	8.77	21.4	9.04
8	9.1	11.83	21	10.32	21.4	8.99
9	8.7	11.78	15	12.53	19.9	11.32
10	8.4	11.77	11.9	12.55	15.7	13.23
11	7.5	11.67	10.6	12.45	12.2	12.81
12	6.8	11.55	9.7	12.15	10.3	11.73
13	6.5	11.43	8.6	11.68	9.1	10.72
14	6.2	11.23	8.2	11.36	8.1	9.98
15	6.1	11.13	8.1	11.31	7.6	9.21
16	6	11.05	8	11.11	7.3	9.01
17	5.9	10.95	7.7	10.83	7	8.87
18	5.7	10.85	7.3	10.41	6.8	8.7
19	5.6	10.7	6.9	9.92	6.7	8.34
20	5.4	10.66	6.8	9.74	6.6	8.04
21	5.4	10.57	6.6	9.58	6.5	7.84
22	5.3	10.51	6.5	9.45	6.5	7.55
23	5.3	10.45	6.4	9.28	6.4	7.24
24	5.3	10.37	6.3	9.16	6.4	6.93
25	5.2	10.25	6.3	9.04	6.3	6.52
26	5.2	10.03	6.2	8.72	6.3	5.73
27					6.2	3.6

South Basin

	May 10/2016		July 18/2016		Sept 15/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.1	11.92	23.1	8.97	21.2	9.36
1	9.8	12	23.1	8.98	21.2	9.34
2	9.4	12	23.1	8.96	21.2	9.29
3	9.2	11.99	23	8.96	21.2	9.26
4	9.1	11.99	23	8.93	21.2	9.23
5	9.1	11.94	23	8.94	21.2	9.19
6	9	11.93	22.8	8.97	21.2	9.16
7	9	11.9	18.5	11.67	21.2	9.13
8	8.9	11.89	14.9	12.94	21.1	9.12
9	8.9	11.85	13.1	12.99	21.1	9.09
10	8.3	11.84	10.7	12.8	14.7	13.6
11	8.3	11.8	10	12.52	11.7	13.45
12	7.7	11.82	8.9	12.01	9.9	12.5
13	6.7	11.71	8.2	11.78	9.1	12.12
14	6.4	11.58	8	11.8	8.3	11.56
15	5.7	11.22	7.5	11.45	7.7	10.98
16	5.7	11.16	7.3	11.25	7.4	10.51
17	5.6	11.09	7.4	11.29	7.1	10.1
18	5.5	10.98	7	10.84	6.8	9.54
19	5.4	10.91	6.8	10.65	6.6	9.16
20	5.2	10.8	6.8	10.53	6.4	9.02
21	5	10.71	6.8	10.46	6.2	8.7
22	5	10.66	5.9	9.35	6	8.46
23	5	10.64	5.8	9.36	5.9	8.17
24	4.9	10.53	5.8	9.33	5.7	8.12
25	4.8	10.46	5.6	9.15	5.5	7.95
26	5	10.46	5.4	9.11	5.4	7.82
27	4.9	10.42	5.3	9.03	5.3	7.66
28	4.8	10.35	5.3	9.02	5.1	7.57
29	4.8	10.28	5.2	8.86	5.1	7.54
30	4.7	10.23	5	8.72	5	7.65
31	4.6	10.19	4.9	8.68	5	7.58
32	4.6	10.12	4.9	8.66	4.9	7.5
33	4.5	10.09	4.8	8.65	4.8	7.42
34	4.5	10.03	4.8	8.5	4.7	7.37
35	4.4	9.93	4.8	8.46	4.7	7.25
36	4.4	9.85	4.7	8.38	4.6	7.05
37	4.4	9.81	4.6	8.37	4.6	7.01

38	4.4	9.75	4.6	8.35	4.6	6.88
39	4.3	9.73	4.6	8.31	4.6	6.84
40	4.3	9.68	4.6	8.19	4.5	6.62
41	4.3	9.62	4.5	7.91	4.5	6.38
42	4.3	9.57	4.5	7.88	4.5	6.2
43	4.2	9.48	4.5	7.8	4.5	5.95
44	4.2	9.4	4.4	7.53	4.4	5.75
45	4.2	9.34	4.4	7.3	4.4	5.5
46	4.2	9.26	4.4	7.37	4.4	5.2
47	4.1	9.23	4.4	7.38	4.4	4.87
48	4.1	9.13	4.4	6.92	4.4	3.65
49	4.1	9.07			4.4	2.55
50	4.1	8.84			4.4	1.3

Robertson Lake

	May 30/2016		July 4/2016		Sept 6/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	22.1	9.67	22.7	8.98	23.0	9.08
1	22	9.72	22.3	9.08	22.7	9.06
2	21.6	9.71	22.1	9.12	22.5	9.06
3	19.1	10.99	22	8.91	22.4	9.03
4	16.9	11.23	21.9	8.92	22.3	9.03
5	15.4	11.39	21.7	8.88	22.2	8.89
6	13.6	11.88	18.2	9.58	22.1	8.73
7	11.8	12.38	15.3	10.7	21.4	8.50
8	9.4	11.96	11.8	10.77	16.6	9.47
9	7.6	10.84	9.3	9.45	12.6	8.20
10	6.4	8.6	7.7	8.09	9.9	4.61
11	5.6	7.6	6.9	6.97	8.3	2.89
12	5.3	6.74	6.3	5.81	7.5	1.13
13	5	5.578	5.8	4.89	6.6	0.26
14	4.6	4.71	5.2	3.36	6.1	-0.18
15	4.5	4.24	4.9	2.29	5.4	0.25
16	4.4	3.67	4.7	1.36	5.1	0.27
17	4.3	3.17	4.5	0.53	4.7	-0.28
18	4.2	2.44	4.3	-0.18	4.4	-0.39
19	4	0.7	4.3	-0.33	4.3	-0.41
20	4	0.1	4.2	-0.37	4.2	-0.42
21	4	0	4.1	-0.39	4.1	-0.43
22	3.9	-0.28	4	-0.4	4.1	-0.44

