WHITE LAKE PROPERTY OWNERS ASSOCIATION ENVIRONMENT VOLUNTEERS

REPORT

Water Quality Monitoring Program and Research Activities: 2024

Conrad Grégoire, PhD and David Overholt, BA

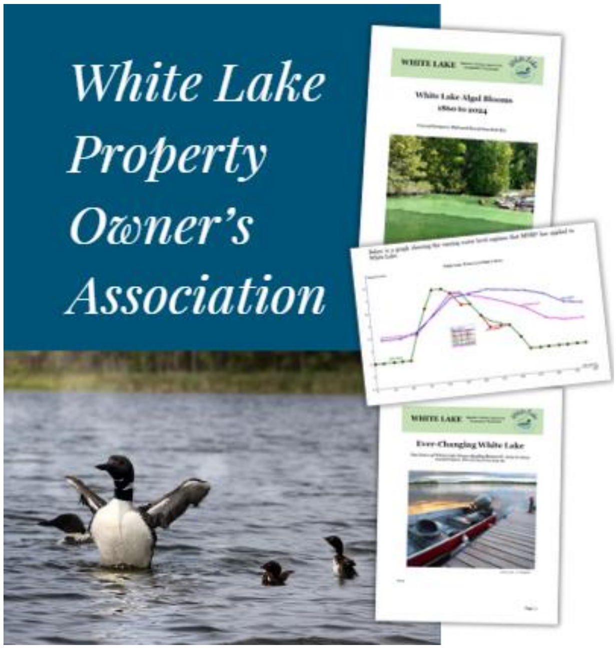
White Lake Marsh…Nature's Water Purification System

White Lake Property Owners Association Wins Environment Award

The Federation of Ontario Cottage Associations (FOCA) has given the 2024 Terry Rees award to the White Lake Property Owners Association (WLPOA). FOCA has a membership of 525 lake and road associations representing 250,000 families living seasonally and year-round in waterfront communities across Ontario.

The award is given annually to a FOCA member association that has demonstrated innovation in its work, and dedication to community betterment.

The WLPOA received the 2024 Award for environmental monitoring and stewardship of White Lake by enthusiastic community science volunteers Conrad Grégoire and David Overholt.



For the last 12 years Conrad and David have been sampling White Lake every two weeks at 9 separate sites, collecting water samples and doing physical measurements. They write and distribute bi-monthly White Lake Checkups, monthly Environment Bulletins, annual State of the Lake Reports, and a White Lake Science website that goes into great detail on various environmental issues effecting the lake. They also conduct wildlife monitoring including loon and cormorant counts, and provide extensive environmental education through the website, webinars, bulletins, and ongoing community science efforts. They have participated in FOCA's Lake Partner Program for over a decade.

Water Quality Monitoring Program And Research Activities 2024

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Water Quality Monitoring Program

2024 Water Quality Monitoring Program and Research Activities

Summary and Highlights

Conrad Grégoire PhD and David Overholt BA

1.1 Introduction

2024 marked the 11^{th} year that we have been monitoring water quality in White Lake. In our work, we keep track of changes in phosphorus concentrations, water clarity, algal blooms and much more in order to accurately asses water quality. The interpretation of this data is validated by research reports in the scientific literature. This approach forms the basis of annual water quality reports. Data obtained over a period of years is valuable in detecting long and short-term trends. The more data we have the more realistic is our assessment of the changing state of White Lake.

Water quality is a term which can mean different things to different people. Depending on your interest, it could refer to clear water, good fishing, or water suitable for drinking free of toxic chemicals or pathogens. In fact, it is all of these and more. Wikipedia defines it as "the chemical, physical, and biological characteristics of water based on the standards of its usage. The most common standards used to monitor and assess water quality convey the health of ecosystems, safety of human contact, and condition of drinking water".

In this Summary Report we provide highlights of our findings for 2024. For a complete referenced account of our work, we ask that you access the White Lake Science Website for full-length Water Quality Monitoring Reports as well as Special Reports on individual topics.

1.2 The State of White Lake Report

In 2022, we published The State of the Lake Report; White Lake and the Environment. The state of White Lake is constantly changing over time. However, over the years since the arrival of settlers, certain events have made dramatic changes to lake water quality. Among these are logging operations during the 1800s, the construction of the dam at Waba Creek in 1845 (reconstructed 1948 and 1968), and the arrival of invasive species such as the Zebra Mussel in 2015.

This State of the Lake report is a snapshot of the condition of the lake today. It explains why and how the lake is changing and what we can do to help preserve the lake.

This report, along with extensive information available on the White Lake Science website, provides the reader with a comprehensive source of virtually all available data collected and reports written on the lake by government and independent sources.

The annual collection of chemical and biological data allows us to detect when significant changes to the lake occur, and guides us in our research on White Lake water quality. More changes are coming with possible invasions of more aquatic invasive species, and the increasing effects of climate change and lake overuse. At some point, a new State of the Lake report may then have to be written.

1.3 Algal Blooms - 2024

During 2024 one algal bloom was observed. This algal bloom was a filamentous green alga. This bloom occurred in early June and lasted for about a month. Green algal blooms are unsightly, but do not produce any dangerous toxins.

Although high concentrations of blue-green algae were observed in late September and in October, we determined that these did not constitute a bloom and therefore did not pose a threat to the general population.

2024 was only the second year in eleven years of monitoring during which there were no blue-green algal blooms. During those 11 years, White Lake experienced 16 blue-green algal blooms.

1.4 Total Phosphorus, Water Clarity, Water Levels and Temperature

Total Phosphorus

Total phosphorus levels in White Lake changed dramatically when zebra mussels infested the lake. Prior to this event, total phosphorus concentrations reached levels of about 22 parts per billion. These concentrations were above the Provincial Water Quality Objective at the time. Once zebra mussels were established, total phosphorus levels measured decreased by about 50% and have not changed greatly since that time.

Unfortunately, lower total phosphorus levels were not achieved by any improvement in lake usage, but rather because of a side effect related to the presence of zebra mussels.

Zebra mussels filter out suspended phosphorus-containing particles leaving behind the dissolved phosphorus that algae thrive on. Also, zebra mussels eat green algae but leave blue-green algae intact making it easier for this type of toxin producing algae to bloom.

Now, algal blooms occur annually when the measured total phosphorus level is about 10 parts per billion (ppb). Ministry of the Environment scientists are now proposing using a different measure in setting its new objective for a lake at shoreline development capacity. For White Lake, the new maximum is 11 parts per billion. Total phosphorus levels in White Lake currently peak at about 14 parts per billion, which is over the new limit.

Water Clarity

Water clarity, as expressed as the Secchi depth, doubled after zebra mussels arrived in 2015. Since that time, water clarity has remained relatively stable from year to year. Any variations are likely due to weather conditions and changes in the number and size of active zebra mussels in the lake. One of the reasons why there has been an increase in aquatic plant growth and spread to deeper waters, is the greater intensity of sunlight now available at any given depth. On average, water clarity for 2024 was slightly greater than for 2023 with minimum Secchi depths of about 3 m (lowest water clarity) recorded in mid-August and a maximum of 8.0 m recorded in early October.

Temperature

When comparing lake water temperatures measured during the past ten years, 2024 results were about mid-range or average for the period. The maximum temperature recorded was 26.6 C.

Water Levels

Water depth levels during the entire 2024 ice-free season were significantly higher, by about 10 cm, than the target depths. This is a departure from previous years where generally, levels more closely followed the Ministry of Natural Resources program.

We are not aware that the Ministry of Natural Resources Forestry, who manage the dam, has decided to change the rule (blue line) in favour of greater lake depths. We will continue to monitor water levels and report annually on them.

1.5 Loon and Cormorant Counts

We were not able to complete a thorough loon survey in 2024. We can report that there were only 9 chicks on the lake down from 22 last year. Anecdotal observations suggests that the number of adults was comparable to those of recent years. We are not aware of the reason for lower chick counts.

Our observations (taken every two weeks) show that there are currently fewer than ten cormorants making White Lake their home. Considering the presence of non-reproductive juveniles, this translates to about 4 or 5 nesting pairs.

Over the last six years, cormorant numbers have ranged from 8 to 17 individuals.

1.6 Environmental DNA (eDNA) Analysis for Detection of Invasive Species

The Federation of Cottage Associations (FOCA) invited the White Lake Property Owners Association to participate in a series of experiments in an effort to apply eDNA techniques to the early detection of the presence of aquatic invasive species. These techniques analyze DNA from lake waters in an effort to provide an early detection of the presence of invasive species. The full report is published in the full-length version of our annual report.

Testing for the presence of zebra mussels and the spiny waterflea was done on water samples collected at three different locations on the lake.

As expected, White Lake tested positive for zebra mussels as this invasive species has been well established in the lake since 2015. White Lake tested negative for spiny waterflea. We have not received any reports of the presence of this invasive nor have we observed them in the field.

1.7 White Lake Water Quality is in Decline: What can we do?

Over the last eleven years, we have completed many studies on White Lake in addition to monitoring changes in water quality. During this time, we have published over 1300 pages of annual and special reports. All of these are available on the White Lake Science Website. We have also co-authored an academic research paper in collaboration with Carleton University, published in an international journal, which supports all of our findings with more hard evidence.

Our special reports on the History of White Lake Water Quality and on White Lake Algal Blooms: 1860 to 2024 unambiguously demonstrate that White Lake water quality is in decline. A cursory reading of personal accounts on White Lake water quality in *White Lake, The Early Years*[1] (available on the members only section of the White Lake Property Owners Association website) reinforce our findings.

It may also be instructive to read our 2022 State of the Lake Report and our recent (short) report entitled Ever-Changing White Lake.

Our goal is to collect and interpret data and to persuade property owners around White Lake to act responsibly. At times, this may require a change in mindset and a re-evaluation of how we are treating the lake.

Many people are not aware that septic systems do not prevent nutrients from entering the lake. The purpose of septic systems is to render human waste free of dangerous

[1] White Lake, The early Years, White Lake Property Owners Association, 2000, 64 pages.

pathogens. In fact, the Ontario Ministry of the Environment clearly states that all nutrients, such as phosphorus, entering a septic system located within 300m of the lakeshore, will eventually reach and be discharged into the lake environment. The same assertion also applies to any fertilizers, pesticides, and herbicides.

White Lake water quality is being affected by climate change, invasive species, and lake overuse. We can make a difference by following the well-developed guidelines for reducing our impact on the lake.

One of the most important actions a property owner can take is to restore their shoreline to a natural state using native plants. Maintaining fully-treed lots as much as possible interrupts and/or delays movement of nutrients from septic systems to the lake. Using native plants will improve water quality, reduce shoreline erosion, enhance wildlife habitat and increase resilience to the effects of climate change and severe weather events.

Two recently published reports from Watersheds Canada both explain the importance of vegetated shoreline buffers and offer a guide to preparing a shoreline naturalization planting plan. We recommend that you access and read these documents if you want to know more about how to best preserve and improve White Lake water quality.

As in any society, there is always a fraction of property owners who will not fully understand the impact that they are having on the lake. It could also be that they are not interested in knowing, and/or just want to enjoy the lake.

This is when governments can intervene and take action to preserve White Lake. The people who are charged with managing the lake (with the assistance of the Ministry of the Environment Conservation and Parks), are the Councils of the four municipalities sharing White Lake. It is difficult to find evidence that White Lake is being effectively managed by any level of government.

Since the Township of Lanark Highlands has both the greatest number of taxpayers of any municipality and a large percentage of its own taxpayers located on White Lake, it has both the most to lose as well as the most to gain when it comes to the health of White Lake.

One suggestion is for LH to take the lead and establish a 4-municipalty committee which could effectively manage White Lake. This committee would provide a forum for local taxpayers to bring forward concerns related to the management of the lake.

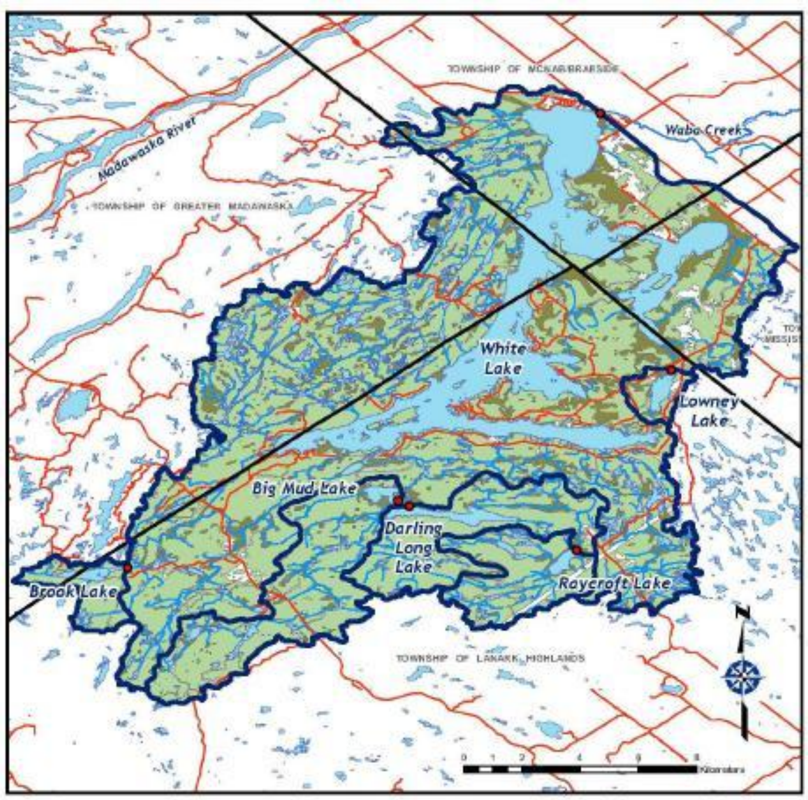
Log on to your municipality's website. Contact your councillors by email and urge them to bring to Council our concerns and request the formulation of an action plan to preserve White Lake for future generations.

PART II

Water Quality Parameters

2.0 2024 Water Quality Monitoring Program

Introduction and Summary



Introduction: White Lake is characterized as a shallow warm water lake. The watershed or drainage basin (pictured on the map) is relatively small compared with the total area of the lake. Most of the water entering the lake is from natural springs.

The western part of the lake shore is comprised mainly of pre-Cambrian (acidic) rocks such as granite, whereas the remainder of the shoreline and the rocks under the lake are mainly calcium rich in nature (alkaline). It is the calcium rich rocks that give the lake its chemical signature with a high pH and high calcium content. Both of these factors strongly favour the growth of algae and zebra mussels, an invasive species which has now been observed in great numbers in all parts of White Lake since 2016.

An examination of the watershed map (above) in concert with topographical maps reveals that the parts of the lake which abut pre-Cambrian rocks are fed by surface and ground waters emerging from heavily forested and hilly terrain. In previous studies reported by the authors, it has been shown that that this terrain does not contribute significantly to the chemical character of White Lake. The remainder of the lake, including areas starting at Hayes Bay and stretching through The Canal, the Narrows and finally the White Lake Village Basin, is surrounded by largely deforested landscape including some farms nearby.

The forested areas, which include numerous beaver dams and ponds, serve as a buffer storing much of the water falling as rain or melting from snow. Trees also have a significant uptake of water during the growing season. On the other hand, the remainder of the drainage basin comprising deforested landscape offers little or no storage of water above the natural water table. In parts of the lake which are surrounded by dense forest, and which also contain the deepest waters, rain and runoff reach the lake at a slower pace relative to the deforested areas. As a consequence of this, the shallowest parts of the lake (including parts of The Canal and areas leading to and including parts of the White Lake Village Basin) receive rain and snow melt surface waters as well as ground water infiltration from the bottom of the lake at a higher rate, especially after a weather event such as a heavy rain.

Water Quality Monitoring: The quality of the water in White Lake is of great importance to anyone wishing to use the lake for recreational purposes and also for the maintenance of a healthy ecosystem including fisheries. The long-term monitoring of water quality will provide a record of how the lake is changing with time. The effects of climate change, increasing use by humans and the influence of invasive species on White Lake need to be recorded so that we can take whatever actions are required to ensure the long-term health of the lake.

Many people ask us to describe the condition of White Lake in a word. They ask if it is in good condition or in only fair condition. Although it would be expedient to do so, these terms are subjective, have little meaning, and cannot be used to paint a complete picture which is in reality much more complex. Our objective is to collect valid data in a systematic and scientific manner, to interpret these data taking into consideration the significant body of knowledge available in the published scientific literature, and in turn inform you of changes taking place in White Lake over time. We publish all of our raw data and invite anyone to suggest alternate interpretations. The only requirement is that adherence to scientific principles is respected. This is how science works. The word '*Preservation*' looms large in our work because one of our main objectives is to keep the lake from further degradation and if possible, improve its current condition.

In 2016, White Lake experienced an explosion in populations of zebra mussels, with numbers estimated to be up to one billion individuals. Zebra mussels have been found in every part of White Lake and are especially prevalent attached to aquatic plants. In 2018, the extent of the infestation continued to increase, but in 2019 and especially 2020 it was clear that zebra mussel populations were decreasing somewhat. This was largely due to natural die-off due to age. Since 2021 zebra mussel populations have rebounded. We know that zebra mussel numbers will fluctuate from year to year, however, our water clarity, calcium concentrations and total phosphorus measurements suggest that the total biomass (weight of all zebra mussels in the lake) changes only marginally.

The most obvious effect of the presence of zebra mussels is the greatly increased clarity of the lake. Looking back at 2015 and years previous, such a finding would have been welcomed as an improvement in water quality. However, attendant effects of zebra mussels are serious and transformative. Zebra mussels are filter feeders and can lead to the wholesale (~90%) transfer of suspended nutrients from open lake waters to waters and sediments near the shoreline. White Lake is only 9.1 m deep at the deepest location and has an average depth of 3.0 m. Secchi depth readings which measure water clarity reached over 9 m in 2018. This means that virtually the entire floor of the lake was and continues to be illuminated with sunlight during most the ice-free season.

Since 2015, the concentration of measured total phosphorus in the lake has declined by about 50%. The general reduction in total phosphorus levels in no way indicates that there is less phosphorus entering the lake. There is, in fact, no evidence of any changes in human activity or other factors which would result in lower total phosphorus levels in all parts of the lake other than those resulting from zebra mussels infesting the lake.

The *Summary and Highlights* section of this report summarizes the current status of White Lake based on our observations and the best available science published in the open literature. Reported is the influence of zebra mussels in transferring particulate phosphorus from the deeper parts of the lake to near shoreline environments while leaving behind that fraction of total phosphorus responsible for algae propagation. This means that we can no longer point to lower total phosphorus levels as a positive indicator of lake health.

We now can show[2] that White Lake is at capacity meaning that the lake cannot tolerate additional nutrient inputs such as phosphorus. We also know that the lake is experiencing annual green and blue-green algal blooms. These two issues taken together present us with our greatest challenge in preserving White Lake and should be the driving force motivating us to take action!

The effects of zebra mussels as well as climate change are only two of the multiple stressors affecting White Lake which, taken together, make the lake more susceptible to algal blooms and other undesirable consequences due to human activity. The results contained in this report highlight the importance that we, the caretakers of White Lake, do whatever we can to minimize our impact on White Lake ecosystems.

In the meantime, we have to become more vigilant and press our politicians to work with our lake association. Also, the Ministry of the Environment, Conservation and Parks, and other interested parties must help to ensure that existing bylaws are used properly in planning decisions and enforced, and that we take measures to protect and preserve the lake. These measures could include septic inspections, shoreline rehabilitation, limits on boat sizes and the control of damaging wakes. There are many things we can do to mitigate the effects of other stressors we cannot control, notably the care, restoration and preservation of the 15 metre 'ribbon of life' along the water's edge.

