WHITE LAKE PROPERTY OWNERS ASSOCIATION
ENVIRONMENT VOLUNTEERS

State of the Lake Report

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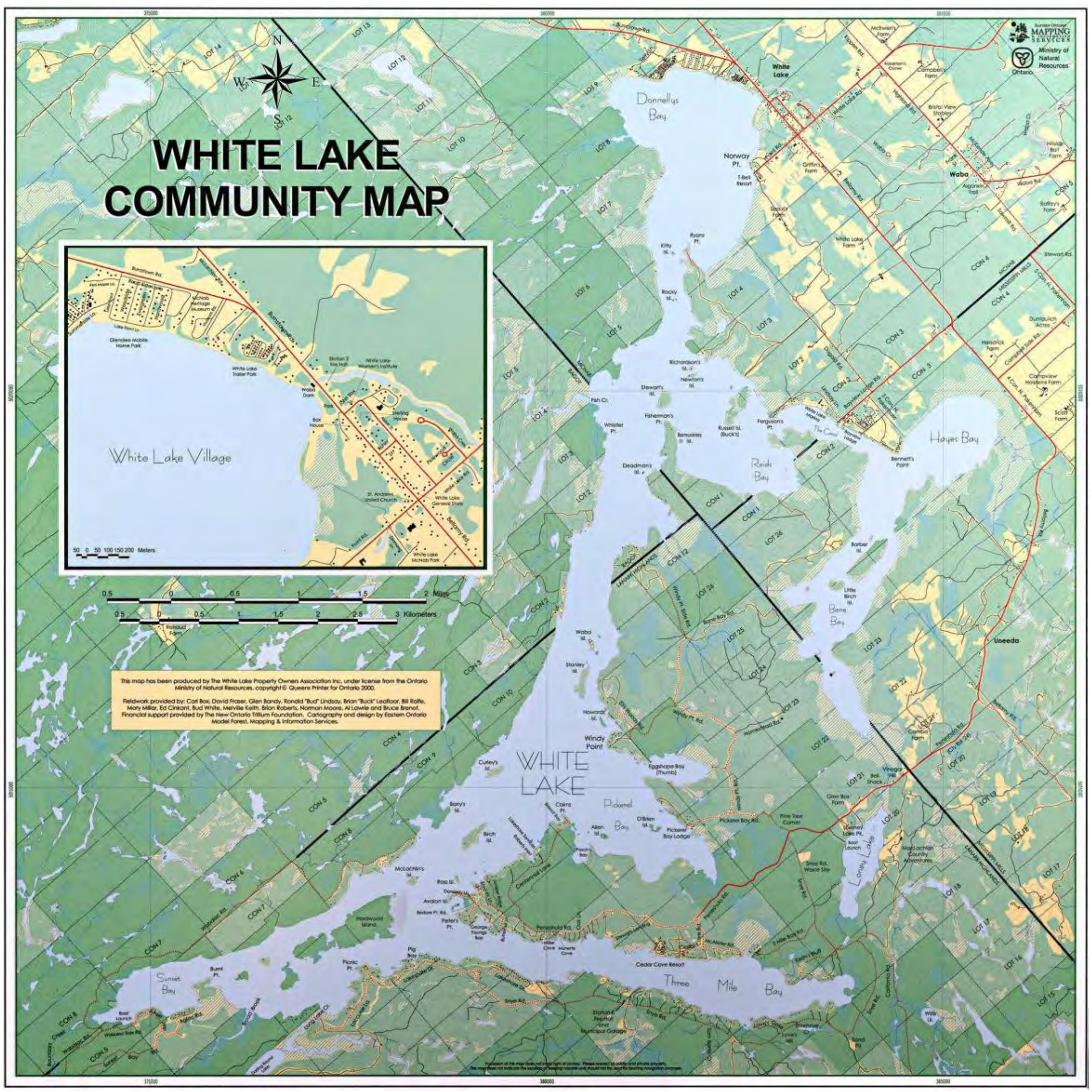
White Lake and the Environment



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WHITE LAKE PROPERTY OWNERS ASSOCIATION ENVIRONMENT VOLUNTEERS

The State of White Lake

Conrad Grégoire PhD and David Overholt BA

2022 marked the 9th year that we have been reporting on White Lake water quality. A number of parameters are monitored which are indicative of water quality. This data, as well as reports in the scientific literature, form the basis of our annual reports. Data obtained over a period of years is also studied for long-term trends. The more data we have the more accurate is our assessment of the state of White Lake

In this volume we provide observations and information on White Lake gathered over the last nine years. For a complete referenced account of our work, we ask that you access the White Lake Science and Information Website for full-length Water Quality Monitoring Reports as well as Special Reports on individual topics. Alternatively, the website can be accessed via the Environment portal on the White Lake Property Owners Website.