23	2.9	-0.35	4	-0.41	4.1	-0.44
24	3.8	-0.37	4	-0.42	4.1	-0.44
25	3.9	-0.4	3.9	-0.43	4.1	-0.45
			3.9	-0.43	4.1	-0.45
			3.9	-0.43	4.1	-0.45

Sunday Lake

	May 18/2016		June 29/2016		Sept 9/2016	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	13.8	10.87	23.7	8.95	23.3	9.08
1	13.6	10.81	23.8	8.89	23.3	9.04
2	13.2	10.79	23.8	8.83	23.1	9.02
3	13.1	10.79	22.9	9.21	22.6	9.17
4	13	10.7	19.4	10.49	22	8.83
5	12.2	10.61	15.9	11.52	20.9	9.07
6	8.1	10.99	10.3	14.51	16.1	12.02
7	5.8	10	7.1	11.85	11.7	10.57
8	5	8.58	5.7	8.78	9.2	9.18
9	4.6	7.27	5.2	8.01	10.9	10.67
10	4.4	6.58	4.8	7.4	6	8.64
11	4.2	5.57	4.4	4.68	5	1.64
12	4.2	4.36	4.2	0.81	4.6	-0.07
13	4.1	2.68	4.2	-0.17	4.5	-0.19
14	4	1.12	4.1	-0.31		
15			4.1	-0.33		
16			4.1	-0.35		

White Lake

	June 1/2016		July 15/2016		Sept 14/2016	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	20.9	9.92	25	9.63	21.8	9.41
1	21.2	9.87	24.9	9.43	21.9	9.34
2	21.3	9.82	24.7	9.29	22	9.3
3	21.2	9.81	24.6	9.25	22.1	9.25
4	21.2	9.79	24.5	9.29	22.1	9.21
5	16.7	11.61	24	9.36	22.1	9.81
6	14.5	11.68	22.5	9.7	22.1	9.15
7	13	11.79	17.1	12.87	22.1	9.07
8	10.8	12.34	13.6	12.62	19.5	9.1
9	9.3	12.39	11.2	12.24	15.6	10.06
10	8.4	12.29	10.1	11.5	11.9	9.13
11	7.7	11.68	8.4	13.31	10	7.24
12	7.1	11.2	7.8	10.04	8.6	5.39
13	6.7	10.54	7.1	8.15	7.7	3.4
14	6.3	9.25	6.5	5.97	7.1	1.71
15	6	8.33	6.1	4.94	6.7	0.45
16	5.8	8.16	5.8	4.15	6.4	-0.05
17	5.6	7.93	5.6	3.8	6.1	-0.18
18	5.4	8.07	5.5	3.31	5.8	-0.24
19	5.3	7.94	5.3	2.72	5.6	-0.27
20	5.1	7.53	5.3	2.22	5.5	-0.29
21	5.1	7.33	5.2	1.96	5.5	-0.31
22	5	7.09	5.2	1.87	5.4	-0.32
23	4.9	6.82	5.1	1.66	5.4	-0.33
24	4.9	6.23	5.1	0.95	5.3	-0.34
25	4.8	4.93	5.1	0.4	5.2	-0.35
26	4.8	3.98	5	0.05	5.2	-0.36
27	4.8	0.48				

Appendix C: OFAH Invasive Species Sampling Results for 2016

Lake	County	Township	Date of Sampling	Spiny Waterflea	Zebra Mussel
Ardoch Lake	Frontenac	North Frontenac	June 30 2016	No	No
Black Lake	Frontenac	Central Frontenac	July 8 2016	No	No
Blue Lake	Frontenac	North Frontenac	July 9 2016	No	No
Buckshot Lake	Frontenac	North Frontenac	July 9 2016	No	No
Canonto Lake	Frontenac	North Frontenac	July 11 2016	No	No
Crotch Lake	Frontenac	North Frontenac	July 13 2016	Present	No
Dalhousie Lake	Lanark	Tay Valley	July 6 2016	No	No
Flower/Round Lake	Lanark	Lanark Highlands	July 7 2016	No	No
Joe's Lake	Lanark	Lanark Highlands	July 5 2016	No	No
Kerr Lake	Lanark	Lanark Highlands	July 8 2016	No	No
Malcolm Lake	Frontenac	North Frontenac	August 15 2018	No	No
Marble Lake	Frontenac	North Frontenac	August 24 2016	No	No
Mazinaw Lake	Frontenac	North Frontenac	July 19 2016	No	No
Palmerston Lake	Frontenac	North Frontenac	July 18 2016	No	No
Patterson Lake	Lanark	Lanark Highlands	August 23 2016	No	No
Robertson Lake	Lanark	Lanark Highlands	July 4 2016	No	No
Shabomeka Lake	Frontenac	North Frontenac	July 18 2016	No	No
Silver Lake	Frontenac	not listed	July 25 2016	No	Suspect
Sunday Lake	Frontenac	North Frontenac	June 29 2016	No	No
White Lake	Frontenac	Central Frontenac	July 15 2016	No	No
*Suspect - Results were inconclusive, samples should be taken again in 2017.					