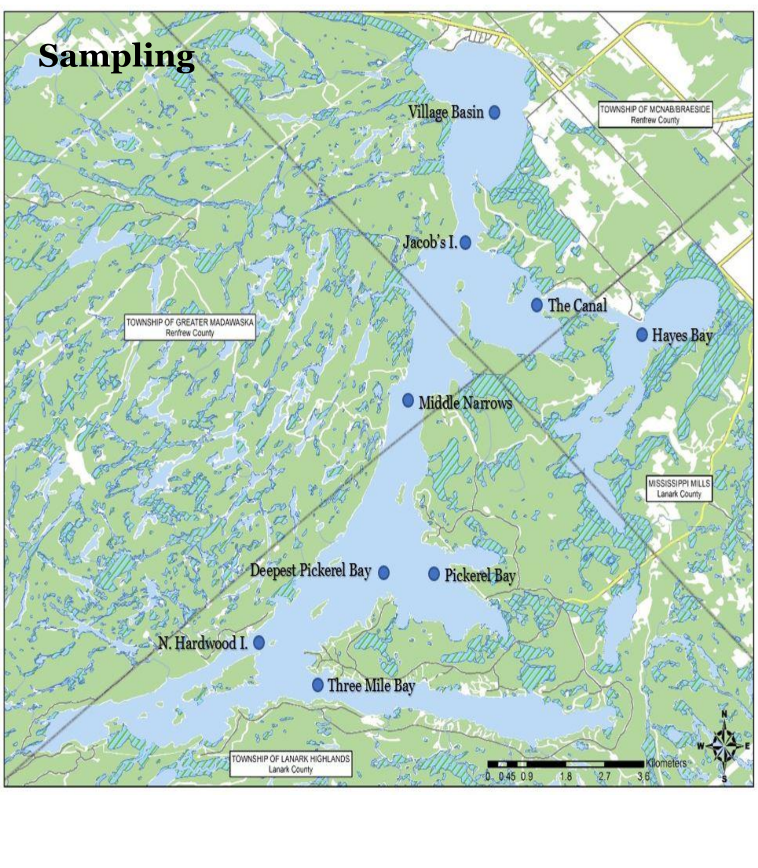
We should also become organized as a society to pro-actively work to prevent the infestation of White Lake with other invasive species some of which have effects far worse than zebra mussels. They are just around the corner. We should also be pro-active in preventing the spread of zebra mussels from White Lake to other local non-affected water bodie

[2] State of the Lake Report, White Lake Property Owners Association, 2022, 117 pages.

White Lake Water Quality Monitoring Program

The water quality monitoring program for 2024 was carried out by volunteers (Conrad Grégoire and David Overholt) and involved the collection of water samples mid-month for 6 months starting in May. Duplicate water samples were collected for phosphorus analysis and a single separate sample was collected for calcium and chloride measurements Water samples were filtered through an 80-micron mesh filter to remove any large biota such as daphnia which would skew analytical results. Note that the total phosphorus data obtained is for both phosphorus available as free phosphorus (there are many phases or chemical species of phosphorus suspended and in solution) as well as phosphorous contained in small phytoplankton and zooplankton. Secchi depth (water clarity) readings as well as temperature at the Secchi depth were recorded at the same time. Additionally, Secchi depth and temperature readings were taken every two weeks during the summer season providing additional data. Throughout the summer we monitored biota populations in the lake and monitored the lake for algal blooms.

All water samples collected for the determination of total phosphorus content were shipped to the Dorset Environmental Science Centre (Ontario Ministry of the Environment Conservation and Parks) for analysis under the auspices of the Lake Partner Program. The method used for the determination of phosphorus is described in the publication: B.J. Clark et al, *Assessing variability in total phosphorus measurements in Ontario lakes*, Lake and Reservoir Management, 26:63-72, 2010. The limit of detection for phosphorus using this method is 0.2 parts per billion (ppb).



3.0 Algal Blooms – 2024

During 2024 one algal bloom was observed. This algal bloom was a filamentous green alga. This bloom occurred in early June and lasted for about a month. Green algal blooms are unsightly, but do not produce any dangerous toxins.

Green Algae Western Shore: June 2. 2024

Although high concentrations of blue-green algae were observed in late September and in October, we determined that these did not constitute a bloom and therefore did not pose a threat to the general population.

2014 was only the second year in eleven years of monitoring during which the were no blue-green algal blooms. During those 11 years, White Lake experienced 16 blue-green algal blooms.

The authors emphasize that the algal blooms observed by our team are the minimum number for White Lake, and there may very well have been others on the lake which went undetected or unreported. No Provincial or local authority monitors water bodies for algal blooms. The Ministry of the Environment and local health units respond only to reports from the public at large. Currently only two volunteers are monitoring the 22 Km^2 of White Lake, which has a shoreline stretching nearly 100 km!

3.1 What Controls Algal Blooms?

Algae bloom when conditions are right for its rapid and uncontrolled growth. These conditions include the presence of excess nutrients (phosphorus) and other chemical species, favourable water temperature and clarity, sunlight, and the action of wind and waves. For White Lake, the presence of zebra mussels is an additional factor promoting the growth of filamentous green algae. These mussels tend to concentrate nutrients from open waters to the shoreline area where filamentous algal blooms occur. Zebra mussels also selectively filter out and consume green algae while at the same time rejecting blue-green algae. This promotes the growth of blue-green algae over green algae.

The severity of the algal bloom resulting from the sum of the above factors can be intensified by the runoff of nutrients from areas of shoreline which have been de-treed or altered in such a way that nutrients can enter the lake unmoderated by the presence of trees and other natural shoreline vegetation which prevents or slows entry nutrients into the lake. Algal blooms are notoriously hard to predict because they result from the interactions of a number of physical and chemical parameters, some of which are very difficult to measure.

As mentioned above, algal blooms can be significantly influenced by the presence of zebra mussels (Dreissena polymorpha), an invasive species that has transformed many freshwater ecosystems across North America and Europe. These mollusks, originally from the Caspian and Black Sea regions, were introduced to the Great Lakes in the 1980s and have since spread to numerous inland lakes. Their impact on algal blooms is multifaceted, involving nutrient cycling, water clarity, and ecological interactions.

Nutrient Dynamics

One of the primary factors influencing algal blooms is nutrient availability, particularly phosphorus and nitrogen. Zebra mussels are filter feeders that consume plankton, including phytoplankton (the microscopic algae responsible for blooms). By filtering out these algae, zebra mussels can initially reduce algal populations, leading to clearer water. However, their feeding habits also contribute to a shift in nutrient dynamics.

When zebra mussels filter water, they selectively remove smaller phytoplankton while allowing larger particles, including detritus and dissolved nutrients, to accumulate in the water column. This process can lead to a paradoxical situation where, despite the initial reduction in algal biomass, nutrient concentrations increase, particularly phosphorus. The accumulation of nutrients can promote conditions favourable for certain algal species to thrive, particularly cyanobacteria (blue-green algae).

Changes in Water Clarity

The filtering action of zebra mussels increases water clarity by reducing the concentration of suspended particles. While clearer water might seem beneficial, it can alter the ecosystem in ways that promote algal blooms. Increased light penetration can enhance the growth of submerged aquatic plants, which can subsequently die back and decompose, releasing additional nutrients into the water. These nutrients, combined with the right environmental conditions, can trigger harmful algal blooms.

Moreover, clearer water can change the competitive dynamics among phytoplankton species. Some algal species, particularly those that are adapted to high light conditions or those that can rapidly take advantage of nutrient spikes, may dominate the community, leading to blooms that can produce toxins harmful to aquatic life and humans.

Ecological Interactions

The presence of zebra mussels can also disrupt established food webs. By significantly reducing the abundance of certain zooplankton species that graze on phytoplankton, zebra mussels can indirectly facilitate algal blooms. With fewer grazers in the ecosystem, phytoplankton populations can grow unchecked, leading to increased frequency and severity of blooms such as we have experienced on White Lake..

Additionally, the overall biodiversity of the ecosystem may decline as zebra mussels outcompete native species for food and habitat. This loss of biodiversity can destabilize the ecosystem, making it more susceptible to algal blooms. A less diverse community may be less resilient to environmental changes, further increasing the likelihood of bloom events.

Conclusion

Inland lakes with zebra mussels are subject to complex interactions that can influence algal blooms. While zebra mussels initially reduce algal populations through their filter-feeding behavior, they also alter nutrient dynamics, enhance light penetration, and disrupt food webs in ways that can lead to increased algal blooms. Understanding these interactions is crucial for managing and mitigating the impacts of algal blooms in affected ecosystems. Effective management strategies must consider the role of zebra mussels and other invasive species to promote healthier aquatic environments and protect local biodiversity.

4.0 Water Clarity – Secchi Depth

One of the most dramatic changes in White Lake water quality which we have observed since the arrival of zebra mussels in 2016 is the increase in water clarity. So how much clearer is the water now compared to 2015 when the lake was in its natural state?

It turns out that changes in water clarity is not the same in all parts of the lake. In areas close to shorelines (where most zebra mussels are found) like Three Mile Bay, water clarity has increased up to 138%! At locations further away from shorelines, the Secchi depth has increased up to 109%. In the middle of the lake, the increase is about 95%.

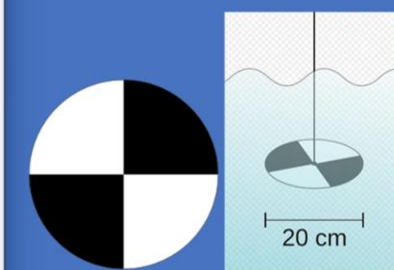
In July of 2015, the Secchi depth in Three Mile Bay was 2.1 metres and by July 2018, the Secchi depth had increased to 5.0 metres. We are now measuring Secchi depths of over 9 metres at some locations. So what?

Water clarity on the surface appears to be a good thing. However, there are some important consequences to consider, especially since the increased clarity is due to the presence of zebra mussels in White Lake:

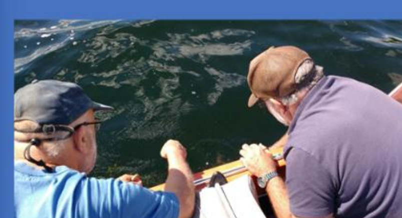
- Aquatic plants will propagate in deeper parts of the lake.
- Aquatic weed beds will thicken in shallow areas where weeds currently exist.
- More zebra mussel habitat will be created on new plant beds.
- Enhanced water clarity means less food for small creatures, including fish.
- The presence of filamentous green algae along shorelines will become more prominent. This 'green angel hair' was visible in nearly all parts of the lake this year.
- Fish will have a harder time hiding from predators in clear water.
- Currently, there are no approved ways of reversing any of the changes noted above.
- We must now prevent the spread of zebra mussels from White Lake to other water bodies.

WHAT IS SECCHI DEPTH AND HOW IS IT MEASURED?

The Secchi depth is a measure of the clarity or transparency of the water. The Secchi disk, named after an Italian scientist, is used to make the measurement. The disk is segmented black and white and 20 cm in diameter:



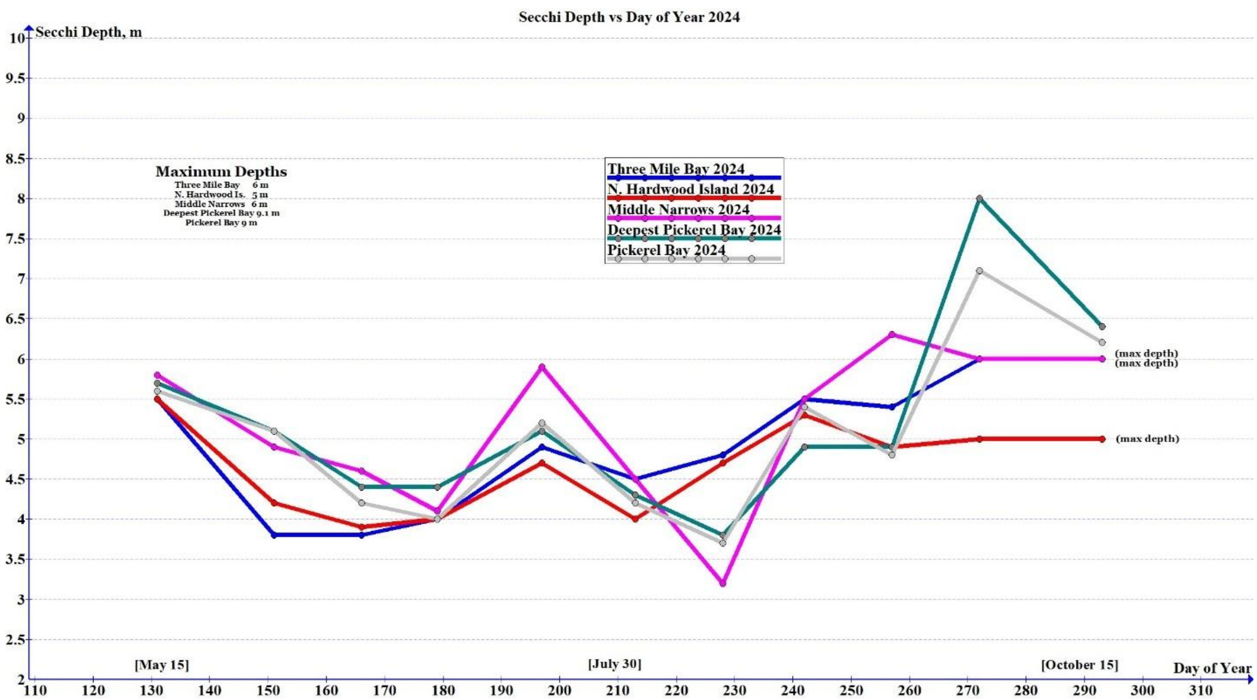
The disk is lowered into the water until it is no longer visible. The recorded depth, in metres, is one half of the distance that light can travel through the body of water being measured. A Secchi depth of 6 metres, for example, means that light can travel through 12 metres of water. White Lake is a maximum of 9.1 metres in depth.



4.1 Secchi Depth Data:

Below is a graph containing the Secchi depth readings for White Lake taken during the 2024 ice-free season.

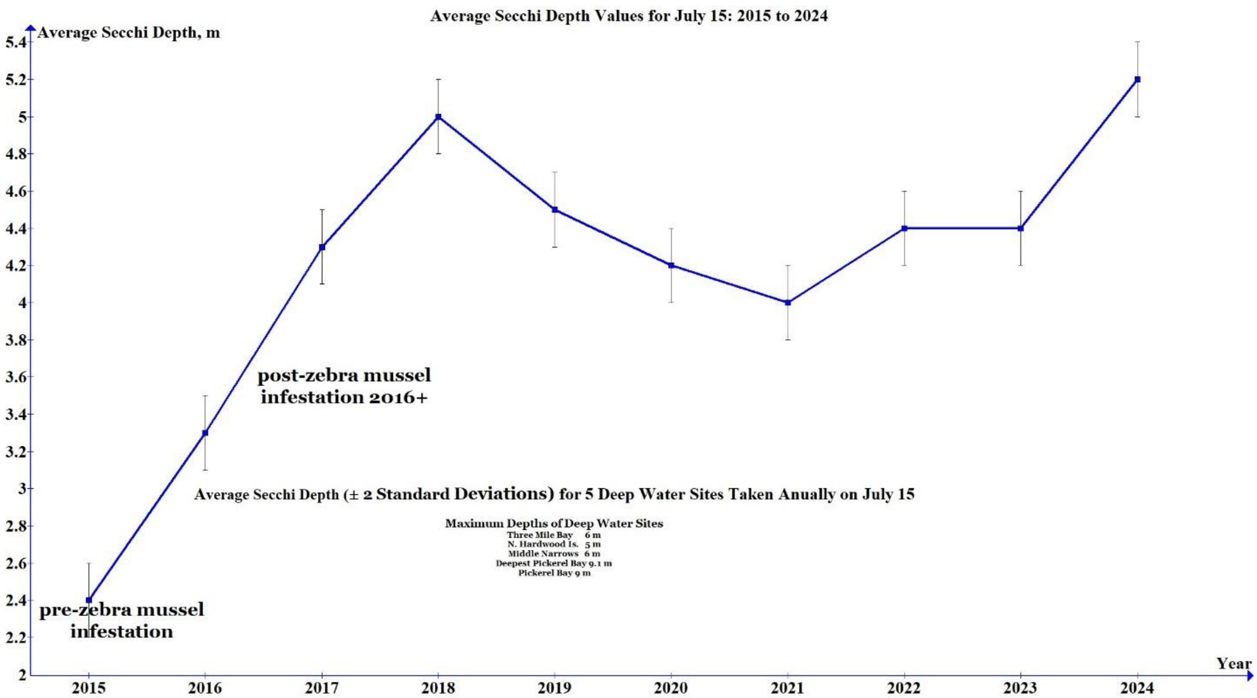
Of the nine sites we sampled, there were only five that had measurable Secchi depths. The remainder of sites were too shallow or the water was too clear at all times. The pattern of Secchi depth readings in 2024 was similar to those of previous years. Secchi depths increase as the lake water column becomes uniform in temperature in the spring and then decreases as the temperature of the lake increases. At higher temperatures there is more biological activity as well as a greater supply of nutrients. Minimum Secchi depths of about 3 m (lowest water clarity) were recorded in mid-August with a maximum of 8.0 m recorded in early October.



The highest value for Secchi depth (~9m) was recorded in 2017. Since that time, water clarity has decreased somewhat, but is still much higher than it was prior to the invasion of zebra mussels. One can speculate that this pattern may be related to weather conditions, but it is possible that nutrient levels in the lake have increased in recent years. Alternatively, the presence of reduced numbers of zebra mussels may also have had an effect in decreasing water clarity.

A clearer illustration of year over year changes in Secchi depths can be obtained by plotting the average Secchi depth obtained annually on July 15th for all deep-water sampling sites (Zone 1, see Appendix 1).

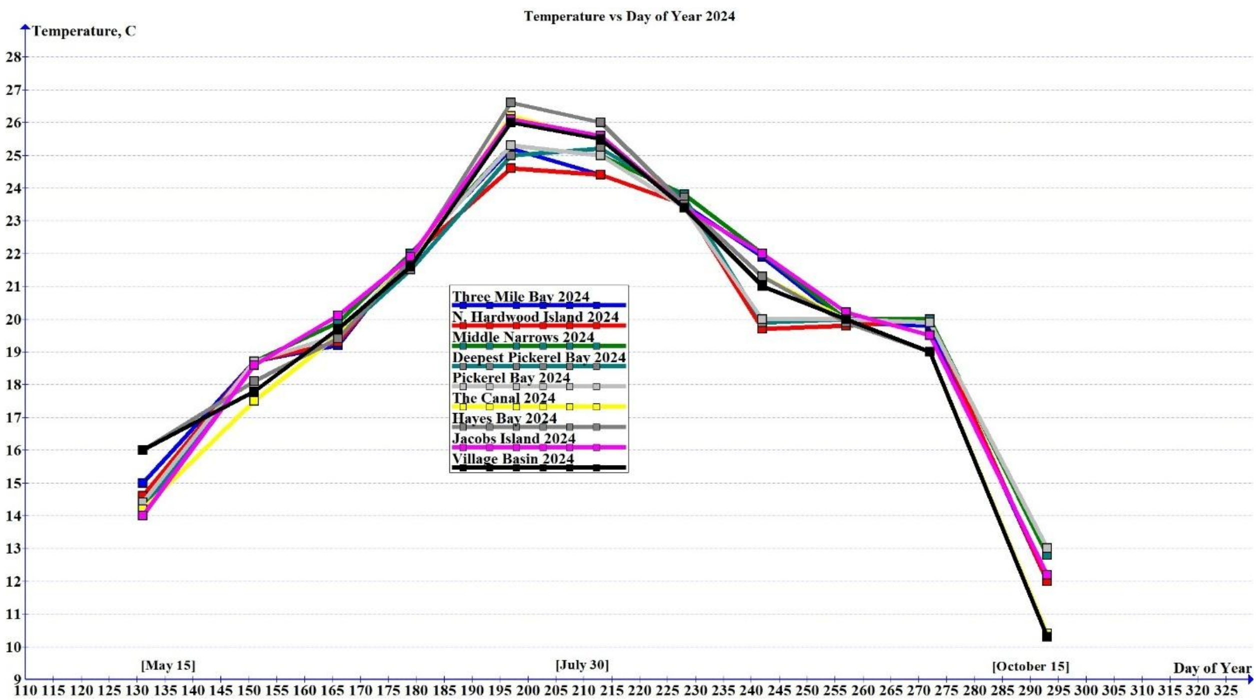
The graph below shows that after 2018, when Secchi depths reached a maximum, water clarity decreased moderately each year thereafter and then increased starting in 2022 with the highest value (greatest water clarity) recorded in 2024.