Water Quality

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”.

White Lake is a shallow warm-water lake with high productivity of both plant and animal life. As such, it is very sensitive to nutrient inputs.

One way to assess the impact that nutrient inputs are having on a lake is the number and frequency of algal blooms. Algal blooms are both a sign and a measure of declining water quality.

A recently published report traces the history of algal blooms in White Lake from 1860 to 2021. The detection of algal blooms prior to the construction of the concrete dam at Waba Creek is based on the analysis of sediments using special techniques. Algal blooms to 1977 are reported in the scientific literature and (MOECP) in reports published by the Ministry of the Environment, Conservation and Parks. For the period starting in 1977 and ending in 2012 (35 years), no algal blooms were recorded.

Starting in 2013 and to the present, at least one algal bloom occurred in each year. Four algal blooms were recorded in 2018, two in 2019 and 2020. In 2021, there were 5 algal blooms. In each of these years, there was at least one blue-green algal bloom, some of which released toxins into the lake.

Annual algal blooms are a sign that White Lake is under stress and cannot absorb any increase in nutrients or other impacts of human activity, such as shoreline erosion.

Three factors combine to create this situation: lake overuse, invasive species, and climate change.

Lake Overuse

From 1977 to 2008, the number of cottages, trailers and commercial tourist units on White Lake have increased from 475[1] to 1538, an increase of 324%. Available numbers also show that from 1985 to 2018, permanent homes on White Lake increased by 354% to 209. These trends are continuing today with ever increasing human impact on the lake. More people spending more time using White Lake inevitably means greater amounts of septic system outflow, more and larger boats, etc.

Invasive Species

The presence of zebra mussels in the lake has changed the way phosphorus is cycled creating a near-shore zone where nutrients concentrate causing algal blooms in the spring and fall. This zone is depicted as the red line in the above figure. The arrows indicate that nutrient inputs are transferred to the near-shore area both by land from runoff (above and below ground) and from deeper parts of the lake by the action of zebra mussels, which feed by filtering lake water at the rate of about 1 litre per day per mussel.

Phragmites is slowly invading our marshlands and could eventually displace cattails and other native plants. Fish and other animals which depend on cattail marshes for reproductive purposes will be harmed. European milfoil is now resident and spreading in White Lake. There are a number of other invasive species including quagga mussels and a number of very harmful plants which could enter the lake soon if nothing is done to stop them.

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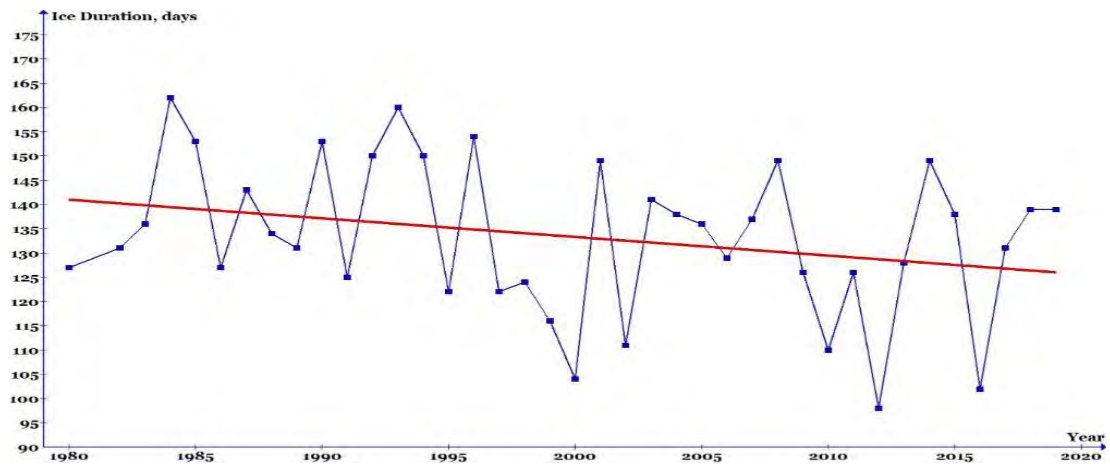
[1] J.P. Ferris, White Lake Integrated Resources Management Plan, Part I, *Ministry of Natural Resources, Lanark and Renfrew Counties, December 1985.*

Climate Change

Climate change is causing unpredictable and unexpected weather patterns. In recent years White Lake has experienced tornados, a microburst and high wind events causing damage to buildings and infrastructure. Low-snow winters, and prolonged periods of hot weather have resulted in lower water levels and higher water temperatures.