The reason for the increased water clarity could be attributed to the growing presence of zebra mussels in White Lake. The Secchi depth values obtained in 2015 were typical of those measured in years prior to 2015, when no zebra mussels were present in the lake.

5.0 Water Temperature

Temperature is one of the most important factors when discussing water quality parameters. Changes in temperature affect the rates of chemical reactions, pH, and also the equilibrium concentrations of dissolved gases in the water column such as oxygen and carbon dioxide. Temperature also affects the solubility of many chemical compounds and can therefore influence the effect of pollutants on aquatic life. Increased temperatures elevate the metabolic oxygen demand, which in conjunction with reduced oxygen solubility, impacts many species. For White Lake, increased water temperatures could also increase the release of phosphorus by internal loading from sediments into the water column. All temperatures reported in this study were taken at the Secchi depth using a thermometer calibrated against a secondary standard mercury glass thermometer.



The graph above shows the temperature of White Lake water during the 2024 ice-free season.

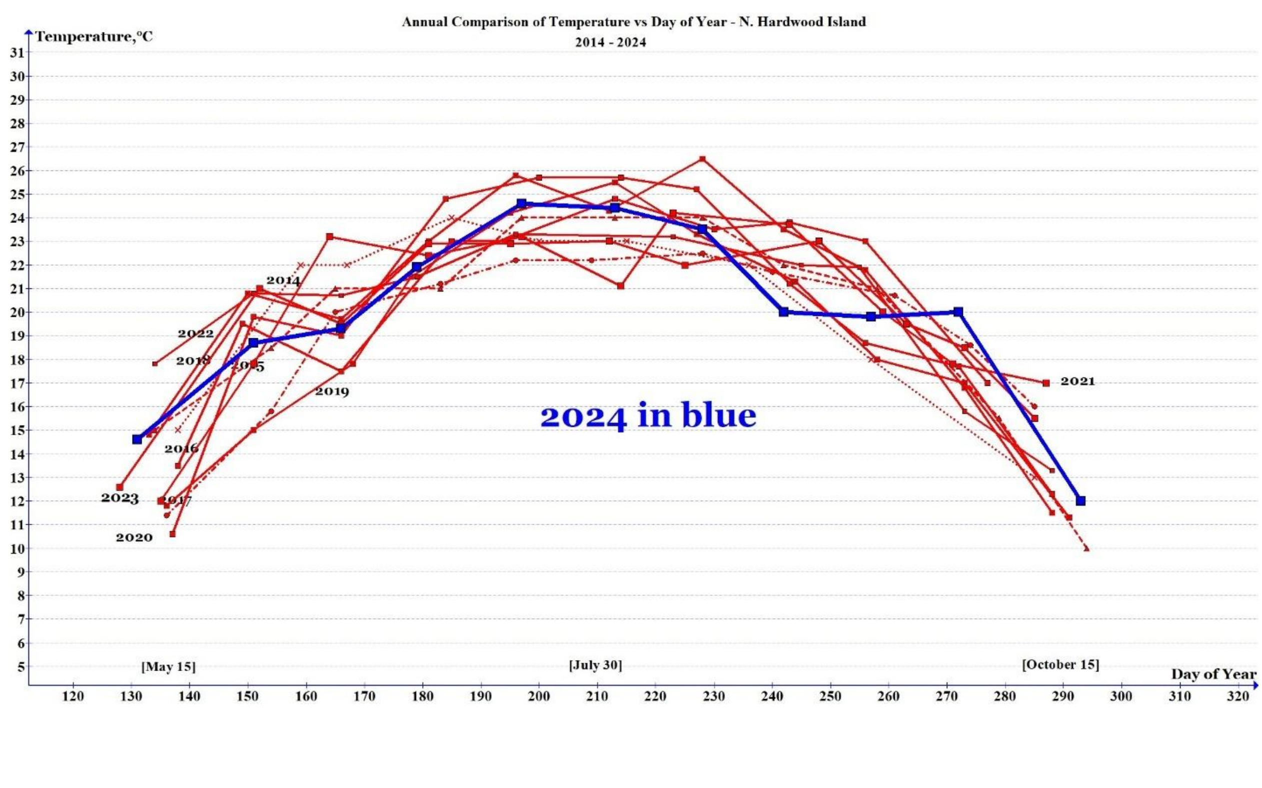
Although there is clearly some variation in measured temperatures depending on the location of the sampling site, the temperature curves follow a trajectory very similar to those observed in previous years. The noticeable 'dips' in temperature which occur from time to time are usually correlated with significant rain events one to three days prior to sampling. Cooler waters resulting from rain enters the lake via springs in the floor or the lake as well as from surface runoff. Because White Lake has such varied bathymetry, there are differences in temperatures at different sampling sites. For the most part, water temperatures for all of the deeper sites were almost the same differing by no more than 0.5 °C. However, temperatures for the shallow sites were at times quite different from those of the deeper sites because they are more susceptible to recent or current weather conditions. A full explanation of this topic can be found in the 2016 and 2019 Water Quality Monitoring Program Reports available on the White Lake Science website.

5.1 Annual Trends in Lake Water Temperatures

Although there are some year-to-year differences for temperatures recorded on a given date, the same general pattern in water temperatures with day of year is observed (see previous reports). This indicates, along with the other data in this section, that the temperature regime of the lake is quite regular from year to year, but may be subject to change due to local climatic conditions.

We now have 10 consecutive years of water temperature measurements for the deeper sites (Zone 1: Main Water Body) on White Lake. The figure above gives temperature measurements obtained at the North Hardwood Island site for the years 2014 to 2024. The thick blue line is 2024 data.

The 2024 data shows that temperatures were generally within the range of temperatures measured over the past decade.



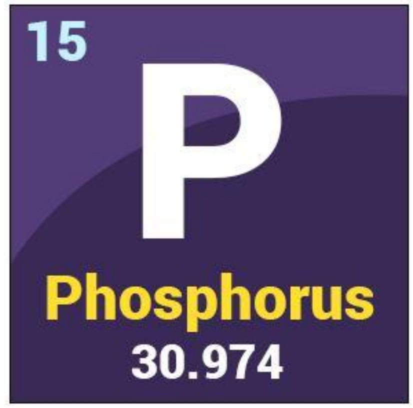
The table below gives maximum temperatures recorded for White Lake during the past 10 years. 2018 had the highest water temperature recorded to date was 4.1 ◦C higher than the lowest temperature recorded during 2017. Maximum temperatures were almost always recorded in the shallow parts of the lake.

Year	Day of Year	Maximum Temperature, ˚C
2014	199	24.1
2015	217	24.0
2016	223	24.7
2017	216	22.9
2018	196	27.0
2019	213	25.6
2020	214 and 227	26.0
2021	181	25.2
2022	210	24.3
2023	152	24.1
2024	197	26.6

Note that temperatures cited in these pages are for sampling sites located in open water away from the shoreline. During the day, higher temperatures than open water temperatures are expected which could result in more prolific aquatic plant growth and also encourage propagation of algae, including blue-green algae.

6.0 Phosphorus

What is Total Phosphorus?



Phosphorus is element 15 of the Periodic Table. It is so important because life cannot exist without it. Phosphorus is one of the building blocks of DNA and hence proteins, and is integral to any ecosystem including lakes like White Lake. However, if there is too much of it, then we can have problems such as dangerous or nuisance algal blooms. For this reason, we monitor the levels of phosphorus in the water so that we can assess the health of the lake and hopefully modify our behaviour to prevent excess quantities of phosphorus from entering the lake.

But what are we measuring anyway? We report our results for phosphorus as 'Total Phosphorus' which implies that total phosphorus is not just one thing but the sum of many things. This is the case!

Phosphorus is a very reactive element and can exist in many oxidation states, which is to say that it likes (as much as an element can 'like') to combine with other elements in many different ways.

But where does it come from? Phosphorus occurs in nature mostly as the mineral apatite which is also called calcium phosphate $Ca_5(PO_4)^+$. It can enter lake water by a number of ways including: rain which contains atmospheric dust; pollen which is high in proteins; fertilizers, detergents, septic systems, etc.; surface soil runoff, and ground water containing dissolved phosphorus compounds. It has been estimated[3] that the concentration of total phosphorus in White Lake waters prior to the arrival of Europeans was about 7.5 parts per billion or nanograms/ml.

When it comes to lakes, we are not really interested in ALL forms of phosphorus, but only the forms which can affect living creatures including fish, plankton (including certain algae, bacteria, protozoans, crustaceans, mollusks) and us!

In lake water, the term 'Total Phosphorus' includes all of the phosphorus that can be measured in water which has passed through an 80-micron (micro or millionth of a metre) filter. The 80-micron filter is used only to remove large zooplankton and, for example, colonies of chrysophyte algae which can form into relatively large 'clumps. Everything else including phytoplankton, small zooplankton, particles containing phosphorus, dissolved inorganic and organic phosphorus compounds pass through the filter and are measured together as total phosphorus. These are true total phosphorus

[3] J.P. Ferris, White Lake Integrated Resources Management Plan, Part I, Ministry of Natural Resources, Lanark and Renfrew Counties, December, 1985.

samples and are not in any way interpreted as only containing dissolved phosphorus. If you place one 1 mm-sized daphnia in a phosphorus sample tube and analyze it in distilled water, one can get a result of 35 µg/L (ppb)[4]. For this reason, these larger organisms must be filtered out prior to analysis.

The dissolved phosphorus-containing fraction is sometimes called the bioavailable phosphorus. This definition is great for most people, but chemists and biologists will want to tell you that the term' Total Phosphorus' includes all forms of organic phosphates, inorganic phosphates and also organic and inorganic soluble reactive phosphates as well as small particulate phosphate-containing materials.

Since zebra mussels have established themselves in White Lake, the total phosphorus concentrations measured in the lake have decreased by about 50%. This is because zebra mussels are filter feeders and they very efficiently remove all particulate material (down to 1 micron) containing phosphorus. The phosphorus which remains in solution is not filtered out by mussels, but remains available for algal growth. In effect, even though overall phosphorus concentrations have diminished, the amount of phosphorus which algae feed on has not changed at all. Therefore, the total phosphorus concentrations we are now obtaining (much lower than before) do not reflect a reduced risk for algal blooms!

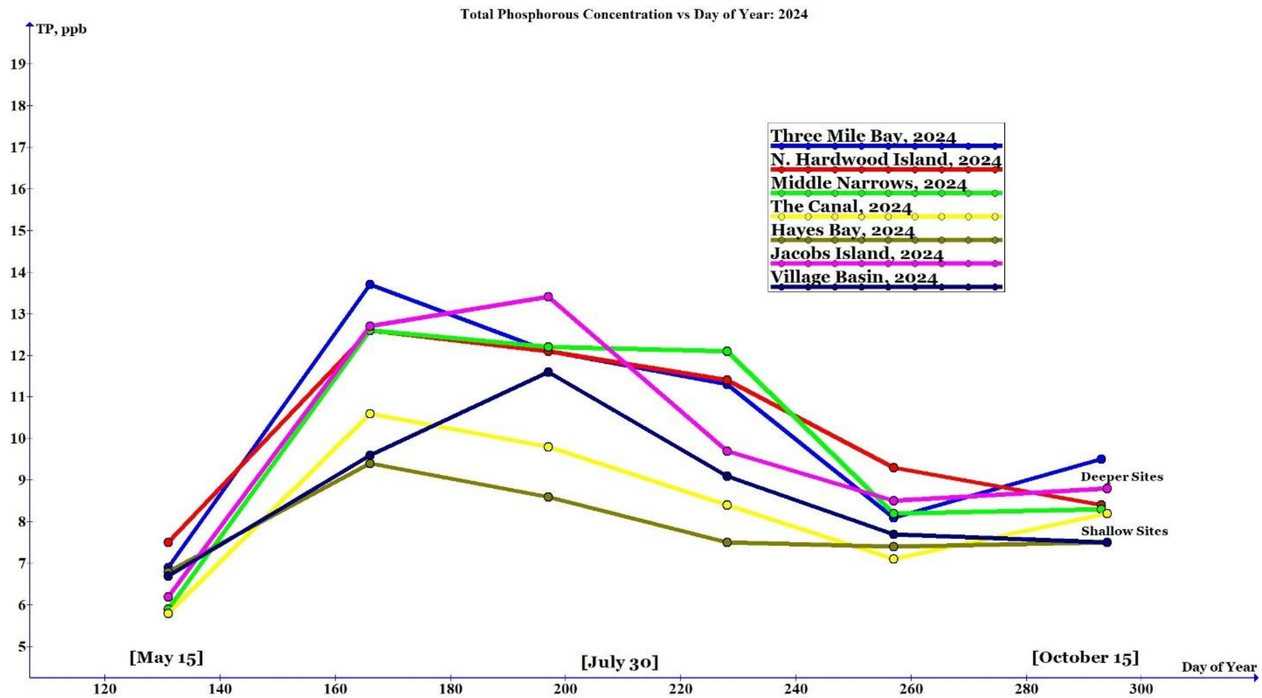
The phosphorus contained in sediments is just as complex if not more so. It is easy to realize that the study of lakes as well as other bodies of water is very challenging and requires the highest levels of science and ingenuity to completely describe the complexity of an aquatic system.

One final note: It is important to realize that the 'Total Phosphorus' we are measuring in White Lake waters only accounts for a small portion of the total amount of phosphorus which enters the lake. Most of the phosphorus entering the lake falls to the bottom of the lake (such as pollen) and once there, eventually decomposes and becomes available to animals and plants. This is why the concentration of phosphorus in lake sediments is literally hundreds of thousands of times greater than in the water just above it!

Now we can discuss the total phosphorus results for White Lake for 2024.

The graph below shows the change in total phosphorus concentrations during the 2024 ice-free season.

[4] B.J. Clark et al, *Assessing variability in total phosphorus measurements in Ontario lakes*; Lake and Reservoir Management, 26:63-72, 2010.



The data for 2024 (above) show an increase in the total phosphorus concentration over the summer months reaching a peak or highest value in July. After this date, the total phosphorus concentration decreases towards the end of summer and into the fall. These data also show that the highest total phosphorus values were obtained at the southern part of the lake especially at the Three Mile Bay sampling site. Over the past decade, the Three Mile Bay and N. Hardwood Island sites have consistently had the highest total phosphorus concentrations when compared to all sampling sites. These results and trends are in agreement with measurements recorded during the last ten years by government agencies and lake association volunteers.

The total phosphorus curves in the figure above can be separated into two groups. The first group are those representing the deeper sampling sites, which have higher total phosphorus concentrations. The second group of curves are those representing the shallow sampling sites, located in the northern part of the lake. These sites uniformly have significantly lower total phosphorus concentrations.

There are two main reasons for which shallower locations have lower total phosphorus concentrations. The first is because of more effective mixing of the water column all the way to lake sediments. More oxygen-rich conditions reduce the amount of phosphorus released from sediments.

The second reason contributing to lower total phosphorus values in shallow areas is the nature of the sediments themselves and their ability to sequester (physically entrap) phosphorus contained in waters entering the lake through sediments.

Marl sediments are formed when waters rich in bicarbonate enter from the floor of the lake and upon reaching the surface encounter higher temperatures and lower pressures. Under these conditions, bicarbonate can spontaneously decompose releasing carbon dioxide and leaving behind finely divided (small particle size) insoluble calcium carbonate (marble). When this process occurs, phosphorus can be trapped in the calcium carbonate matrix resulting in lower total phosphorus concentrations.

Parts of the lake such as the Village Basin, The Canal and Hayes Bay are all shallow areas underlain by these marl deposits, a process which is still unfolding today. If one takes a sample of these sediments and adds droplets of 10% hydrochloric acid, the mixture fizzes releasing carbon dioxide while forming calcium chloride. This test is a positive for marl. Sediments devoid of calcium carbonate will show no reaction when this test is applied.

The table below gives the concentration of calcium carbonate in sediments from four shallow areas of White Lake[5].

Location	Percent Carbonate*
Village Basin	47.2
The Canal	46.6
Hayes Bay	37.5
Bane Bay	18.2
*Average of two measurements	

Sediments from the first three locations: Village Basin, The Canal and Hayes Bay, all have very high carbonate content and are documented sources of marl[6]. Although there is a relatively high percent content of carbonate in Hayes Bay sediments, it is less than the two other sites. Bane Bay is even further away from the marl-producing sediments and shows even lower carbonate levels.

6.1 Annual Trends in Total Phosphorus Concentrations

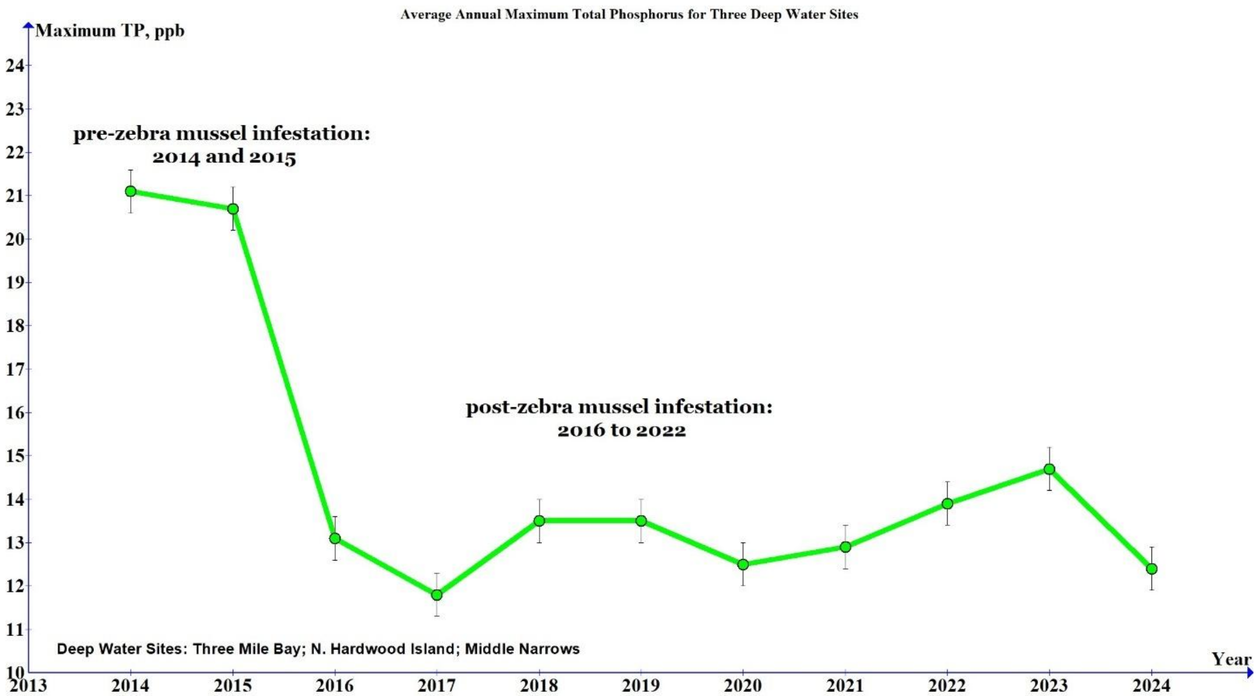
The figure below shows the annual average total phosphorus concentration for three deep water sites in Zone 1 (Main Water Body of White Lake – see Appendix 1).

Total phosphorus concentrations declined significantly from those in 2014 and 2015 (and years prior to that) when in 2016 the zebra mussel infestation took full effect. Maximum phosphorus concentrations declined by about 50% or more from 2015 onwards.

However, the explosion of zebra mussel populations in White Lake during the 2016 season explains why total phosphorus levels have decreased significantly over previous years. Zebra mussels can remove over 90% of the plankton and other particles normally found in an unaffected lake. Zebra mussels are efficient at removing particulate phosphorus from the water column and transferring it to sediments via feces and pseudo-

[5] M. Murphy and J. Vermaire, Carleton University, 2019; personal communication.
[6] W.E. Logan, The Geology of Canada, Geological Survey of Canada; 1863, p. 765.

feces. It is also reported that the concentration of soluble reactive phosphorus remains unchanged allowing for further phytoplankton production. However, this type of phosphorus is a primary food for zebra mussel veligers (larvae). The phosphorus transferred to sediments by zebra mussels eventually becomes available for algae growth and results in an increase in both green and blue-green algal blooms. This is exactly what we have observed in White Lake in recent years.



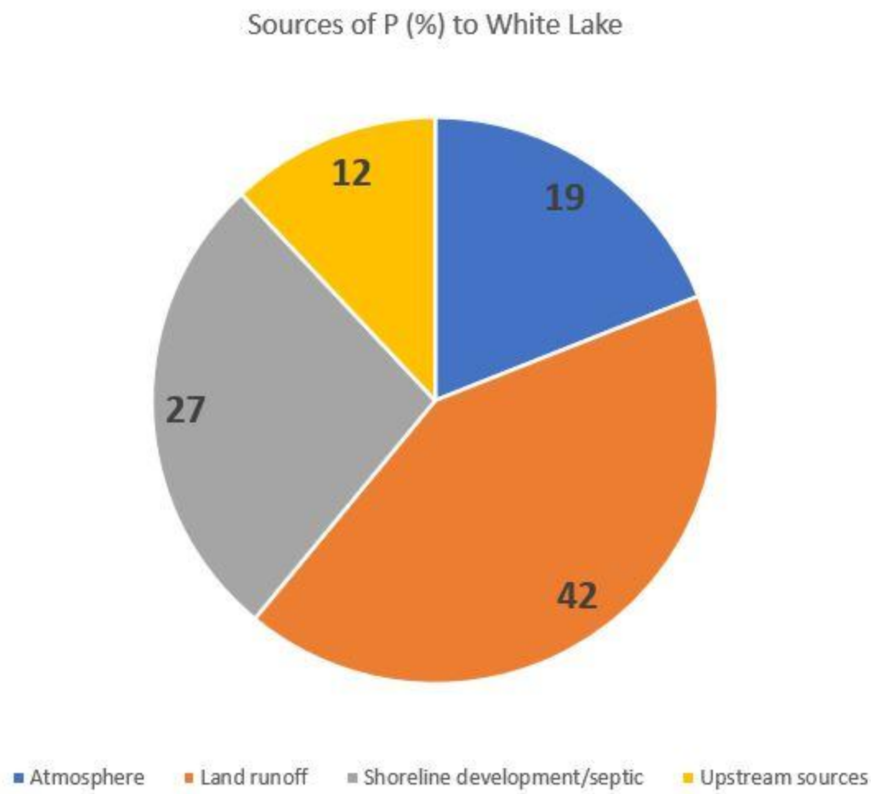
Even though we know that the population levels of zebra mussels in White Lake can both increase and decrease from year to year, it is evident from the above graph that the impact of zebra mussels on total phosphorus concentration levels changes very little as evidenced by the relatively constant total phosphorus concentrations measured from 2018 onwards.

It may be useful to remind ourselves of the relative sources of phosphorus entering White Lake[7] and note that not all of the phosphorus entering the lake is represented in the 'total phosphorus' that we measure every month during the ice-free season.

The pie chart below indicates that land run-off, septic systems and shoreline development account for about 70% of the phosphorus entering White Lake.

[7] These data are outputs of the Lakeshore Capacity Model for White Lake reported by Bev Clark. Bev Clark is a retired senior career research scientist from the Ministry of the Environment, Conservation and Parks. He was the director of the Lake Partner Program at its inception and both collected research data and contributed to the develop of the Lakeshore Capacity Model used by the Ontario Government Ministry of the Environment..

Relative Sources of Phosphorus in White Lake



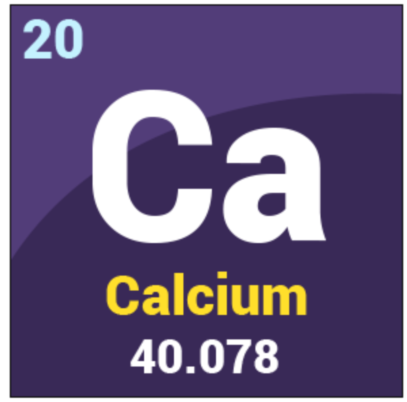
This clearly shows the importance of effective shoreline management to improve water quality and help control nuisance and toxic algal blooms such as those which we have been documenting during the past nine years.

The chart also shows that we, as users of the lake, can have an effective role in maintaining and even improving White Lake water quality.

Returning now to the results obtained for total phosphorus from 2016 to 2024: One might be tempted to explain the sudden decrease in total phosphorus levels to lower levels (compared to previous years) as a decrease of <u>input</u> into the lake. Unfortunately, there is no evidence to support this assertion. More likely, however, is the introduction of a new pathway by which phosphorus is <u>removed</u> from the water column and it is this phenomenon which results in lower overall total phosphorus measurements.

Measured total phosphorus concentrations are derived from water samples filtered through an 80-micron (80 one-millionth of a metre) filter. Phosphorus taken up by certain algae which form colonies larger than 80 micrometres (e.g., chrysophyte) would tend to lower the <u>measured</u> total phosphorus value underestimating the actual amount of phosphorus in the water column.

7.0 Calcium



The table below contains values for calcium concentrations measured in White Lake waters. Data are tabulated on a monthly basis and also for each individual site sampled. Analyses were performed by the Lake Partner Program laboratories in Dorset, Ontario.

Across the entire lake during May to October, the concentration of calcium varied from a low of 25.1 ppm to a high of 36.0 ppm. Although the average values for all individual sites (green) are very close to one another, the absolute values for Hayes Bay were significantly higher. This site, in particular, has a total dissolved solid content which is 20% higher than at all other sampling sites on White Lake. Because of this, these calcium values are excluded from calculated means and are treated separately. The higher values found in Hayes Bay could be due to a higher concentration in waters entering the bay and/or increased rates of evaporation relative to the rest of the lake. Hayes Bay is very shallow (1.5m), has a large surface area and is usually warmer than the rest of the lake; all of these factors increase the evaporation rate resulting in higher calcium concentrations.

When looking at mean calcium values for all sites for a given month (red), variation is very small and within one standard deviation. This indicates that lake waters are well mixed.

Calcium (ppm) – Sampling Site by Month: 2024

Sampling Site	May	June	July	Aug	Sept	Oct	Average
Three Mile Bay	31.3	32.4	30.6	28.8	26.4	27.8	**30.6**
N. Hardwood I.	31.3	32.3	30.8	27.7	26.3	27.4	**29.3**
Middle Narrows	30.7	31.9	31.0	29.9	26.1	26.7	**29.5**
Jacob's Island	31.0	31.5	30.4	27.5	25.8	26.9	**28.9**
The Canal	31.5	32.6	31.1	25.1	25.4	29.2	**29.1**
Hayes Bay	35.9	36.1	36.7	33.5	32.0	36.0	**33.3**
Village Basin	28.6	31.4	30.2	27.3	26.4	30.0	**29.0**
Mean	30.7±1.0	32.0±.5	30.7±.3	27.7±2	26.1±.4	28.0±1	

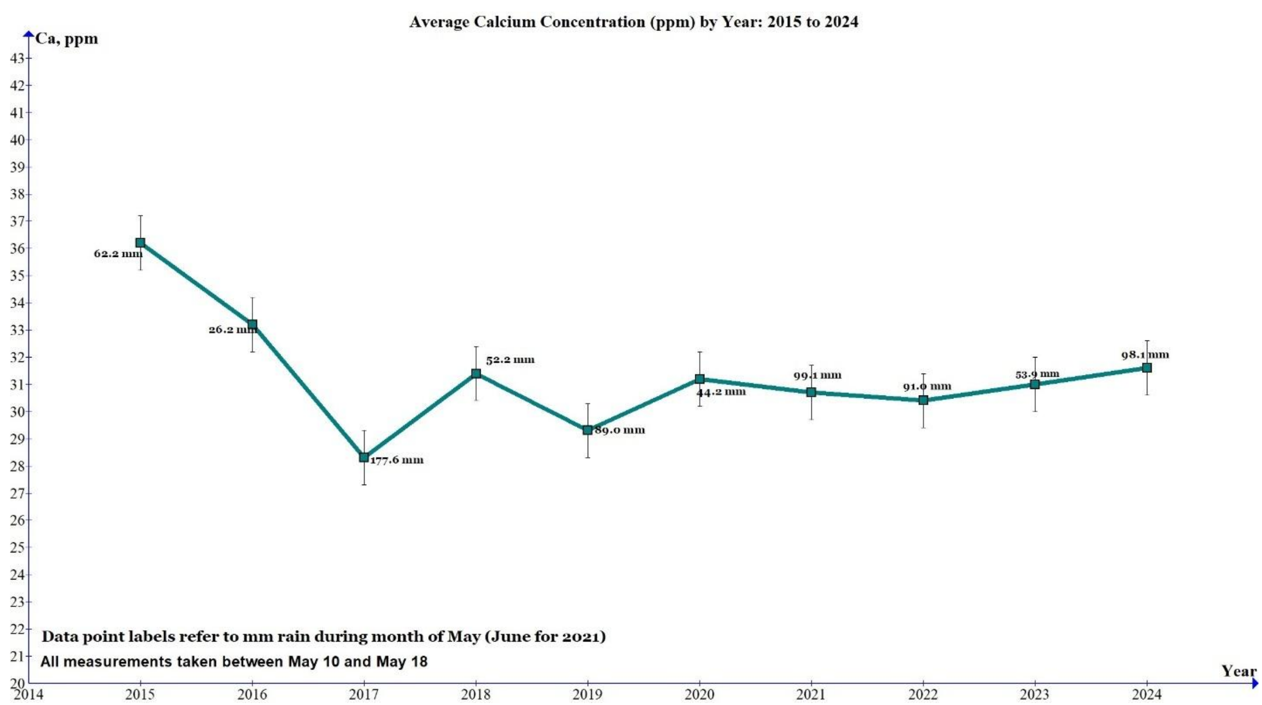
The table below compares the average calcium concentrations for individual sites over a ten-year period. With the exception of 2015, where values appear to be anomalously high (see section 31 of this report), calcium concentration at each individual site in White Lake do not appear to be changing appreciably over time. We have noted in other studies that rainfall is an important factor when interpreting changes in calcium concentrations.

Higher levels of precipitation result in a ‘dilution effect’ causing calcium levels to decrease following high rain events.

Sampling Site	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
Three Mile Bay	30.6	30.1	28.6	31.6	30.6	28.8	32.8	28.4	36.4	36.2
N. Hardwood I.	29.3	30.3	29.0	31.3	30.8	28.6	33.0	28.5	31.8	37.3
Middle Narrows	29.4	30.7	29.3	31.4	31.2	30.3	33.4	28.4	31.1	35.3
Jacob’s Island	28.9	29.9	28.5	30.5	30.6	28.4	34.0	27.7	31.4	36.2
The Canal	29.1	30.2	28.7	30.2	30.7	30.8	34.4	29.4	34.3	35.8
Hayes Bay	33.4	33.3	35.1	34.3	32.6	30.4	37.8	31.0	36.6	-
Village Basin	29.0	29.2	27.7	29.6	30.0	27.9	31.6	27.3	31.0	-

The graph below shows calcium concentrations for each year from 2015 to 2024 for the month of May (June for 2021). Individual data points are provided with an error bar indicating the standard deviation of ± 1 ppm. The size of the error bars relative to the actual plotted value indicates that the changes in calcium concentration from year to year are significant but have remained nearly constant since 2017.

The decrease in calcium concentrations starting in 2016 correlate with the beginning of the zebra mussel infestation of the lake. From 2017 to the present, calcium concentrations had remained lower and nearly constant from year to year. For a possible explanation of this phenomenon, please read Section 13 of this report.



In our 2017 report we published a correlation graph of average calcium concentrations, measured monthly from 2015 to 2017, plotted against monthly rainfall. A linear regression analysis of these data indicated that the calcium concentration in White Lake waters was dependent on the amount of rainfall entering the lake. The correlation coefficient (R^2) obtained was 0.783 which is relatively high indicating that the relation between the two parameters is significant. When the correlation plot was extrapolated to zero rainfall, a calcium concentration of 36.8 ppm was calculated. This concentration was taken as the actual calcium concentration of water entering the lake from springs or other ground water sources. The variance in the actual measured calcium concentrations, which accounts for the different monthly values obtained, were the result of a dilution effect from rain water and surface runoff, which contain little or no calcium.

At each point in the above plot is given the total precipitation for the month of May for each year. When this data is plotted, as was done in 2017, but including all data to 2020, 'zero rainfall' intercept gave a calcium value of 35.1 ppm calcium. This value is (within error) identical to the value obtained in 2017.

These results support the conclusion (see 2017 Water Quality Monitoring Report report) that more than 80% of the water entering White Lake is derived from ground water sources with the remainder coming from rain and surface water runoff.

8.0 <u>Chloride</u>

The table below contains values for chloride concentrations measured in White Lake waters. All samples were collected between May 8 and May 18 of any given year. Analyses were performed by the Lake Partner Program laboratories in Dorset, Ontario.

The concentration of chloride does not vary significantly from site to site especially when comparing deeper water sites (such as the first three in the table below) with values obtained for shallower sites, such as Hayes Bay. Hayes Bay has higher chloride concentrations than at any other location on the lake. These concentrations are nearly three times those of other locations, especially those in Zone 1, the main water body. Water draining from Hayes Bay into the Canal Area and downstream on the way to the Village Basin is responsible for elevated chloride values at The Canal sampling site as well as the Village Basin sampling site.

Chloride (ppm) – May, 2015 to 2024

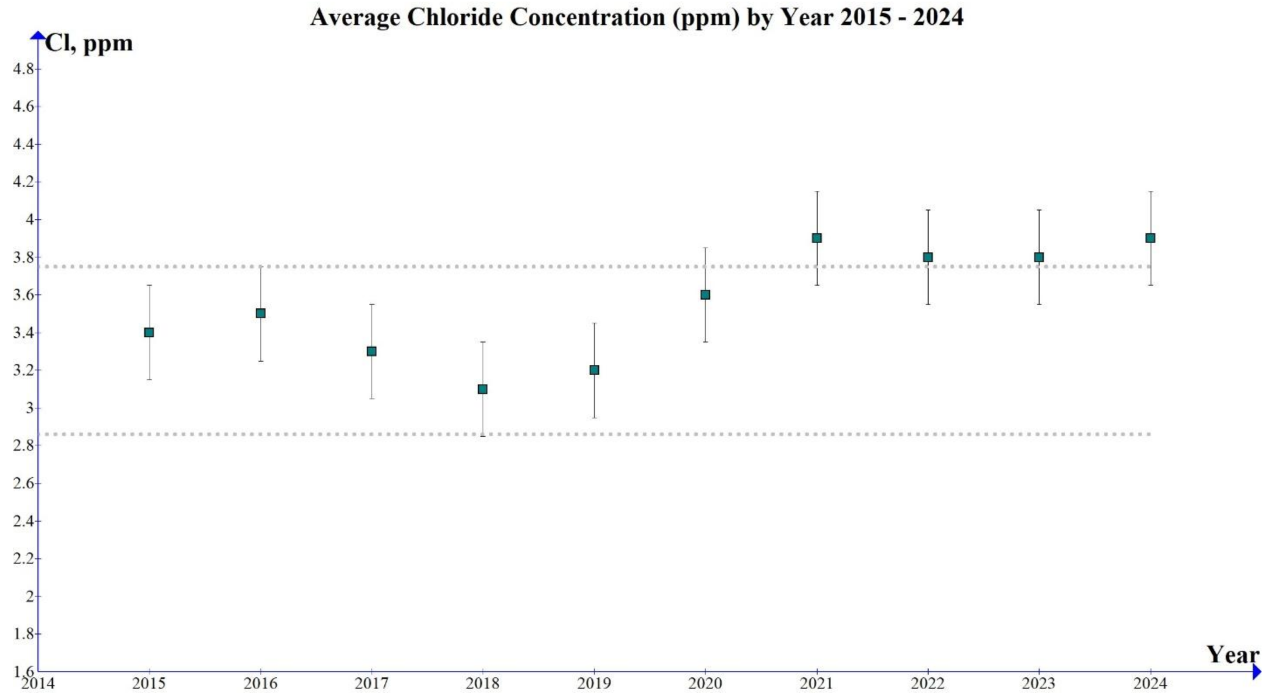
Sampling Site	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
Three Mile Bay	3.9	3.4	3.9	-	3.4	2.8	2.9	2.8	3.4	3.5
N. Hardwood I.	3.9	3.3	3.8	-	3.4	2.8	2.9	3.1	3.4	3.3
Middle Narrows	3.9	3.6	3.8	3.8	3.5	3.2	3.5	3.3	3.5	3.5
Jacob's Island	4.0	3.7	4.4	3.9	3.7	3.6	3.2	3.7	3.7	3.5
The Canal	4.5	4.5	5.1	4.8	4.7	4.1	4.1	6.2	5.4	3.9
Hayes Bay	8.6	8.4	10.0	9.0	9.0	7.6	8.3	9.5	10.0	-
Village Basin	4.0	3.6	3.9	3.9	4.0	3.6	3.6	3.8	3.7	-

Average chloride data for 2015 to 2024 are given in the table below. Data from The Canal and Hayes Bay were excluded from this table so as not to skew results for the remainder of White Lake.

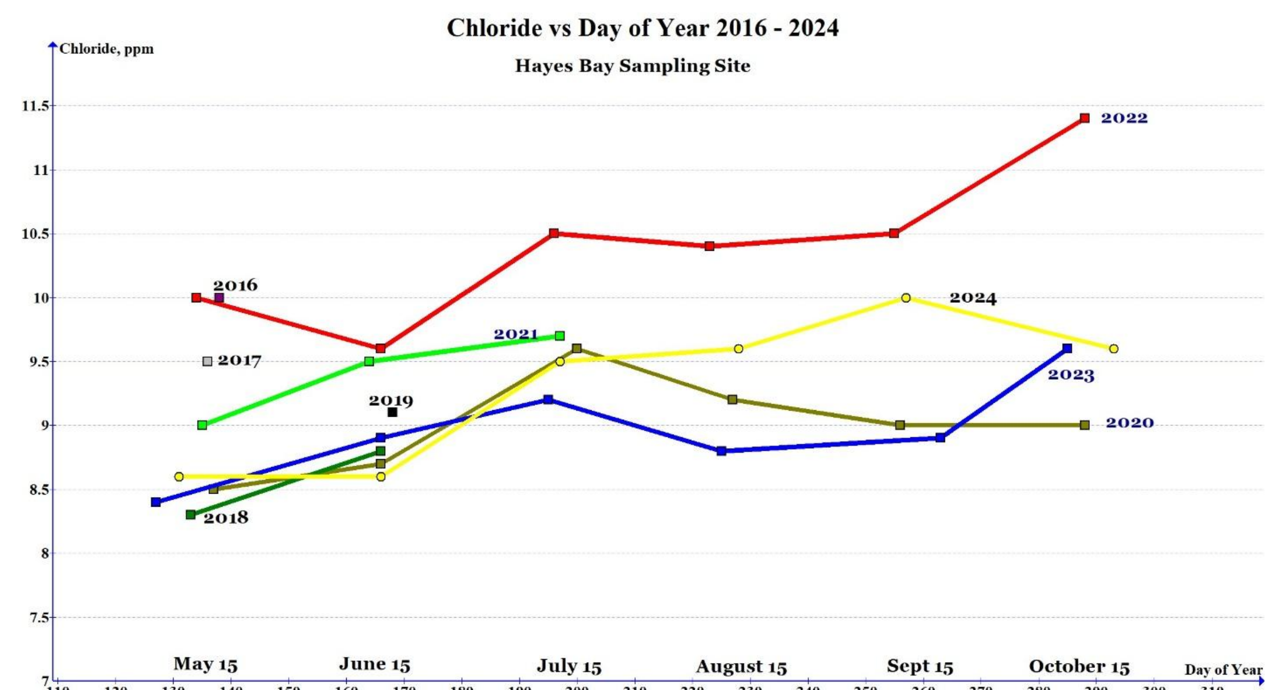
Average Chloride Concentration (ppm) 2015 to 2024

Year	Average ± SD
2024	3.9 ± .2
2023	3.8 ± .2
2022	3.8 ± .2
2021	3.9 ± .1
2020	3.6 ± .3
2019	3.2 ± .2
2018	3.1 ± .3
2017	3.3 ± .4
2016	3.5 ± .2
2015	3.4 ± .1

When these data are plotted (below), it is clear from the error bars on each data point that it is difficult to conclude that chloride levels are increasing over time. It does appear that between 2019 to 2021 that chloride levels rose from precious years and thereafter were relatively constant. Longer term monitoring may reveal a trend in chloride concentrations. At any rate, chloride levels are very low and do not pose a threat to wildlife or water quality parameters.