Since 1980, the ice-free season on White Lake has increased by nearly 2 weeks, as shown by the downward sloping redline on the graph below. This means that there are now two additional weeks per year for cottagers and residents to be at the lake and to be using the lake for residential and recreational purposes.



What Can We Do?

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. Download your own copy of the Lake Protection Workbook and assess your shoreline.

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 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 MOECP), are the Councils of the four municipalities sharing White Lake.

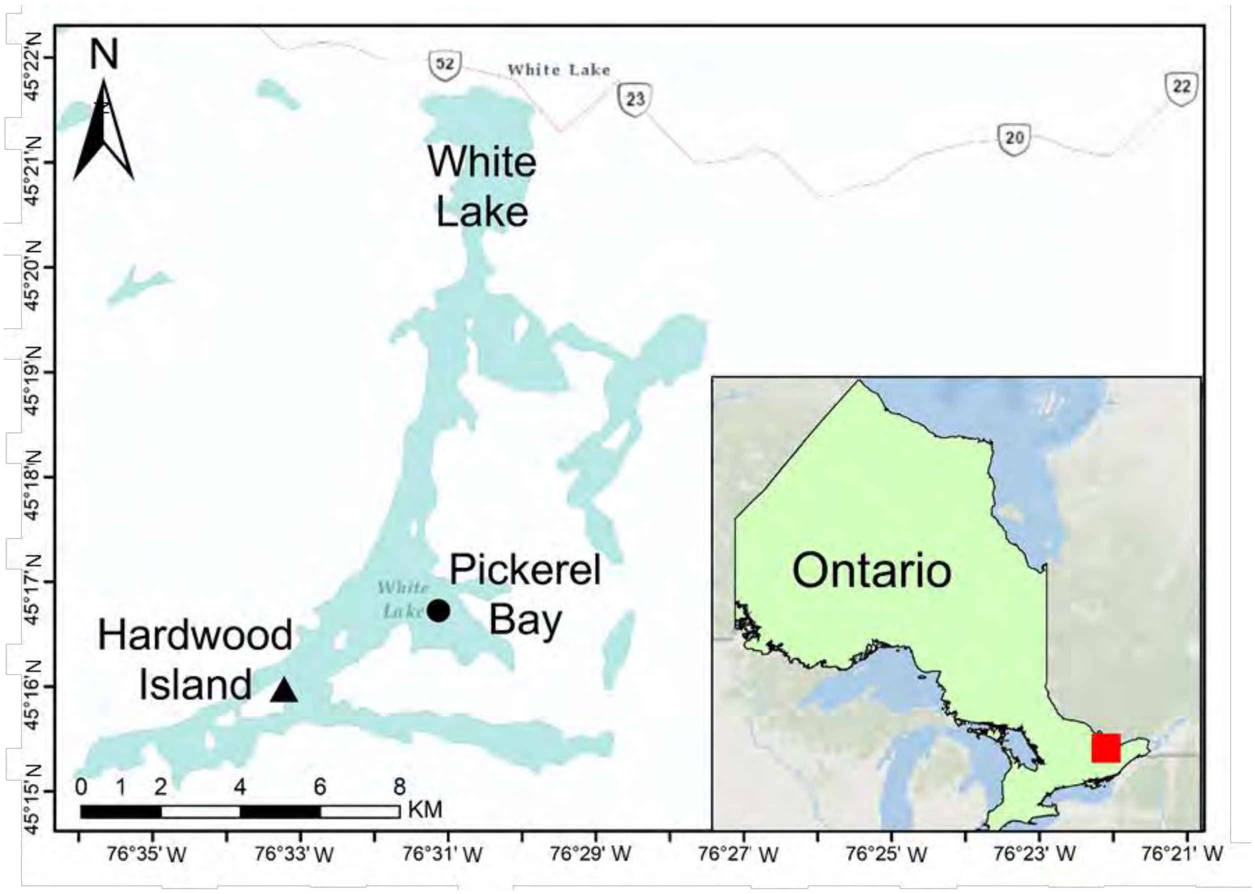
Since the Township of Lanark Highlands has both the greatest number of taxpayers of any municipality and the greatest number of its own taxpayers located on White Lake, it has both the most to lose as well as the most to gain when it comes to the health of White Lake.

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.

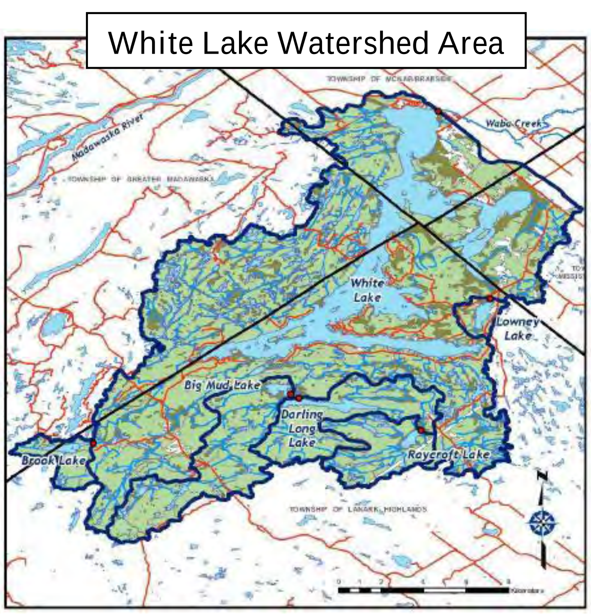
White Lake and the Environment

About White Lake

White Lake: Vital Statistics

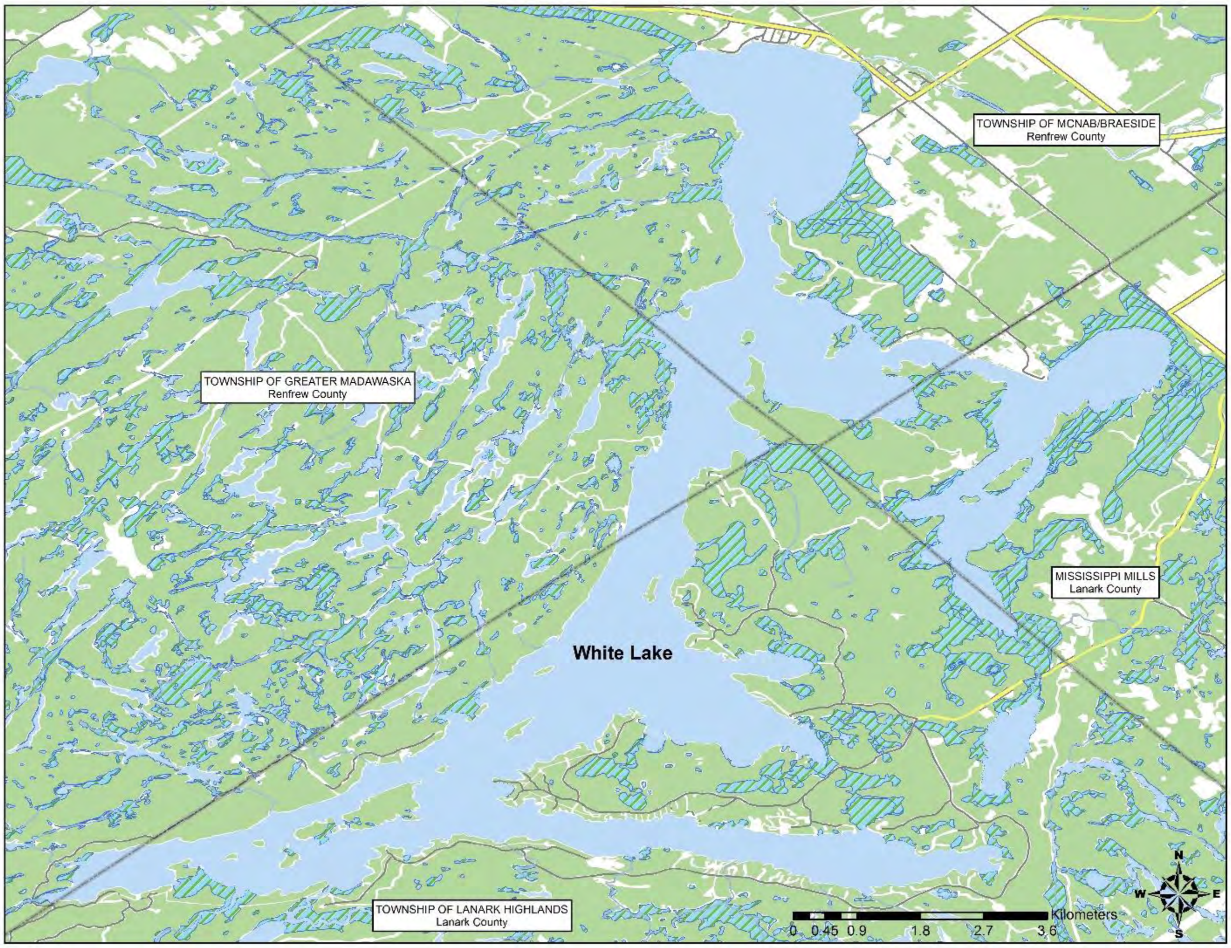


White Lake is located about 60 km west of Ottawa, Ontario between Calabogie to the West and Arnprior to the East.