Conductivity measurements (see 2018 Water Quality Monitoring Program Report) showed that the total dissolved solids in Hayes Bay waters were 20% higher than in any other part of the lake.



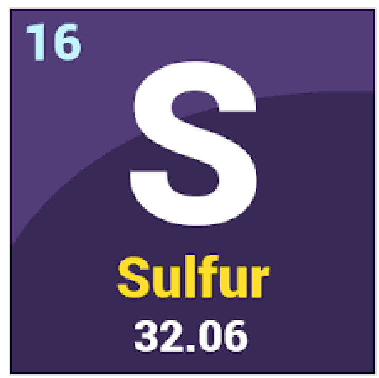
The source of the additional chloride in Hayes Bay waters (see table above) could be from the intrusion of road salt from the nearby road. A second possibility is that Hayes Bay receives additional chloride from subterranean brines fed by a spring(s) or aquifer.

The above graph plots chloride concentrations measured at the Hayes Bay site during the ice-free season. In general chloride concentrations are low during the spring and tend to increase over the summer. The data for 2020 also shows low chloride concentrations in the spring, with values peaking mid-summer and then slightly decreasing over time.

Road salt may not be the source of the chloride because we would expect that the concentration of chloride would be highest in early summer and taper off to normal lake levels (~3.5 ppm) by mid-summer. For all years, at no time did the concentration of chloride at Hayes Bay equal the much lower values obtained in other parts of the lake.

This makes the possibility of a year-round source of chloride, such as from a salt spring, more likely. Variations over time in chloride concentrations may be due to changes in weather conditions such as rain and periods of drought.

9.0 <u>Sulphate</u>



Sulphur is a non-metallic element. The three most important sources of sulphur for commercial use are elemental sulphur, hydrogen sulphide (H_2S, found in natural gas and crude oil) and metal sulphides such as iron pyrites. Hexavalent sulphur combines with oxygen to form the divalent sulphate ion (SO_4^{2-}). Sulphates occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4 \cdot 7H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$). The reversible interconversion of sulphate and sulphide in the natural environment is known as the "sulphur cycle." Sulphate enters the lake by a variety of ways including dust in the atmosphere, minerals in the local rocks and from human activity.

Sodium, potassium and magnesium sulphates are all soluble in water, whereas calcium and barium sulphates and the heavy metal sulphates are not. Dissolved sulphate may be reduced to sulphide, volatilized to the air as hydrogen sulphide, precipitated as an insoluble salt or incorporated in living organisms.

Sulphate levels in Canadian lakes typically range from 3 to 30 mg/L. Recent data from Ontario show similar levels in small lakes (12.7 ± 11.3 µg/ml); sulphate concentrations were 7.6 µg/ml in Lake Superior at Thunder Bay and 19 mg/L in Lake Huron at Goderich.

The average daily intake of sulphate from drinking water, air and food is approximately 500 mg, with food being the major source. The objective for sulphate concentrations in drinking water is ≤500 µg/ml, based on taste considerations. The World health Organization (WHO) reports that no adverse health effects have been identified for sulphate ion in drinking water.

Below is a table containing sulphate concentrations for White Lake samples taken during 2024. Most values are within 1 part per million (ppm) from each other. Concentrations for Hayes Bay are a bit lower than for other sampling sites owing to the higher concentration of calcium in that part of the lake (see calcium section above). Month to month variations are small and may be attributed to different levels of rainfall or evaporation.

Sulphate (ppm) – Sampling Site by Month: 2024

Sampling Site	May	June	July	Aug	Average
Three Mile Bay	3.7	3.2	2.8	2.7	**3.1±.4**
N. Hardwood I.	3.6	3.2	2.9	2.7	**3.1±.4**
Middle Narrows	3.4	3.2	2.9	2.8	**3.1±.2**
Jacob's Island	3.5	3.1	2.8	2.8	**3.1±.3**
The Canal	3.3	2.9	2.7	2.8	**3.1±.2**
Hayes Bay	2.7	2.5	2.0	2.1	**2.3±.3**
Village Basin	3.3	3.1	3.0	3.1	**3.1±.1**
Average*	3.5±.2	3.1±.1	2.9±.1	2.8±.1	

***Excluding Hayes Bay**

The average concentrations for sulphate for 2017, 2018, 2019, and 2024 (table below) are similar varying by only by about 1 ppm. Sulphate concentrations are very low owing to the very high concentration of calcium in the water. Calcium sulphate (main ingredient in wall board) is very insoluble which means that most of the sulphate entering the lake would precipitate to the lake bottom as solid particles. Sulphate concentrations in White Lake are well below drinking water or even aesthetic concentrations levels and therefore should be of no concern to lake users, including fish and other wildlife.

Average Sulphate (µg/ml or ppm) by Year

Average Sulphate by Year	Mid-May	Mid-June	Mid-July
2024	3.5 ± .2	3.1 ± .1	2.9 ± .1
2019	3.4 ± .2	3.4 ± .2	3.4 ± .1
2018	3.5 ± .5	3.0 ± .1	3.0 ± 0
2017	4.5 ± .3	4.6 ± .2	3.9 ± .3

10.0 Weather Conditions: 2014 – 2024

When interpreting data such as total phosphorous and calcium concentrations as well as other parameters, it is often useful to take into account weather conditions. This report contains comparisons of data and interpretations of such data from 2014 to 2024. For this reason, we have included meteorological data from all of these years. The data contained in these tables are those taken at the Ottawa International Airport. Available data from other locations near White Lake (e.g., Pembroke, ON) show similar trends and are not substantially different from those reported below.

An examination of the table below indicates that, with the exception of 2017, total precipitation during the ice-free season for White Lake is generally about 0.5 to 0.6 metres. In that respect, 2024 was a slightly above-average year for precipitation when compared to values for other years. The number of rain events of greater than 1 mm was average.

Total Precipitation April to October: 2014 to 2024

Year	Total Precipitation, mm	Number of Days with Precipitation of 1mm or more
2014	561	81
2015	518	61
2016	431	44
2017	990	81
2018	553	70
2019	631	77
2020	532	56
2021	586	64
2022	661	65
2023	601	64
2024	694	66

During the six-month period from April to October 2024, White Lake received **694** mm of rain and experienced **66** days with rain of 1mm or more. Monthly meteorological tables for previous years starting in 2014 can be found in our previous annual reports on the White Lake Science website.

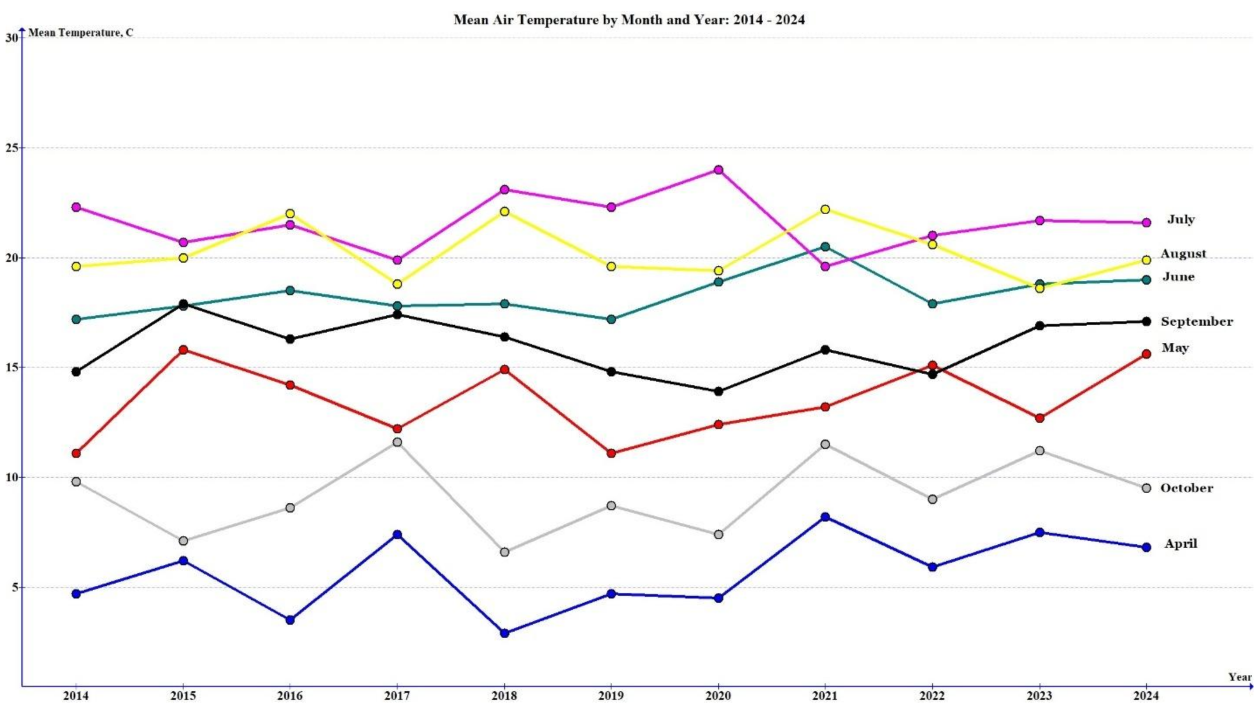
The table below presents monthly meteorological data from April to October, 2024. This table does not reveal a year-by-year comparison of monthly temperature values. This data is pertinent because one of the most important mechanisms by which White Lake loses water is by evaporation. Prolonged periods of high temperatures with little or no rain could make evaporation the major water-loss mechanism during periods of high atmospheric temperatures. This would be especially significant for shallower parts of the lake such as Hayes and Bane Bays and the White Lake Village Basin.

Monthly Meteorological Values – Environment Canada: *2024*

Ottawa Intl. Airport	Mean Temp., °C	Lowest Monthly Min. Temp	Highest Monthly Max. Temp.	Total Precip., mm	Number of Days with Precip. of 1mm or More
April	6.8	-4.4	22.2	107.8	17
May	15.6	4.6	30.6	98.1	8
June	19.0	5.8	33.7	149.5	11
July	21.6	11.3	30.5	154.0	11
August	10.9	9.3	32.1	101.9	9
September	17.1	4.8	29.1	44.3	4
October	9.5	-4.2	24.5	37.9	6
Total				**693.5**	**66**

The figure below shows the change in mean air temperature for individual months over the years spanning 2014 to 2024.

Although there is some variation from year to year in air temperatures, it is very difficult to discern any trends over the 10-year period. Any monthly differences from year to year are likely due to local weather conditions.

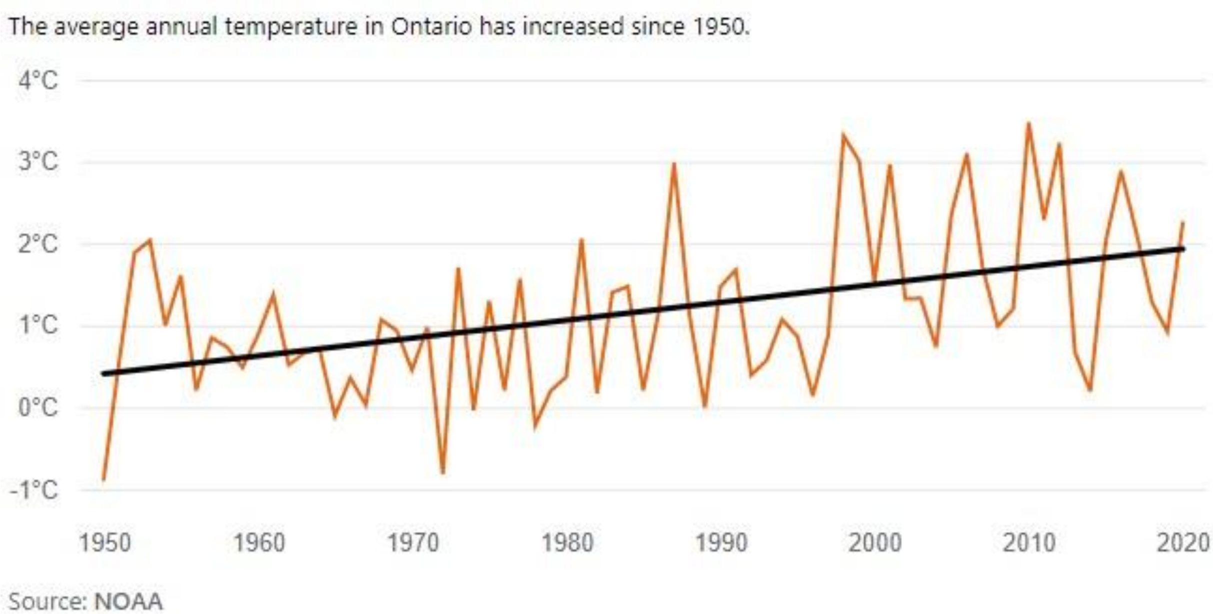


It is important to take note of these temperatures because the ambient air temperature will affect the temperature of lake water. This in turn could have an impact on aquatic plant growth, plankton succession over the summer as well as the timing of the zebra mussel reproduction cycle.

The above data describes local weather and not climate change or global warming. Data related to climate change and global warming is taken from longer term studies (decades) and reference much larger geographical areas.

Recent data published by the US National Oceanic and Atmospheric Administration shows that air temperatures in Ontario have risen by 1.6 degrees since 1950.

Data reported in our 2022 Water Quality Report documents that since 1980, the time White Lake is free of ice cover has increased by 15 days as a result of global warming.



The actual weather on and just before lake water sampling dates is also very important. Heavy rains just prior to sampling could result in sharp changes in the concentrations of chemical species as well as the temperature of the lake. Just as important are dry hot spells which can result in warmer water and increased concentration levels of some parameters due to evaporation.

Below is a table showing the actual atmospheric conditions prevalent on our water sampling days. Information in this table was used to help interpret some of the chemical and physical parameters studied in this report.

10.1 Sampling Date Weather Conditions 2024

Date	Day of Year	Weather Conditions
May 10	131	Partly cloudy morning; Winds of about 5 to 10 km per hour; Air temperature of 13 C; 8 mm rain three days before sampling.
May 30	151	Full sun. Wind increasing over two hours from 0 km/hr to about 10 km/hr. Air temperature 15C. No rain three days prior to sampling, but 25 mm of rain fell during preceding two weeks
June 14	166	Mostly cloudy; Winds from 5 t0 15 km/hr; 5 mm rain evening before sampling; Air temperature 13-16C
June 27	179	Clear skies; Winds from 10 to 25 km/hr; Rain showers evening before sampling with 60 mm rain falling since last sampling on June 14; Air temperature 16C
July 15	197	Clear sunny sky; air temp. 25C; wind 0k to 10 km/hr.;50 mm rain since June 15; No rain three days prior to sampling; water levels 10 cm higher than planned (depth rule).
July 30	212	Clear sunny day. Ver hot. 15 cm rain since last lake sampling (2 weeks). Air temp 22 to 26C; wind 0 to 5 k/hr. Lake is 7 cm higher than the rule.
August 15	228	Full sun; 65 mm rain during last two weeks. No rain 48 hours prior to sampling; Air temperature from 22 to26C; no wind.
August 29	242	Full sun; wind 5 km/hr; Air temp. 15 to 17C.
September 13	257	Full sun, no wind; air temp 22-25C; 51 mm rain since last sampling; Lake depth 134 cm, 11 mm higher than rule.
September 28	272	Full sun; <5 km/hr wind; 5 mm rain during precious two weeks; Air temperature 17 to 22C; lake depth 126.4 cm, 10.6 cm higher than rule.
October 19	293	Full sun; <5 km/hr wind; 41 mm rain during precious two weeks; Air temperature 8 to 14C; lake depth 119.5 cm, 12.8 cm higher than rule.

11.0 Water Levels – White Lake Dam: 2024

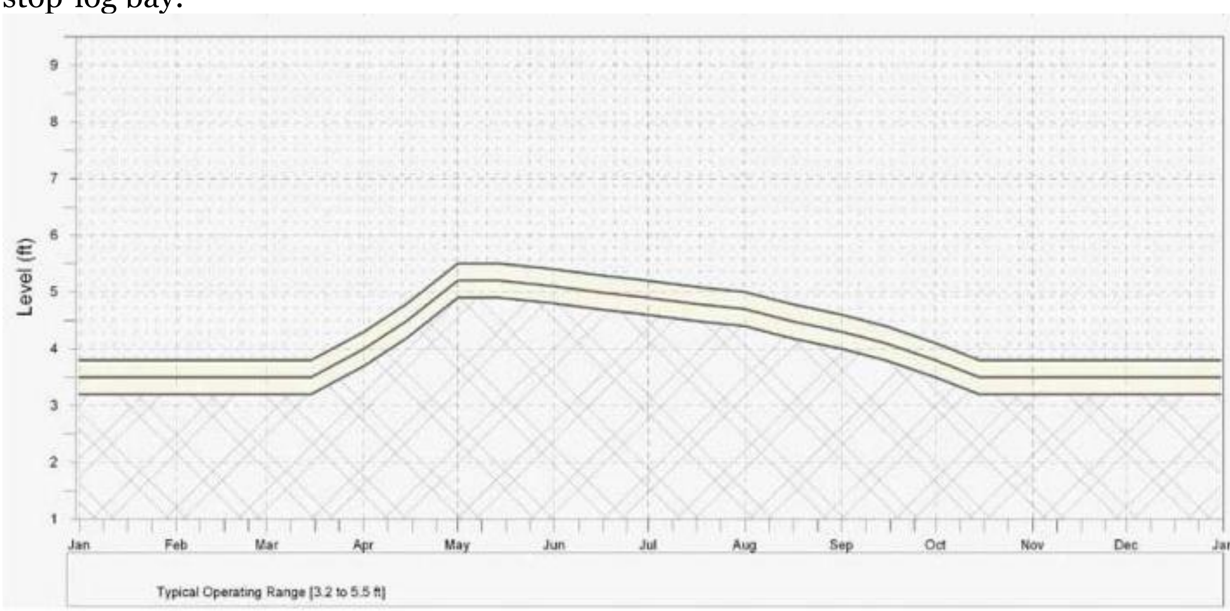
White Lake Dam is managed by the Ministry of Natural Resources and Forestry, Kemptville District office. The operational plan is part of the Madawaska River Water Management Plan, 2009.

The White Lake Dam is a concrete structure, 29 m (98 ft.) long incorporating three log sluices: one central 2.44m (8 ft.) stoplog bay between two 4.27 m (14 ft.) bays. Each bay contains six 12-inch by 12-inch stoplogs. Half logs and spacers are available to fine tune operations.

The table at right gives the target water levels for White Lake as read on the water level gauge at the dam. The water level gauge is calibrated in decimal feet.

The White Lake Dam Operating Regime is described on page 194 and 195 of the Madawaska River Management Plan and is quoted directly below:

The compliance framework for MNR facilities in the Madawaska River watershed does not require the use of mandatory level or flow limits. The level of White Lake is usually maintained between 3.5 and 5.2 feet. A minimum flow (baseflow) requirement for the White Lake Dam has been established. A flow of 0.14 m^3/s will be maintained at the dam at all times to ensure a sufficient flow is discharged into Waba Creek. This will provide a flow for the maintenance of fish habitat and address other ecological concerns during low flow conditions. A notch will be placed between the second and third log of the middle stop-log bay.



The annual variation of the operating band is given below. Water levels will decrease gradually from the spring flood peak in April to a constant level through the first half of

May. In the middle of May, the summer drawdown will commence which, by the late fall, will bring the lake down to the winter holding level.

Over the ten-year period during which we have monitored the lake level, the Ministry of Natural resources has changed the depth gauge at the White Lake dam several times. Originally calibrated in decimal feet, this gauge was changed for one calibrated in centimetres above the sill of the dam. In 2023, the gauge was again changed with one calibrated in metres above sea level.

The conversion table below gives the relationship among the three systems of depth measurement used to set the target levels of the lake.