Length: 16 km
Surface Area: 22.69 square km
Perimeter: 98 km
Greatest Depth: 9.1 m
Mean Depth: 3.1 m
Height Above Sea Level: 161.5 m
Percent Crown Land: <20%
Lake Volume: 75 million cubic m
Water Level Fluctuation: 0.6 m
Watershed Area: 211 square km
Flushing Rate: 0.9 times/year
Number of Inlets: 11 (7 intermittent)
Number of Outlets: 1

Political Boundaries

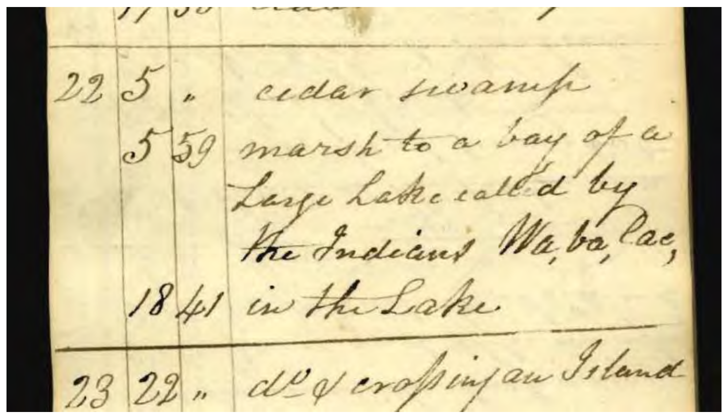


White Lake falls within the boundaries of four municipalities and two counties: The Township of Lanark Highlands and the Municipality of Mississippi Mills are within Lanark County, and the Townships of Greater-Madawaska and McNab-Braeside are in Renfrew County.

White Lake is not served by an Ontario Conservation Authority. Thus, it is the responsibility of the four municipalities with the assistance of the Ontario Ministry of the Environment, Conservation and Parks to manage the lake. Currently, there is no committee or other body made up of representatives from the four municipalities tasked with managing White Lake.

White Lake: What's in a Name?

The first published report including the name of the lake we know today as White Lake, was that of surveyor Reuben Sherman. An excerpt from his 1823 field notes (shown to the right) reads "*cedar swamp marsh to a bay of a large lake called by the Indians Wa,ba,lac*". A hand drawn map (below) of the area resulting from this survey labels the lake as 'Wa,ba,lak'.



White Lake is a translation from the Algonquin name 'Wàbà Sagaigun'[2]. Taking into consideration that the final letter of the name of the lake found in the field notes was a 'c' and on the map a 'k', one can speculate which European group first re-named the lake. It could have been either the French (lac) or the British (lake). The first recorded Europeans, however, who explored this area were French; Étienne Brûlé (1610) and Samuel de Champlain (1613).

Today, it is not obvious to anyone boating the lake, why it should be called White Lake. Everywhere you go, the lake water ranges in colour from clear to brownish. The sediments are essentially black and quite muddy. Yet, for First Nation Peoples, it was obvious to them that the lake was exceptional and named it Waba (white) for its defining property.

[2] Hessel, Peter (1987). *The Algonkin Tribe, The Algonkins of the Ottawa Valley: An Historical Outline*. Kichesippi Books. ISBN 0-921082-01-0.

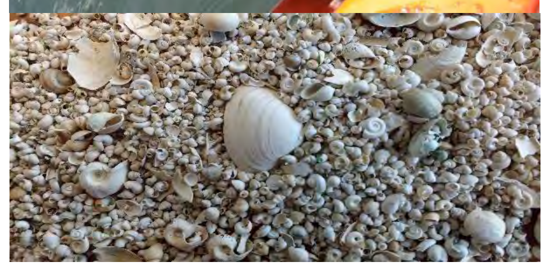
The installation of a dam on White Lake in 1845 started a process resulting in the covering up of the existing lake bed (especially at the Northern end of the lake) with black sediments which are today about 15 cm thick. Below these sediments is a layer of white marl[3]. The Southern, and deeper part of the lake, already had from 3 to 5 m of black sediments dating back to nearly the end of the last ice age.

The very first description of marl in White Lake was by William Logan[4], who founded the Geological Survey of Canada in 1842 and for whom Mt. Logan, Canada's highest peak, is named. He described White Lake marl in this way: 'In the lower part of White Lake about seven hundred acres are covered with marl, which was found to have a depth of from five to seven feet, and was covered by not more than two or three feet of water'. The location on the lake he was referring to is off of Norway Point on the White Lake Village basin.

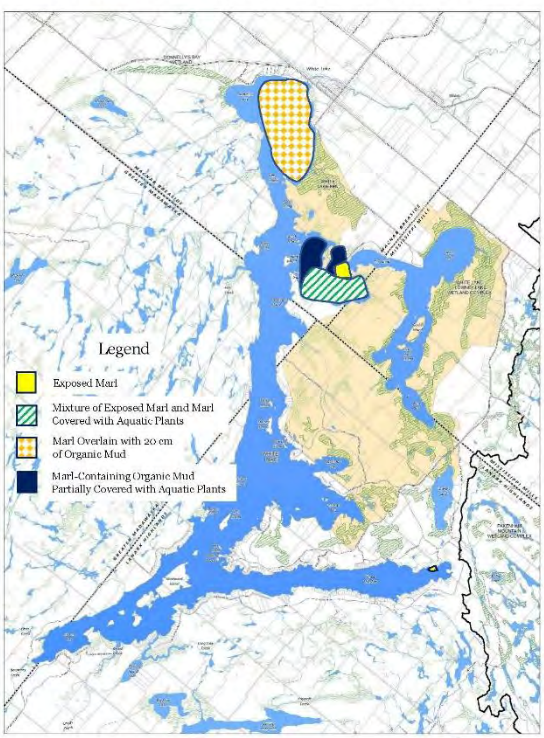
Marl is a calcium-rich sediment formed by the precipitation of calcium carbonate from mineral-rich spring waters entering the lake.

It is also formed by the accumulation of snail and small clam shells.

Both of these are white in colour, as shown in the photo on the right of marl sediments recovered from near Norway Point in the Village Basin.



Areas of White Marl on White Lake



The map on the left show areas on White Lake where there are marl deposits. Anyone arriving at White Lake at any time prior to the construction of the dam would have seen large very shallow areas of the lake that appeared to be white in colour.

It could be that when First Nations peoples arrived on its shores and looked out over the water, they would have pointed towards the lake and said 'Wàbà Sagaigun'.

September 1, 2021

3 Marl in Ontario, G.R. Guillet, Industrial Mineral Report 28, 1969, Ontario Department of Mines.
4 W.E. Logan, The Geology of Canada, Geological Survey of Canada; 1863, p. 765.

White Lake: Myths and Maps

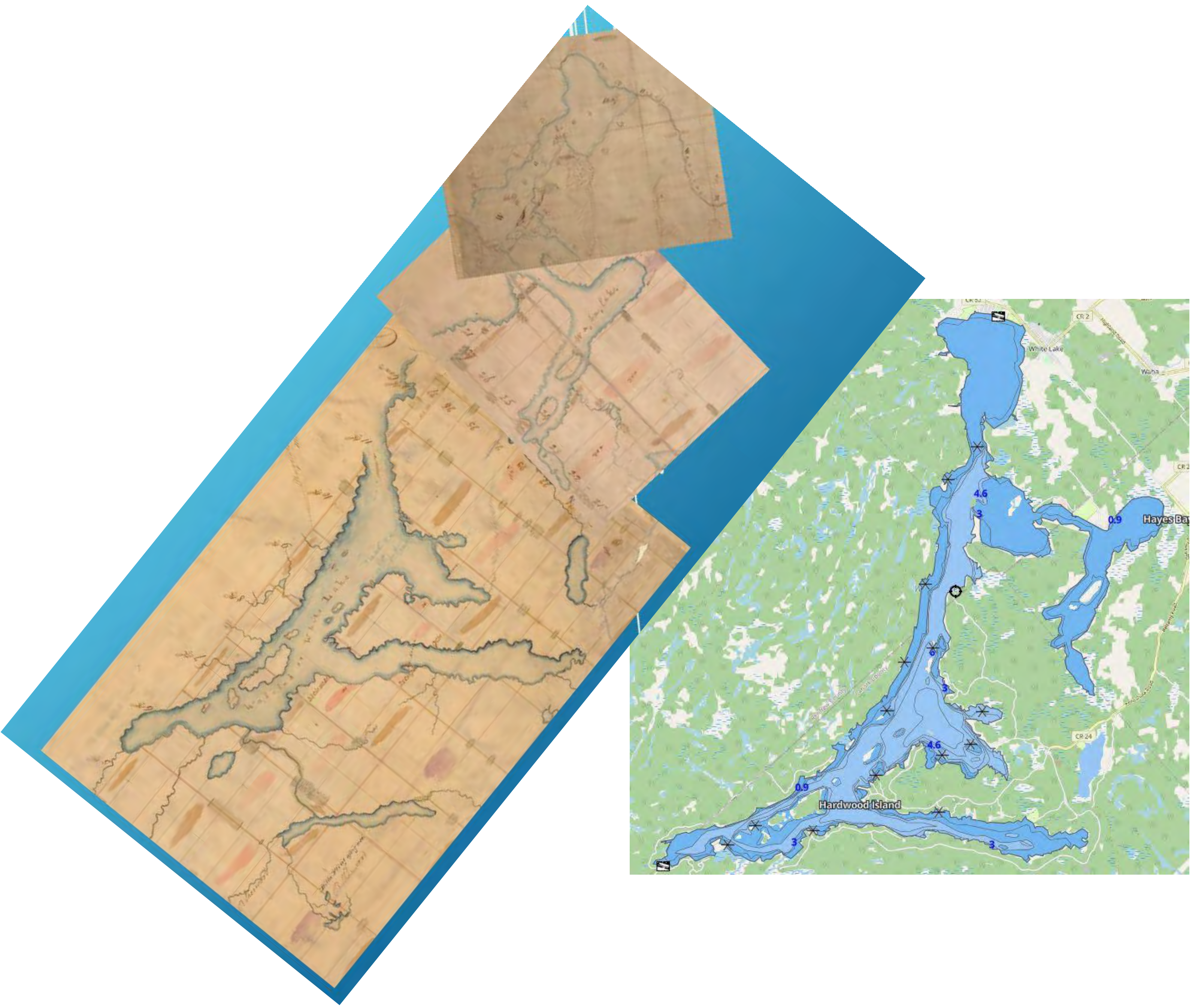
Over the years we have heard cottagers and residents of White Lake bristle at the suggestion that the lake is artificial, created when the first dam was built in 1845. In one publication[5], the author states that "*when a dam on Waba Creek was constructed it*