CONVERSION TABLE FOR RULE DEPTHS – WHITE LAKE DAM/WABA CREEK			
Dates	**Target Levels**		
	Decimal Feet Above Sill	**Centimetres Above Sill**	**Metres Above Sea Level**
January 1 to March 15	3.5	106.7	162.310
April 1	4.0	122.0	162.467
April 15	4.5	137.2	162.631
May 1	5.0	152.4	162.781
May 15	5.2	158.5	162.843
June 1	4.9	149.4	162.750
June 15	4.8	146.3	162.718
July 1	4.7	143.3	162.687
July 15	4.6	140.2	162.655
August 1	4.5	137.2	162.631
August 15	4.3	131.1	162.561
September 1	4.2	128.1	162.529
September 15	4.0	122.0	162.467
October 1	3.8	115.9	162.405
October 15 to December 31	3.5	106.7	162.310

The typical annual mode of operation of White Lake Dam is summarized as:

Spring: The logs should be left at the winter setting until the water level rises above 3.5 feet on the gauge, at which point the logs should be replaced. By May 1, the water level should attain a target level of 5.2 feet. However, depending on the timing of the spring freshet (to avoid ice damage), all attempts should be made to attain the 5.2 feet level by April 15 to facilitate pike spawning. Stop logs should be manipulated through the remainder of the spring period so that water levels follow those prescribed by the operation plan. The drawdown is to begin May 15.

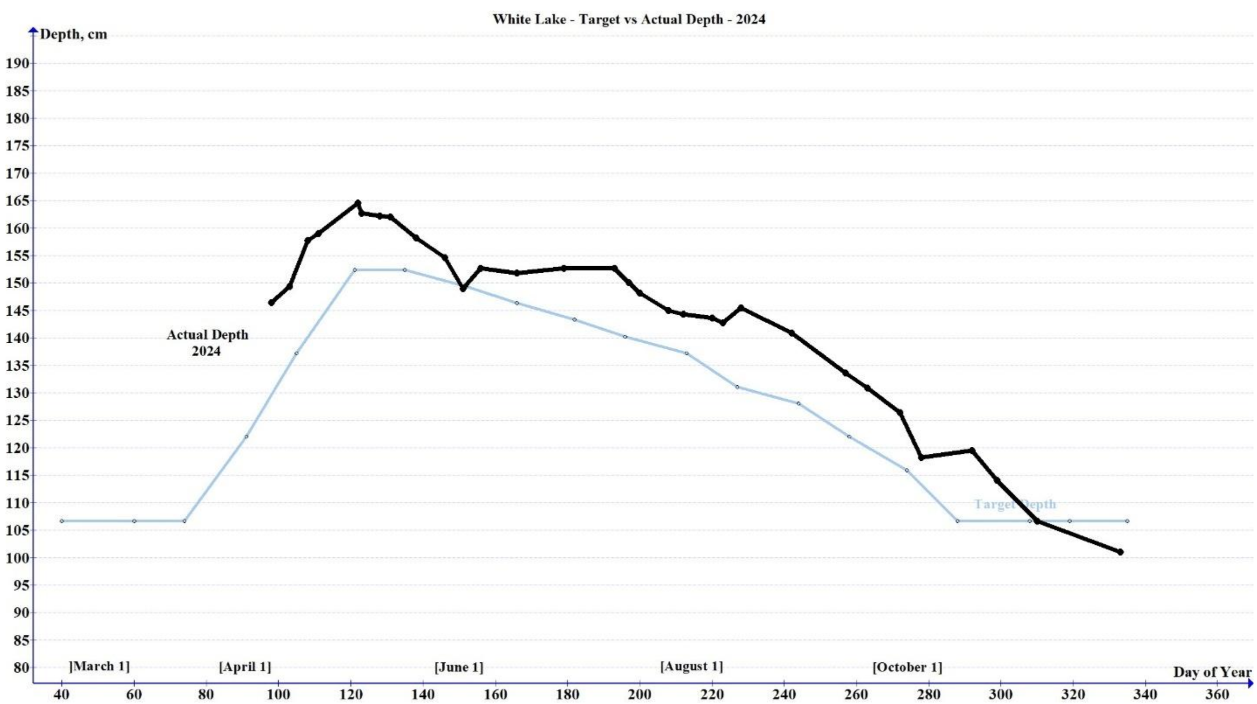
Summer: The target level for July 1 is a gauge reading of 4.9 feet, and the dam should be operated to reach this level. During the period from May 1 to September 1, water levels should be dropped gradually to reach 4.3 feet.

Fall & Winter: The fall/winter holding level is 3.5 feet which should be reached by October 15. If this level is not achieved by November 1, then that recorded level on this date will be considered the fall/winter holding level. Levels throughout the Fall and Winter should be maintained within ± 0.3 feet of the holding level. If the level should drop below 3.5 feet, it will be as a result of natural variation. Within the management plan the operating curve for water levels is shown in the graph below.

During dry years, such as 2016, the challenge is to balance water levels in the lake since a flow of .14 m^3/s must be maintained at the dam at all times to ensure a sufficient flow into Waba Creek.

In order to monitor water levels in White Lake, the authors took regular and frequent readings of water levels at the White Lake Dam using the gauge fixed to the dam structure.

The figure below shows actual depth measurements read at the dam. The heavy black line is for 2024. The blue line is for the target water levels set by the managers of the dam.

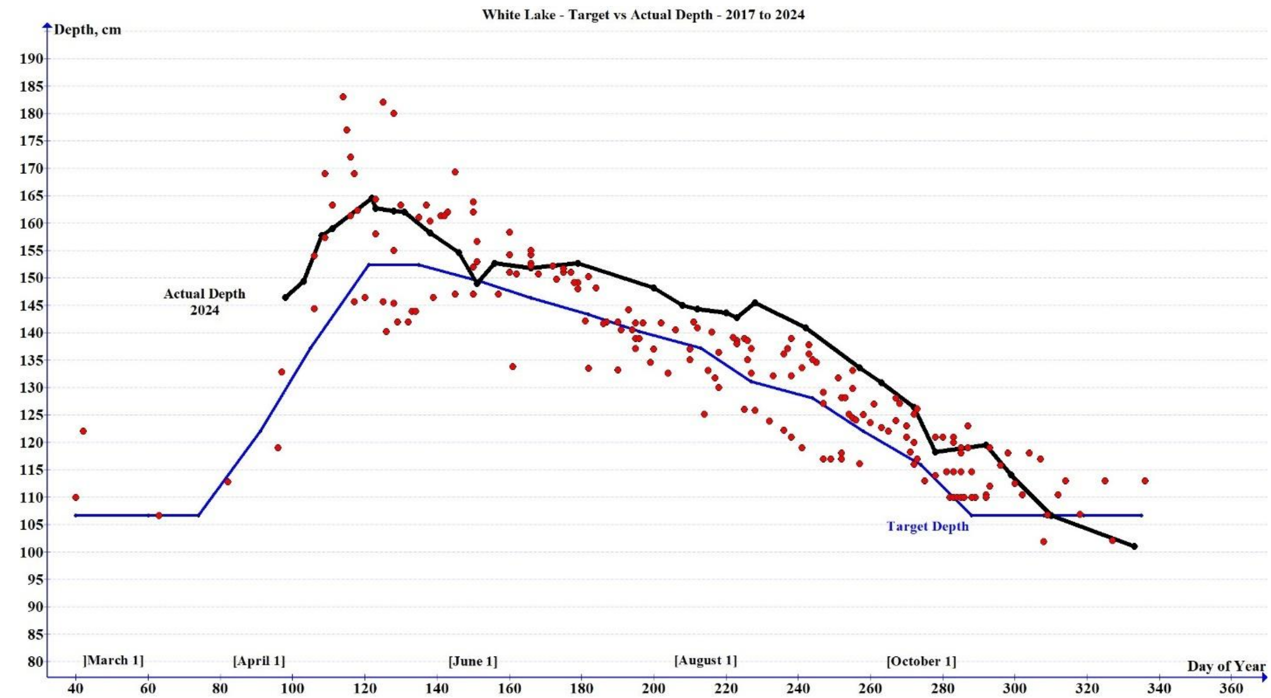


It is clear from the graph that during the entire 2024 ice-free season, water levels were significantly higher, by about 10 cm, than the target depths.

We can graphically compare the lake depths measured in 2024 with those of previous years. The graph below adds to the one above red dots which represents individual depth measurements taken since 2017.

The red dots show that water levels are generally higher during the spring melt than planned levels represented by the blue line. After that, water levels straddle both sides of the blue line with a small bias towards greater depth levels. The 2024 (black line) profile shows that this year in particular, water levels were significantly above the blue line and most of the red dots.

We are not aware that the Ministry of Natural Resources Forestry, who manage the dam, has decided to change the rule (blue line) in favour of greater lake depths. We will continue to monitor water levels and report annually on them.



PART III
Research Activities

12.0 Environmental DNA (eDNA) Analysis for Detection of Invasive Species

The Federation of Cottage Associations (FOCA) invited the White Lake Property Owners Association to participate in a series of experiments in an effort to apply eDNA techniques to the early detection of the presence of aquatic invasive species.

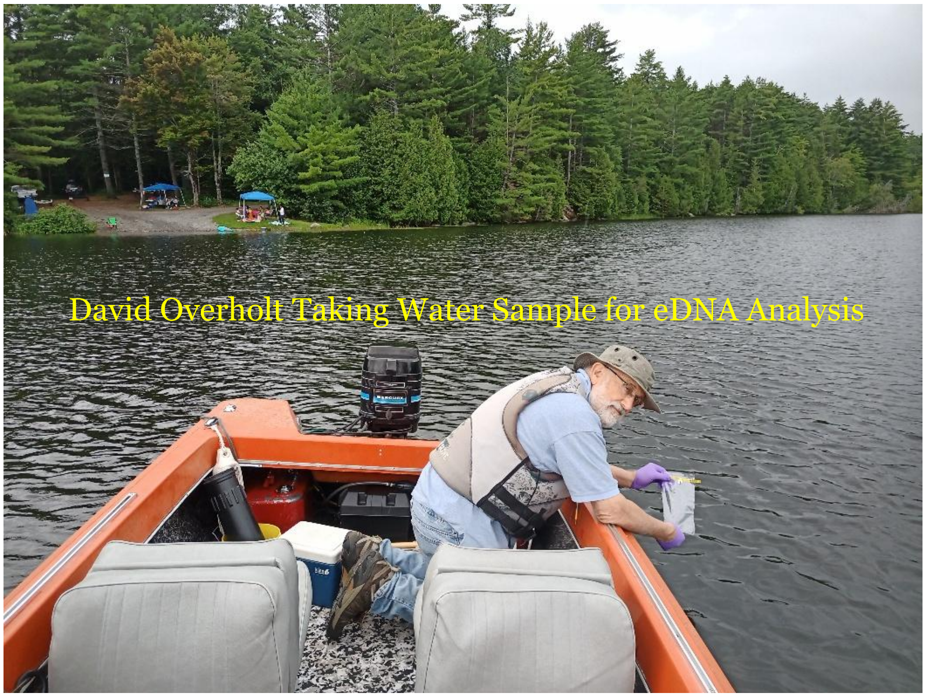
Below you will find the full report for the 2024 sampling program which screened for the presence of zebra mussels and the spiny waterflea. For this sampling round, only five lakes were invited to participate.

As expected, White Lake tested positive for zebra mussels as this invasive species has been well established in the lake since 2015. White Lake tested negative for spiny waterflea. We have not received any reports of the presence of this invasive nor have we observed them in the field.

We also participated in a 2023 sampling round along with 75 other lakes. This sampling focussed on the detection of water soldier, a very aggressive aquatic plant. The results from this study are not reproduced here because the results were non-conclusive for the three lakes testing positive, White Lake being one of them. Laboratory contamination was cited for the inconclusive results. We have not observed the presence of this plant in White Lake.

For the 2024 study, water and plankton net samples were taken at three separate locations on the lake. The photos below show the array of sampling and sample processing equipment used in this study.

eDNA Sampling and Processing Equipment



Invasive Species Centre:
eDNA and Zooplankton Sampling Results 2024-2025

Prepared By:

Invasive Species Centre Sault Ste. Marie, Ontario

Completed for IsampleON

November, 2024

Background

The IsampleON Project, a collaboration between the Invasive Species Centre (ISC), and the Federation of Ontario Cottagers' Associations (FOCA), was piloted in 2021 to help prevent zebra mussels, spiny waterflea, and other aquatic invasive species from becoming established in inland lakes and gain a better understanding of distribution. The main project focus is the collection and analysis of water samples by FOCA volunteers through the Lake Partner Program, while raising awareness about the importance of AIS prevention. This year's focus was to study the accuracy of different sampling methods in detecting the presence of zebra mussels in Ontario lakes. The two sampling methods compared were traditional plankton towing nets and eDNA analysis.

Traditional Zooplankton Monitoring

Each lake was sampled in three locations: boat launch, windward, and deep water, and each of the 3 samples is tested 3 times to increase accuracy.

Densities for positively tested lakes are measured based on the average number of individual species present within each sample taken and labelled accordingly as low, medium, or high density. Zebra mussel (ZM) densities were determined as such: 1-10 zebra mussels = low density; 10> = medium density; 20> = high density. Spiny waterflea (SWF) densities were determined as such: 1-4 spiny waterfleas = low density; 4> = medium density; 7> = high density.

eDNA Monitoring

Environmental DNA (eDNA) comes from cellular material that is released by living or dead organisms into the environment. This can include tissue, mucus, hair, reproductive cells, feces, and/or urine. eDNA monitoring is a method of sampling which can detect genetic material shed by organisms into the environment. Using eDNA monitoring allows us to detect invasive species early on in the invasion process, from even small amounts of genetic material. This is a game-changing tool for early detection of aquatic invasive species. eDNA monitoring is quick, easy, and cost efficient. However, it does have limitations such as being unable to quantify the number of organisms present, it cannot indicate the life stage of a species or distinguish between hybrids and non-hybrids, or closely related species and it is unable to determine whether that organism remains in the waterbody. For example, the organism may have passed through or died. Further reading on eDNA monitoring can be found on our website.

For eDNA sample processing, Nature Metrics Laboratory was used to analyze samples for the presence of zebra mussels. Spiny waterflea presence was visually identified and therefore not part of the eDNA component of the study. If a positive eDNA sample for zebra mussels was identified, this means that this invasive species might have been in your lake.

See the sections below about *Reading the Results* and *Interpreting Positive/Negative Results*.

Reading the Results

There are two results tables included in this report. Table 1 is a summary of the traditional zooplankton monitoring results for zebra mussel veligers and spiny waterflea, and Table 2 is a summary of eDNA monitoring for zebra mussels.

Find your lake name listed in the first column.

In Table 1 the two columns on the far right show the results for:

- **Zebra Mussel Veliger** shows whether there were larva present from zebra mussels in your sample. This method does not detect genetic material like eDNA.
- **Spiny Waterflea Visual** shows whether there were spiny waterflea present in your sample. This method does not detect genetic material like eDNA.

In Table 2 the right column shows the results for:

- **Zebra Mussel eDNA** shows whether there was zebra mussel genetic material present in your sample.

Negative means the sample did not have one of the tested species in it.

Positive means the sample did have one of the tested species in it, and the density found was indicated for traditional sampling.

Different sampling types provide different forms of information. For example, traditional zooplankton monitoring for zebra mussel veligers only picks up a specific life stage (e.g. larval stage), whereas eDNA sampling picks up all stages of life. However, eDNA sampling will only detect genetic material before it falls apart. It is possible that zebra mussels could shed genetic material into your lake, but it fell apart before you had the chance to capture it in your eDNA sample. Zebra mussel veligers are detectable over a longer period of time.

Additionally, zebra mussel veliger and eDNA results come from different samples of water, therefore different parts of the lake. While a positive result means that the sample had signs of an invasive species in it, that doesn't mean that every sample taken from the lake will have the same result. This is why two different types of samples taken from the same lake may not have the same result. A positive sample from any sampling type is reason enough to take precautions.

Interpreting Positive Results

A positive sample does not mean that an invasive species has established in your lake.

To verify whether the organism is present, we recommend follow-up sampling to visually confirm the extent of invasion. Substrate sampling with dock hangers is one way to do so for invasive zebra mussels and we recommend a wider distribution of sampling throughout the lake.

Only once you have visually confirmed zebra mussels and/or spiny waterflea, we recommend reporting your sighting through one of the sources below.

As always, we advise preparing for possible negative impacts and we strongly encourage you to address possible sources of introduction and spread.

Interpreting Negative Results

Negative samples do not mean invasive zebra mussels and/or spiny waterflea are absent either. This result only means that they were not captured in the samples. Invasive species could be elsewhere in your lake or too low in abundance to detect.

Monitoring is an ongoing responsibility. Continue to keep a watchful eye for signs of invasive species and practice preventative measures like **Clean, Drain, Dry**.

Report invasive species to:

- EDDMapS App or Website
- iNaturalist App or Website
- Ontario's Invading Species Awareness Hotline 1 (800) 563-7711

Zooplankton Results Summary

All samples were processed in-house by the Invasive Species Centre. Five lakes were surveyed, and from this our results found:

- 1 lake was positive for zebra mussels
- 0 lakes were positive for spiny waterflea
- 0 lakes were positive for both zebra mussels and spiny waterflea
- 4 lakes were negative for both species

Zooplankton Results Table

Table 1: Traditional zooplankton monitoring results from the 2024 IsampleON Program. **Sample ID**	**Zebra Mussel Veliger**	**Spiny Waterflea Visual**
Mary Lake	NEGATIVE	NEGATIVE
White Lake	**POSITIVE (HIGH DENSITY)**	NEGATIVE
Lake Wahnapitae	NEGATIVE	NEGATIVE
Big Gull Lake	NEGATIVE	NEGATIVE
Billings Lake	NEGATIVE	NEGATIVE

eDNA Results Summary

All samples were processed by Nature Metrics Laboratory. Five lakes were surveyed, and from this the results were:

- 1 lake was positive for zebra mussels

eDNA Results Table

Table 2: eDNA monitoring results for zebra mussels from the 2024 IsampleON Program. **Sample ID**	**Zebra Mussel eDNA**
Mary Lake	NEGATIVE
White Lake	**POSITIVE**
Lake Wahnapitae	NEGATIVE
Big Gull Lake	NEGATIVE
Billings Lake	NEGATIVE

Comparison of eDNA and Traditional Zooplankton Monitoring Techniques
This year's focus was to study the accuracy of different sampling methods in detecting the presence of zebra mussels in Ontario lakes. The two sampling methods compared were traditional plankton towing nets and eDNA analysis. While traditional sampling can provide a positive visual identification at the larval stage, eDNA is able to detect genetic material at all life stages and can detect species that are present in low numbers.

Both eDNA and traditional zooplankton monitoring provided a positive result for White Lake and were negative for the other four lakes. A positive eDNA detection means that DNA from the species of interest was present at the time of sampling. A negative eDNA detection means that the species of interest could be absent from the location and/or there were inadequate amounts of genetic material shed in the environment, or it had broken down before sampling. In this report, both methods had the same result, which demonstrates that they may be used together to provide an additional metric of validation.

Positive: Now What?

Now that you know invasive zebra mussels are present the most important actions are to prevent the spread to neighbouring lakes. Make other cottagers on the lake and visitors to the lake aware of the presence of invasive aquatic species. Add signage at public boat launches that state the presence of invasive zebra mussels and/or spiny waterflea and the importance of **cleaning, draining and drying** your boat and equipment. Consider setting up for boat washing at your public boat launches. Knowledge is key.

Generally, when zebra mussel veligers are first detected in a lake, there is about a two-year period before adult mussels become visible. Therefore, if veligers are found in your lake, it will give you a chance to prepare for the negative impacts of zebra mussels.

However, it cannot be overemphasized that a negative result is NOT a guarantee that zebra mussels, spiny waterflea and other invading species do not exist in your lake, proper precautions should always be taken in order to prevent the potential spread of invading aquatic species.

The presence of invasive zebra mussels in your lake may also mean some extra work on your part. Zebra mussels can attach to many hard surfaces that can cause clogging of water intake pipes and mechanical issues with boat motors. The good news is there are some tools and strategies you can use to help mitigate some of these consequences.