resulted in the water levels increasing in three previously small interconnected water bodies", and thus forming the lake as we see it now. We do not have a picture of the dam as it was in 1845, however the photo above shows the condition of the dam in 1919. This dam was rebuilt in 1948 and was changed to the present-day concrete structure in 1968.

[5] V.R. Brownell; *A Biological Inventory and Evaluation of the White Lake Study Area, Eastern Ontario;* Ontario Ministry of Natural Resources, Kemptville Ontario District Office; 2001

What if we had a map of the lake both before and after the first dam was built? Then we could compare the outlines of the lake, and see just how the dam affected its contours.

As it turns out, we can do just that. On the left is a composite of the hand-drawn maps of White Lake created in 1822 by surveyor Reuben Sherwood[6]. On the right is a present-day satellite map of the lake.



[6] Province of Ontario Archives

The two maps above clearly show that the contour and shorelines of the lake are essentially identical before and after the construction of the original and replacement dams at Waba Creek.

So, as the current dam raised water levels in the lake by about 1.5 metres, why are the lake contours on both maps essentially the same? If there were three interconnected ponds before the dam was built, why are they not evident on the 1822 map?

The answer to these questions lies in the fact White Lake is a wetlands lake. About 25% of the lake surface area is made up of marshes and very shallow (≈ 1.5 to 2 m) waters.

Lake Contours: When Reuben Sherwood surveyed the lake, he included the extent of wetlands as part of the natural contour of the lake. In his 1985 paper, Ferris[7] said that "*Although there are seasonal fluctuations, there has been very little change in water levels since 1823. Water levels have not increased by more than 20 cm vertical and 9.1 m horizontally*".

What Ferris is saying here is that the MAXIMUM level of the lake has not changed since pre-dam times. Before the construction of the dam, White Lake water levels rose during the spring melt and early summer and then slowly receded. Flooded wetland areas were drained with some areas drying up and others turning into shallow swamps.

What the dam achieved, however, was raising the MINIMUM level of the lake by about 1.5 metres. This explains why the contours of White Lake appear to be the same in the two maps above.

Three interconnected water bodies: How do we explain the assertion by some that the lake was a series of three interconnected ponds before the dam was built? Is there any basis in fact supporting this?

Using bathymetric (depth) data and figuratively 'draining' away 1.5 metres of water from the lake, could these three interconnected water bodies be revealed?

The map below shows in light blue the extent of White Lake at low-water prior to the construction of the dam. This is what the lake would have looked like in late August. The darker blue areas would have been flooded at high-water in the spring and early summer.

It appears from this map that there remained only a single water body and there were no other areas of open water at low-water in late summer.