- **Intake lines and foot valve maintenance**: Draining and drying water intake lines and foot valves can help reduce the risk of blockages. Freezing lines and foot valves after draining is even more effective than simply drying.

- **Water intake pipe filter**: Consider a filter for your intake pipes that feed your cottage water supply to prevent mussels from attaching to the inside of the pipe. This works well for year-round cottage use and with planned maintenance.

- **Lift motor or boat out of water**: After each use, lift your boat motor, propellers and all, up out of the water to decrease the chances of invasive mussels attaching themselves to the motor. If possible, consider investing in a boat lift or ramp to completely remove the boat from the water.

- **Flush boat motor regularly**: Microscopic veligers can be drawn up through the water inlet of the motor and settle inside, causing blockages as it matures. Frequently using a motor flusher or motor muffs can decrease the risk of this occurring.

- **Wear water shoes**: Mussels can have very sharp shells that hurt to step on, especially for children. Invasive mussel populations can grow in such abundance they become difficult to avoid. Consider wearing protection on your feet such as water shoes to avoid injury.

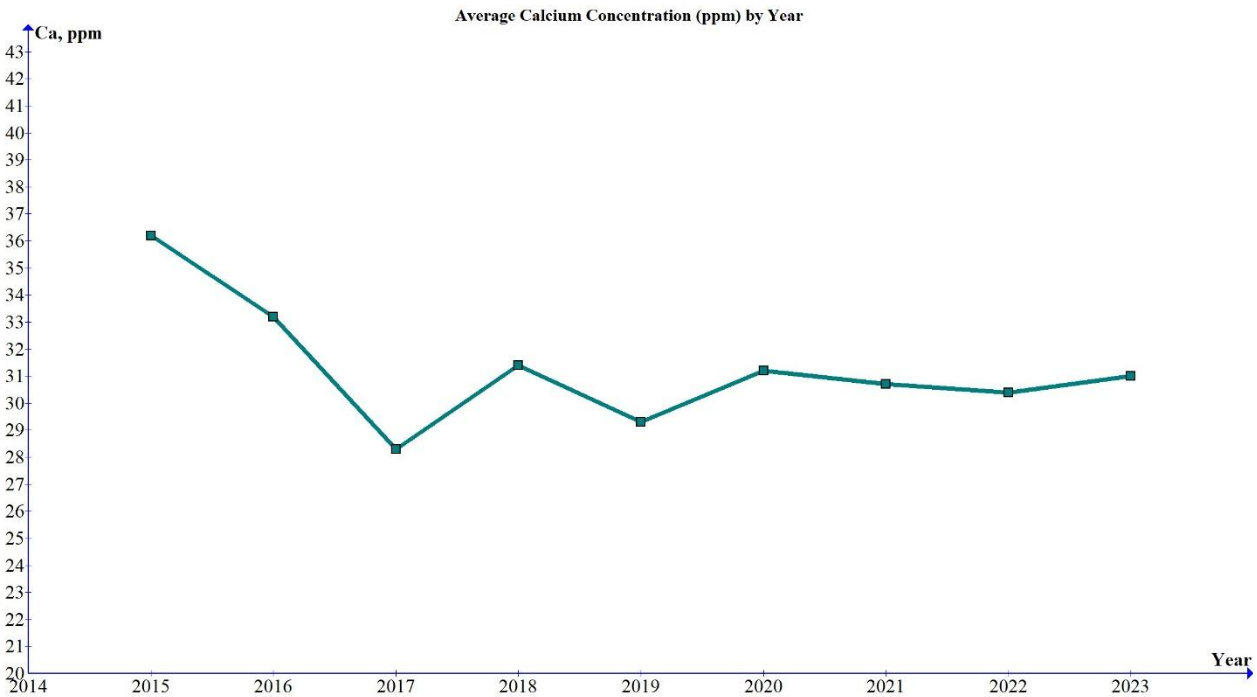
Although there are no recommended management options available in Ontario at this time, there is some research and pilot projects being done in the United States. Check out the Invasive Mussel Collaborative to learn more about the projects that are underway and potential future management options.

We thank IsampleON for the opportunity to collaborate on this important diagnostic work. Your role helps protect Ontario lakes from aquatic invasive species.

For questions on anything represented in this report please contact:
Sydney Currier
Aquatic Invasive Species Coordinator
scurrier@invasivespeciescentre.ca

13.0 Possible Impact of Zebra Mussel Population on Calcium Concentration Levels in White Lake

The graph below shows that the average calcium concentration in White Lake decreased significantly from 2015 to 2017 and varied relatively little thereafter. Is it possible that the decrease shown above is related to the absorption of calcium from lake waters by zebra mussels?



To examine this question, consider the list of facts and subsequent calculations.

Facts:

1. White Lake contains 75 x 10^6 m^3 of water or 75 x 10^9 litres in entire lake.
2. 1 ppm (ug/ml) = 1 x 10^{-3} g of calcium per litre of lake water.
3. 1 ppm of calcium concentration amounts to 75 x 10^6 grams of calcium in the entire lake. This is equivalent to 75 x 10^3 kg calcium per ppm concentration.
4. The average concentration of calcium in lake water was 36.2 ppm in 2015, which represents a quantity of **2,715,000** kg of calcium in White Lake.
5. The average concentration of calcium in lake water was 30.4 ppm in 2023, which represents a quantity of **2,280,000** kg of calcium in White Lake.
6. The different between points 4 and 5 above is **435,000** kg of calcium. This is the difference (decrease) in the amount of calcium present in White Lake when comparing 2015 and 2013 concentrations.

7. Zebra mussel shells are reported in the literature to be made of about <u>*90%*</u> calcium carbonate, which has a molecular weight of 100 grams/mole. One mole of any element or molecule contains 6.022 x 10^{23} atoms or molecules.
8. The calcium carbonate molecule is *40%* calcium by weight.
9. Zebra mussels generally have a mass of from 25 to 40 grams (shell plus organism). For purposes of this calculation, we will use an average mass of 10 grams[8] for a dry empty zebra mussel shell. Ninety percent (see #7) of 10 grams is 9 grams
10. This means that the calcium (see #8) contained in one zebra mussel shell is 3.6 grams. Calculation: 9 x 0.4 = 3.6 grams.

Calculation:

11. Dividing the amount of dissolved calcium loss in White Lake waters, when comparing 2015 with 2024, (435,000 kg or 435 x 10^6 grams), by 3.6 grams (the average amount of calcium in each zebra mussel) we get the number of zebra mussels corresponding to the amount of calcium decrease from 2015 to 2024.
12. The number of zebra mussels is 120.8 x 10^6 or **120.8 million zebra mussels.**
13. Assuming that the average zebra mussel in White Lake has a mass of 20 grams, then the total mass of all of the mussels in the lake (biomass) is **2412 metric tons**.

Conclusion:

It is possible that the loss of calcium concentration in White Lake observed in the graph above is due to the annual absorption of calcium from lake water by zebra mussels. The average life span of a zebra mussel is from three to five years. As adults, calcium absorption would be slower than for a fast-growing juvenile. This means that the calculated result of 120.8 million zebra mussels may be a lower limit with actual values being significantly higher. However, as an approximation, this number is reasonable for a lake such as White Lake.

Caveat:

The concentration of calcium in White Lake is dynamic and dependent on many factors such as the rate of ingress of water from springs in the lake floor, rain, etc. Also, clearer waters resulting from the presence of zebra mussels would stimulate plant growth, which would consume amounts of calcium as well.

Since calcium is constantly entering White Lake, the calcium concentration in the lake will never be close to zero and will very likely remain at the 2023 concentration level barring the infestation of quagga mussels, with could introduce a new calcium sink and lower concentrations even further.

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[8] The distribution, density, and biomass of the zebra mussel (*Dreissena polymorpha*) on natural substrates in Lake Winnipeg 2017-2019; David C. Depew et al; Journal of Great Lakes Research; 47 (2021) 556-566. Page 561.

14.0 White Lake Loon Report

This year circumstances including a broken motor and a family move prevented the completion of a comprehensive loon survey for White Lake. We do have a number for loon chicks on the lake. This year, only 9 chicks were observed. Last year there were 22, a number more typical for White Lake.

We do not know why chick numbers were so low. Hopefully they will rebound next year.

White Lake Loon Report: 2024

-Brian Houle

2024 White Lake Loon Survey Results	
Nesting Pairs	-
Chicks	9
Total Adults	-

13.

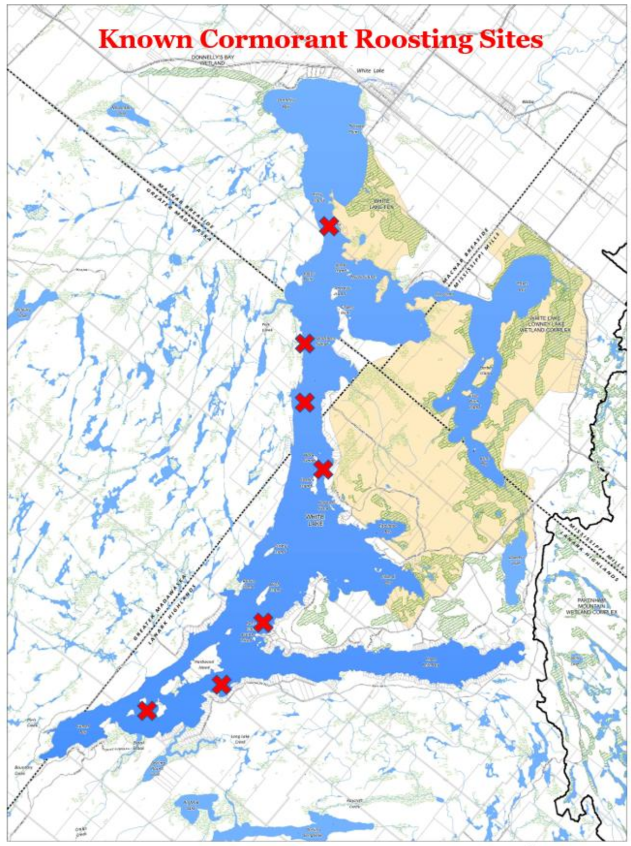
Photo by Joyce Benham

The **double-crested cormorant** (*Phalacrocorax auritus*) is a member of the cormorant family of seabirds. Its habitat is near rivers and lakes as well as in coastal areas, and is widely distributed across North America, from the Aleutian Islands in Alaska down to Florida and Mexico. They are a native species in Ontario including White Lake.

Measuring 70–90 cm (28–35 in) in length, it is an all-black bird which gains a small double crest of black and white feathers in breeding season. It has a bare patch of orange-yellow facial skin. Five subspecies are recognized. It mainly eats fish and catches its prey by swimming and diving. Its feathers, like those of all cormorants, are not waterproof and it must spend time drying them out after leaving the water. Once threatened by the use of DDT, the numbers of this bird have increased markedly in recent years.

When large numbers of cormorants congregate in a roosting or nesting area, their droppings can kill trees and other vegetation. They also compete for food with loons and other fish-feeding birds. For this reason, the cormorant has been vilified, even though exactly the same can be said of the Great Blue Heron, which also roost communally, and destroy patches of forest or even entire islands where their nests are located. The authors do not support the killing of cormorants because they are a natural species to White Lake and are not present in numbers warranting action.

In fact, the Ontario Federation of Anglers and Hunters (OFAH) web page on cormorants specifically says *"Populations of double-crested cormorants are increasing in number and distribution across Ontario's shorelines.* ***Where cormorant numbers are high,*** *they can negatively affect terrestrial habitats by chemical and physical means through corrosive acidic guano, and stripping/breaking tree branches. In some cases, cormorant colonies have destroyed entire island ecosystems. Many people are also concerned about potential impacts on fish populations and angling opportunities.”*



Nobody is calling for the extermination of cormorants, just control of populations ‘where cormorant numbers are high’. The goal of our annual cormorant count is to establish baseline population numbers so that we can, in fact, determine when and by how much populations on White Lake are increasing.

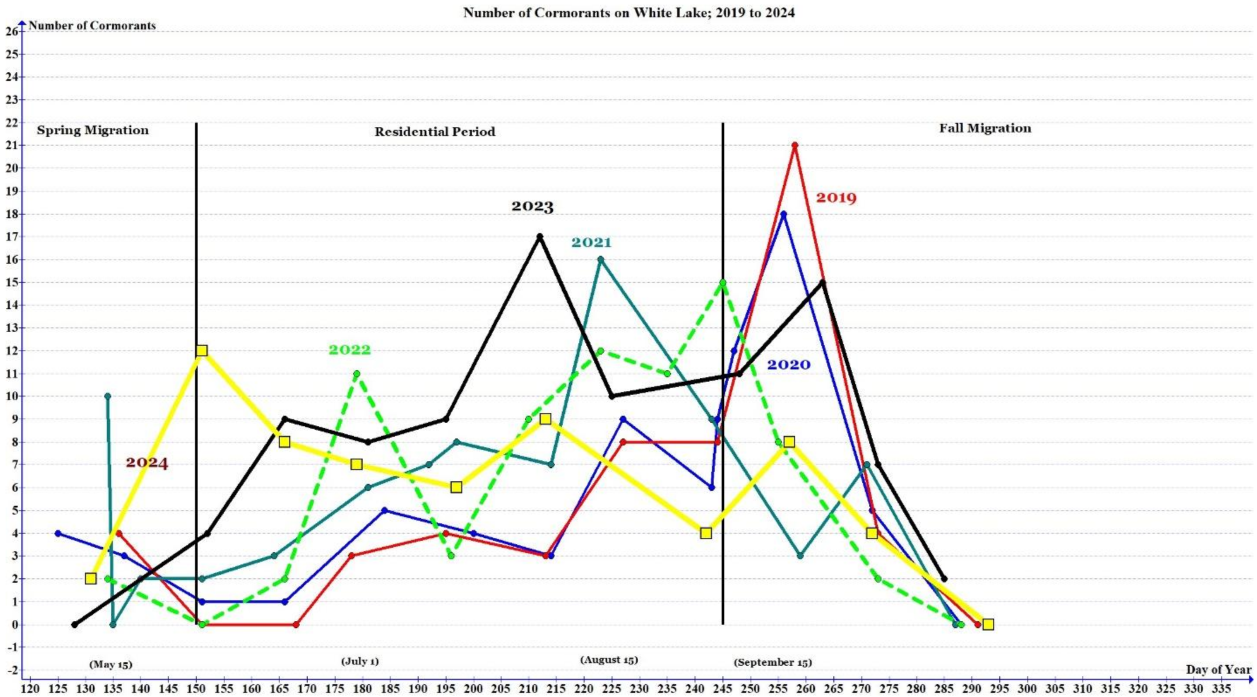
Cormorants have been using White Lake for many years. However, their numbers have always remained small. In recent years, we have noticed that the White Lake population of cormorants may be increasing.

As part of our water quality monitoring program, we decided to start monitoring cormorant numbers on White Lake. Every two weeks we patrol the lake by boat and sample 9 sites in all parts of the lake. Water samples for total phosphorus and plankton counts are collected. Water temperature and clarity measurements are also taken.

During this two-hour period, we collect data on the location and numbers of cormorants. We check all of the roosting sites shown on the map to the right as well as any cormorants we spot in flight or fishing in open water. We do not know the location of the nesting sites at this time, but we know from the scientific literature that cormorants can nest kilometres away from the lake they use for food.

The number of cormorants observed for each date in the graph below can be taken as a minimum number of cormorants, since it is possible that birds in flight or feeding were missed. However, cormorants are communal birds and tend to aggregate in groups rather than be spread out over the entire lake. The graph below shows cormorant observations for five consecutive years. The yellow line is for 2024.

Graph of Cormorant Numbers Observed by Day of Year: 2019 to 2024



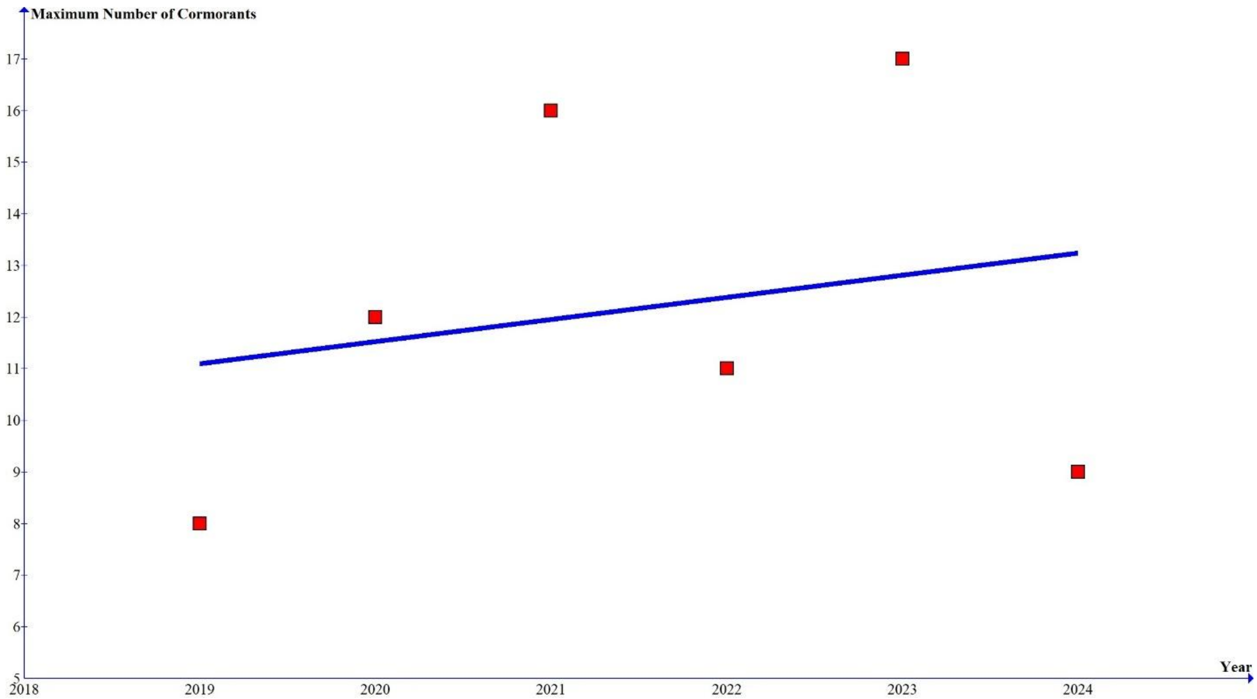
The graph is divided into three sections marked by the two vertical black lines. During spring, as well as at the end of summer, larger numbers of cormorants are often observed. Most of these birds are migrating to other sites and only stop and linger at White Lake for a week or so.

Of greater interest are bird counts taken during the residential period (middle section of the graph). It is possible that the mid-July cormorant population numbers probably reflects the permanent resident adult population of cormorants on White Lake. This data suggests that there are currently less than ten cormorants making White Lake their home. Considering the presence of non-reproductive juveniles, this translates to about 4 or 5 nesting pairs.

The graph below shows the maximum number of cormorants observed on the lake during the nesting period. Over the last six years, the numbers have ranged from 8 to 17 individuals. The blue line is the statistical best fit line for the population data. This line has a positive slope which indicates that there may be a very week trend towards increasing numbers of cormorants on the lake.

We will continue with this initiative and monitor if this increase represents a trend or an isolated occurrence. In any case, the number of cormorants on White Lake remains small.

Maximum Number of Cormorants on White Lake During Nesting Season

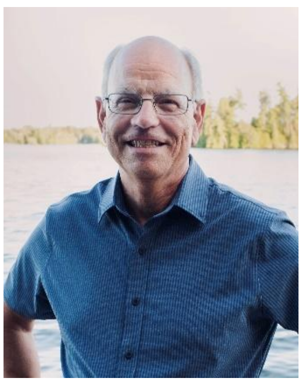


PART IV
Acknowledgements
and
Author Profiles

16.0 Acknowledgements

We are grateful to the Lake Partner Program of the Ontario Ministry of the Environment Conservation and Parks for providing us with sampling equipment and the analysis of water samples for total phosphorus, calcium, dissolved organic carbon, and chloride. Costs and time related to lake sampling and all other activities were self-funded by Dr. Conrad Grégoire and David Overholt.

17 .0 Author Profiles



Conrad Grégoire holds a Ph.D. in Chemistry. He was the Head of the Analytical Chemistry Research Laboratories at the Geological Survey of Canada before retirement where he conducted research in analytical and environmental chemistry. He has authored over 200 scientific papers and other works published in international journals. He was also an Adjunct Professor of Graduate Studies at Carleton University and currently collaborates with Carleton University scientists on White Lake studies. For over 20 years he was a Senior Assessor at the Standards Council of Canada, certifying commercial and government labs for ISO (International Standards Organization) compliance. Conrad is interested in studying the chemistry and biology of White Lake and establishing base line values for water quality parameters. He is the Web Manager of the White Lake Science website.

Dave Overholt is an avid citizen scientist and has, through his own study and research, become knowledgeable in a variety of areas, such as aquatic macrophytes and microorganisms and introduced species. He spends a great deal of time documenting species inhabiting the lake and following the population levels. He is involved in education about introduced species and has motivated and inspired lake residents to become involved in phragmites eradication programs.

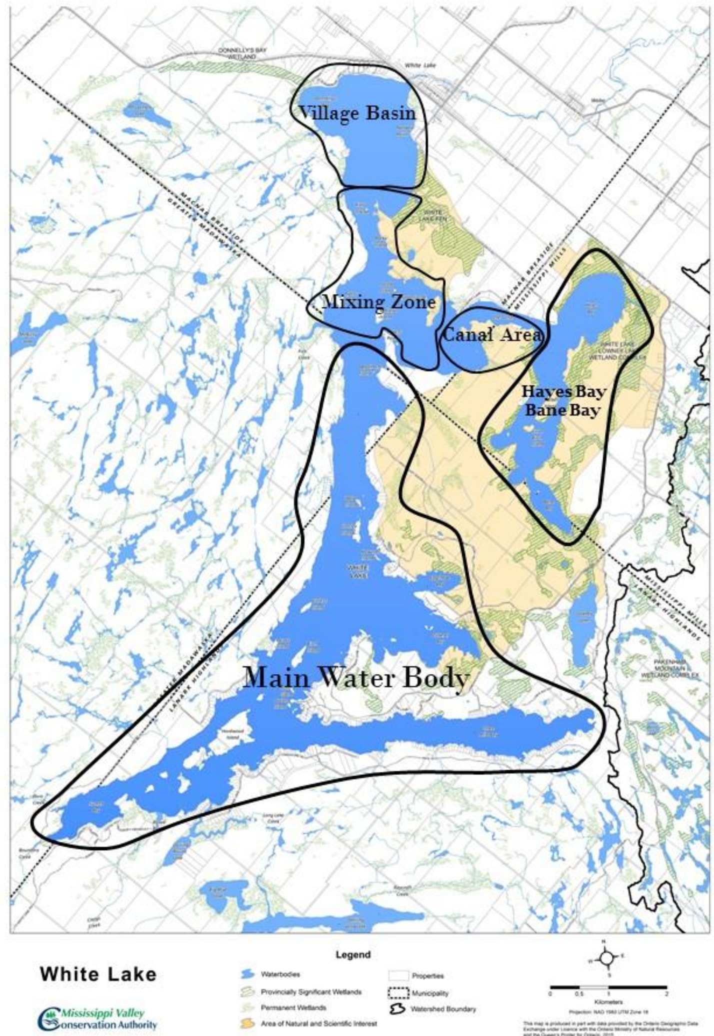
PART V
Appendices

Appendix 1: White Lake Zone Map

Based on our research, we have suggested that White Lake could be thought of as a collection of almost independent interconnected water bodies rather than a unitary lake.

There are a number of criteria which could be used to divide the lake into different zones based on population density, geology, shoreline coverage, etc. We believe that the different zones of the lake can best be described by their chemistry. While all zones have some characteristic in common, there are enough differences between each zone (shown on the map at right) to justify its classification.

As a result of new chemical data, we collected during the past year, we are making some minor changes to the zone map proposed in our 2016 Report. New specific conductivity measurements in addition to temperature measurements in Bane Bay indicate that this water body should be considered as part of the Hayes Bay Zone.



The ***Main Water Body (Zone 1)*** is the part of White Lake which takes in virtually all of the water with a depth greater than four metres. This zone contains Sunset Bay, Three Mile Bay, Pickerel Bay and surrounding areas. This zone existed as a lake before any dam was constructed which raised the level of the lake by about 1.5 metres. Here one finds very deep layers of sediments (up to 6 metres) and very similar water chemistry. The temperature regime, the pH, conductivity, oxygen content, alkalinity and Secchi depths are very nearly the same everywhere. Although the total phosphorus concentrations differ somewhat (with higher levels further South on the lake), the change in phosphorus concentrations over the summer months follows the same pattern with maximum concentrations reached in mid-July.

Hayes Bay/Bane Bay (Zone 2) is a relatively isolated part of the lake and is only 1.6 m in depth at high water in the spring. It is characterized by black gelatinous sediments and is nearly free of aquatic plants in the central basin. The waters there have a slightly higher pH than the rest of the lake and also higher conductivity. The concentration of salt is higher by a factor of three compared to the rest of the lake probably from saline ground water entering through the sediment layer. Because of its dark sediments and shallow depth, this part of the lake heats up the fastest and to the highest temperatures if there had not been a recent rain event. The concentration of total phosphorus is lower here than in the rest of the lake, but slightly higher than concentrations in The Canal area. The waters from Hayes and Bane Bays flow into The Canal Area.

The Canal ***Area (Zone 3)*** on White Lake is characterized by white marl sediments and a depth of 2.4 metres. For both 2015 and 2016, the lowest concentrations of total phosphorus are found here with levels less than half of those found in the Main Water Body. Our temperature data indicates that in this zone, large quantities of subterranean ground waters are infiltrating into the lake and also leaving the lake relatively more quickly than waters from Hayes Bay or the Main Water Body. This is especially evident immediately after a significant rain event. There are no aquatic plants on the lake bed. These waters have a slightly higher salt content than the rest of the lake due to the mixing of waters originating from Hayes Bay. Note that The Canal Area could be described as a marl area. This could impede the growth of phytoplankton and aquatic plants and exhibit lower phosphorus concentrations due to the coprecipitation of calcium and phosphorus.

The ***Village Basin (Zone 4)*** zone is characterized by white marl sediments and an almost uniform depth of 1.65 m at high water. The floor of the lake is largely free of aquatic plants save some bulrush and patches of wild rice. Total Phosphorus levels are about 30% lower than found in the Main Water Body. The water sampled here is representative of the water which is leaving White Lake over the dam and into the creek. Temperature data from this area also shows, as in the case of The Canal and Hayes Bay that there is significant ingress of subterranean ground waters mixing in with lake water.

Hayes Bay, The Canal and the Village Basin have several things in common. Prior to the building of the dam, these areas existed as open water only during the spring freshet and then quickly turned into marshes or wetlands with water depths of perhaps half a metre or less. Another commonality is the lack of aquatic plants in these areas. It could be that since each of these areas is partially flushed by ground water ingress that plants do not have a chance to take hold. Certainly, the white marl of The Canal and the Village Basin would provide a poor source of nutrients to plant root systems. For Hayes Bay, the sediment there is organic but made up of a very fine particulate not offering much of a foothold for aquatic plants. For all three areas, the effect of wind and waves would also contribute to low plant growth.

The ***Mixing Zone (Zone 5)*** encompasses both sides of the narrows including Rocky Island and extends some distance towards the Village Basin. This area is characterized by shallow dark sediments and ranges from 2.5 m to 4 m in depth at high water. In this area, the lake floor is covered with dense mats of aquatic plants. The temperature of the water in this area is intermediate between the waters coming from The Canal and the Main Water Body. The simple reason for this is that this is where waters from both of these zones mix to give water with special characteristics relative to other parts of the lake. Generally speaking, the water in the Mixing Zone is clearer than would be observed in other parts of the lake for a given total phosphorus concentration. Water leaving this area and entering the Village Basin has lost a significant fraction of its phosphorus content to sedimentation and aquatic plants.

Waters originating from the upper four zones have no opportunity to mix with the much deeper waters of the Main Water Basin which contains by far the greatest share of the volume of White Lake. It could be argued that the most vulnerable part of White Lake is Hayes Bay because there is little opportunity for any nutrients entering this bay to be flushed out at a reasonable rate. With the exception of Three Mile Bay whose waters have access to the remainder of the deeper Main Water Body, the shallow areas at the top of the lake contain the densest populated areas with the likely greatest human impact on lake waters.

Appendix 1: Chemical and Physical Data – 2024

Three Mile Bay N. 45° 15.767'; W. 076° 32.521 Depth: 6.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	8:54	131	5.5	15.0	6.7,7.1 (6.9)	31.3	3.9	3.7
May 30	9:04	151	3.8	18.7	-	-	-	-
June 14	9:00	166	3.8	19.2	13.4,14.0(13.7)	32.4	3.9	3.2
June 27	9:06	179	4.0	22.0	-	-	-	-
July 15	9:12	197	4.9	25.2	12.8,11.3(12.1)	30.6	3.7	2.8
July 30	9:08	212	4.5	24.4	-	-	-	-
August 15	9:03	228	4.8	23.5	11.2,11.4(11.3)	28.8	3.7	2.7
August 29	10:00	242	5.5	21.9	-	-	-	-
September 13	9:30	257	5.4	19.9	9.8,8.4 (8.1)	26.4	3.9	-
September 28	10:11	272	>depth	19.8	-	-	-	-
October 19	10:00	293	>depth	12.0	~~12.0~~,9.5 (9.5)	27.8	4.0	-

North Hardwood Island N. 45° 16.162'; W. 076° 33.203' Depth: 5.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	9:06	131	5.5	14.6	7.7,7.2 (7.5)	31.3	3.9	3.6
May 30	9:17	151	4.2	18.7	-	-	-	-
June 14	9:15	166	3.9	19.3	12.5,12.6 (12.6)	32.3	3.6	3.2
June 27	9:12	179	4.0	21.9	-	-	-	-
July 15	9:24	197	4.7	24.6	12.4,11.7(12.1)	30.8	3.7	2.9
July 30	9:20	212	4.0	24.4	-	-	-	-
August 15	9:16	228	4.7	23.5	11.5,11.2(11.4)	27.7	3.6	2.7
August 29	10:19	242	5.3	19.7	-	-	-	-
September 13	9:50	257	4.9	19.8	9.2,9.3(9.3)	26.3	4.2	-
September 28	10:34	272	>depth	20.0	-	-	-	-
October 19	10:11	293	>depth	12.0	8.5,8.3(8.4)	27.4	3.9	-

Deepest Pickerel Bay N. 45° 16.81'; W. 076° 31.63 Depth: 9.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	9:20	131	5.7	14.2	-	-	-	-
May 30	9:31	151	5.1	18.7	-	-	-	-
June 14	9:26	166	4.4	19.5	-	-	-	-
June 27	9:22	179	4.4	21.5	-	-	-	-
July 15	9:51	197	5.1	25.0	-	-	-	-
July 30	9:39	212	4.3	25.2	-	-	-	-
August 15	9:30	228	3.8	23.7	-	-	-	-
August 29	10:36	242	4.9	19.9	-	-	-	-
September 13	10:01	257	4.9	20.0	-	-	-	-
September 28	10:49	272	8.0	19.9	-	-	-	-
October 19	10:28	293	6.4	13.0	-	-	-	-

Pickerel Bay N. 45° 16.33'; W. 076° 31.03 Depth: 7.5 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	9:33	131	5.6	14.4	-	-	-	-
May 30	9:42	151	5.1	18.7	-	-	-	-
June 14	9:36	166	4.2	19.5	-	-	-	-
June 27	9:29	179	4.0	21.9	-	-	-	-
July 15	10:02	197	5.2	25.3	-	-	-	-
July 30	9:54	212	4.2	25.0	-	-	-	-
August 15	9:45	228	3.7	23.4	-	-	-	-
August 29	10:46	242	5.4	20.0	-	-	-	-
September 13	10:15	257	4.8	20.0	-	-	-	-
September 28	11:07	272	7.1	19.9	-	-	-	-
October 19	10:44	293	6.2	13.0	-	-	-	-

Middle Narrows N. 45º 18.548'; W. 076º 31.271' Depth: 6.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, ºC	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	9:50	131	5.8	14.2	5.8,7.0 (5.9)	30.7	3.9	3.4
May 30	9:58	151	4.9	18.7	-	-	-	-
June 14	9:50	166	4.6	19.9	12.8,12.4(12.6)	31.9	4.0	3.2
June 27	9:44	179	4.1	22.0	-	-	-	-
July 15	10:15	197	5.9	25.3	11.6,12.5(12.2)	31.0	3.8	2.9
July 30	10:09	212	4.5	25.0	-	-	-	-
August 15	10:00	228	3.2	23.8	11.9,12.2(12.1)	29.9	4.0	2.8
August 29	11:00	242	5.5	22.0	-	-	-	-
September 13	10:28	257	6.3	20.0	8.4,7.9(8.2)	26.1	4.0	-
September 28	11:23	272	>depth	20.0	-	-	-	-
October 19	10:57	293	>depth	12.8	8.2,8.4(8.3)	26.7	4.0	-

The Canal N. 45º 19.267'; W. 076º 30.013' Depth: 2.4 M

Date	Time	Day of Year	Secchi Depth, M	Temp, ºC	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	10:09	131	>depth	14.2	5.7,5.8 (5.8)	31.5	4.5	3.3
May 30	10:12	151	>depth	17.5	-	-	-	-
June 14	10:06	166	>depth	19.5	10.7,10.4(10.6)	32.6	4.8	2.9
June 27	9:55	179	>depth	21.8	-	-	-	-
July 15	10:34	197	>depth	26.2	9.6,9.9(9.8)	31.1	5.6	2.7
July 30	10:21	212	>depth	25.5	-	-	-	-
August 15	10:20	228	>depth	23.5	8.6,8.2(8.4)	25.1	5.2	2.8
August 29	11:17	242	>depth	21.3	-	-	-	-
September 13	10:43	257	>depth	20.0	6.8,7.3(7.1)	25.4	5.6	-
September 28	11:38	272	>depth	19.0	-	-	-	-
October 19	12:00	293	>depth	10.4	8.4,8.0(8.2)	29.2	5.7	-

Temperatures taken 1 m from bottom.

Hayes Bay N. 45º 19.037'; W. 076º 28.424' Depth: 1.6 M

Date	Time	Day of Year	Secchi Depth, M	Temp, ºC	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	10:15	131	>depth	16.0	~~8.1~~,6.8 (6.8)	35.9	8.6	2.7
May 30	10:21	151	>depth	18.1	-	-	-	-
June 14	10:17	166	>depth	19.4	8.9,9.9 (9.4)	36.1	8.6	2.5
June 27	10:02	179	>depth	21.8	-	-	-	-
July 15	10:45	197	>depth	26.6	8.6,8.6(8.6)	36.7	9.5	2.0
July 30	10:28	212	>depth	26.0	-	-	-	-
August 15	10:28	228	>depth	23.5	7.7,7.3(7.5)	33.5	9.6	2.1
August 29	11:24	242	>depth	21.3	-	-	-	-
September 13	10:52	257	>depth	19.9	7.4,7.3(7.4)	32.0	10.0	-
September 28	11:46	272	>depth	19.0	-	-	-	-
October 19	12:10	293	>depth	10.3	7.9,7.1(7.5)	36.0	9.6	-

Temperatures taken 1 m from bottom.

Jacob's Island N. 45º 19.989; W. 076º 30.622' Depth: 4.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, ºC	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	10:31	131	>depth	14.0	6.3,6.0 (6.2)	31.0	4.0	3.5
May 30	10:44	151	>depth	18.6	-	-	-	-
June 14	10:32	166	>depth	20.1	12.9,12.4(12.7)	31.5	4.1	3.1
June 27	10:14	179	>depth	21.9	-	-	-	-
July 15	11:00	197	>depth	26.1	13.1,13.7(13.4)	30.4	4.0	2.8
July 30	10:39	212	>depth	25.6	-	-	-	-
August 15	10:39	228	>depth	23.4	9.7,9.7(9.7)	27.5	4.1	2.8
August 29	11:36	242	>depth	22.0	-	-	-	-
September 13	11:11	257	>depth	20.2	8.4,8.6(8.5)	25.8	4.1	-
September 28	11:54	272	>depth	19.5	-	-	-	-
October 19	12:20	293	>depth	12.2	8.7,8.8(8.8)	26.9	4.2	-

Village Basin N. 45º 21.233'; W. 076º 30.303' Depth: 1.65 M

Date	Time	Day of Year	Secchi Depth, M	Temp, ºC	Total P, ppb	Ca, ppm	Cl, ppm	SO_4, ppm
May 10	10:43	131	>depth	16.0	6.7,6.7 (6.7)	29.6	4.0	3.3
May 30	10:56	151	>depth	17.8	-	-	-	-
June 14	10:44	166	>depth	19.7	9.5,9.7 (9.6)	30.8	4.2	3.1
June 27	10:25	179	>depth	21.6	-	-	--	-
July 15	11:15	197	>depth	26.0	11.8,11.3(11.6)	29.1	3.9	3.0
July 30	10:56	212	>depth	25.5	-	-	-	-
August 15	10:53	228	>depth	21.0	8.7,9.5(9.1)	25.3	4.4	3.1
August 29	11:46	242	>depth	21.0	-	-	-	-
September 13	11:20	257	>depth	20.0	7.6,7.7(7.7)	24.9	4.3	-
September 28	12:06	272	>depth	19.0	-	-	-	-
October 19	12:35	293	>depth	10.3	7.5,7.5(7.5)	28.4	4.2	-

Temperatures taken 1 m from bottom. B= bottom temperature

Weather Conditions 2024

Date	Day of Year	Weather Conditions
May 10	131	Partly cloudy morning; Winds of about 5 to 10 km per hour; Air temperature of 13 C; 8 mm rain three days before sampling.
May 30	151	Full sun. Wind increasing over two hours from 0 km/hr to about 10 km/hr. Air temperature 15C. No rain three days prior to sampling, but 25 mm of rain fell during preceding two weeks
June 14	166	Mostly cloudy; Winds from 5 t0 15 km/hr; 5 mm rain evening before sampling; Air temperature 13-16C
June 27	179	Clear skies; Winds from 10 to 25 km/hr; Rain showers evening before sampling with 60 mm rain falling since last sampling on June 14; Air temperature 16C
July 15	197	Clear sunny sky; air temp. 25C; wind 0k to 10 km/hr.;50 mm rain since June 15; No rain three days prior to sampling; water levels 10 cm higher than planned (depth rule).
July 30	212	Clear sunny day. Ver hot. 15 cm rain since last lake sampling (2 weeks). Air temp 22 to 26C; wind 0 to 5 k/hr. Lake is 7 cm higher than the rule.
August 15	228	Full sun; 65 mm rain during last two weeks. No rain 48 hours prior to sampling; Air temperature from 22 to26C; no wind.
August 29	242	Full sun; wind 5 km/hr; Air temp. 15 to 17C.
September 13	257	Full sun, no wind; air temp 22-25C; 51 mm rain since last sampling; Lake depth 134 cm, 11 mm higher than rule.
September 28	272	Full sun; <5 km/hr wind; 5 mm rain during precious two weeks; Air temperature 17 to 22C; lake depth 126.4 cm, 10.6 cm higher than rule.
October 19	293	Full sun; <5 km/hr wind; 41 mm rain during precious two weeks; Air temperature 8 to 14C; lake depth 119.5 cm, 12.8 cm higher than rule.

Notes:

1. Temperatures were taken at Secchi Depth. When sampling site depth was less than Secchi depth, temperatures were taken 1 M from bottom.

2. Water samples for total phosphorous were taken at Secchi Depth or when sampling site depth was less than Secchi depth, samples were taken 1 M from bottom.

3. All water samples were filtered through 80-micron filter prior to determination of total phosphorous.

4. Sampling dates were ideally the first of the month for temperature and Secchi depth and the 15th of the month for Secchi depth, temperature and total phosphorus. Some adjustments in timing had to be done to accommodate inclement weather and availability of personnel.

5. Total phosphorous water samples were not taken at the Pickerel Bay or Deepest Pickerel Bay locations as these locations were not part of the Lake Partner Program .