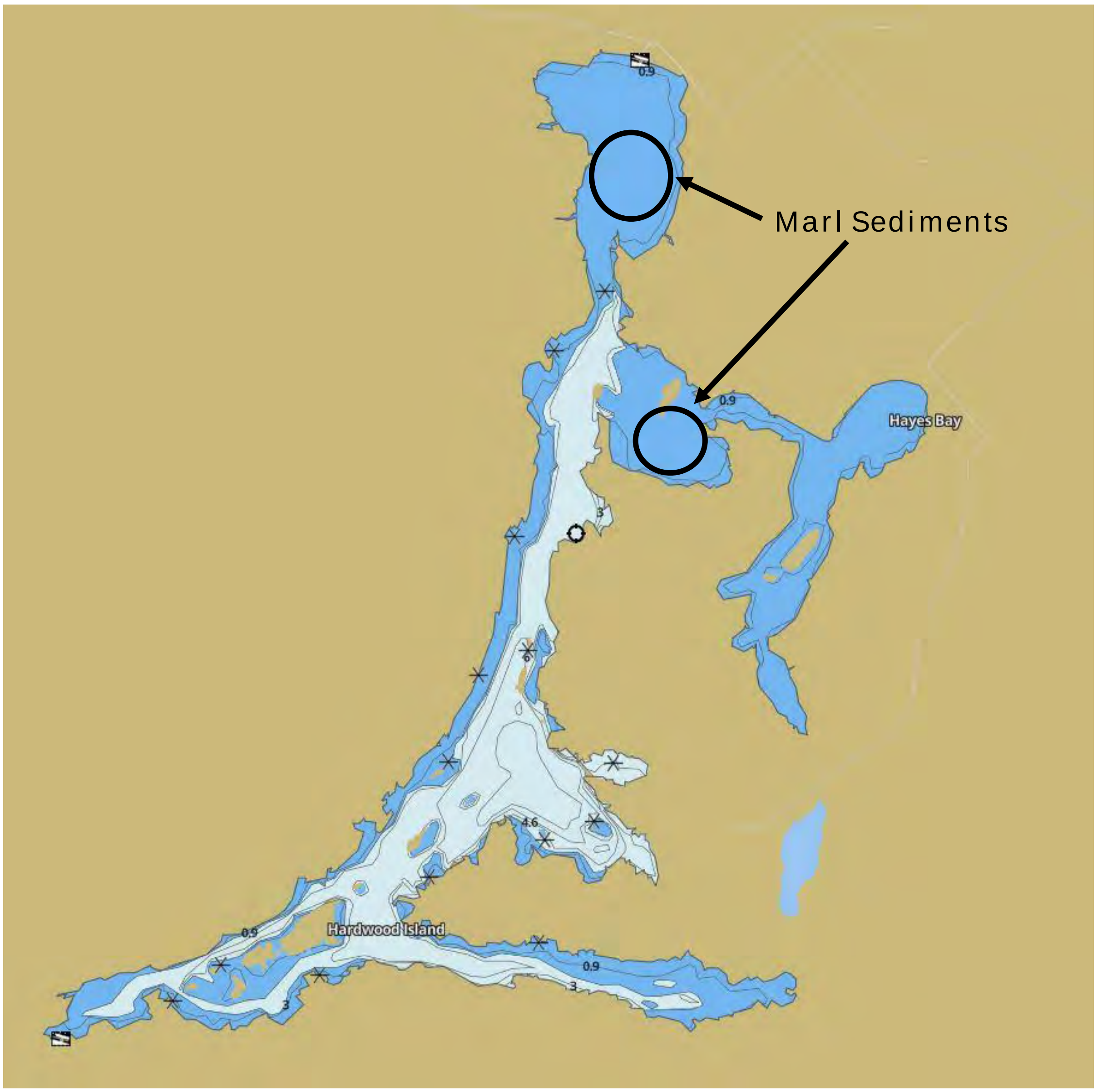
However, we know from present day observations that there are parts of the lake which do not support the growth of aquatic plants because the sediments there are composed of marl, a calcium mineral. These areas are shallow (≈2 m) and circled on the map below. It

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

is possible that at low water levels, prior to the construction of the dam, these parts of the lake appeared as open water perhaps only .5 metres deep.

In the end, all theories appear to be correct. We can have an unchanging lake contour at high water before and after dam construction as well as several interconnected open water bodies during seasonal low water conditions.

The secret to understanding all of this is that the dam increased low water levels while not substantially changing high water levels.



What Kind of Lake is White Lake?

It's obvious that White Lake is a lake; but what is a lake? A popular definition is that "*A lake is an area of land that is filled with water. Aside from the streams and rivers that flow in and out, a lake is completely surrounded by land and can be formed in basins or depressions*."[8]

In Canada, our lakes contain about 20% of the worlds fresh water. The total number of lakes in Canada is not exactly known, but there are estimated to be over 2 million. About 250,000 of these are in Ontario.

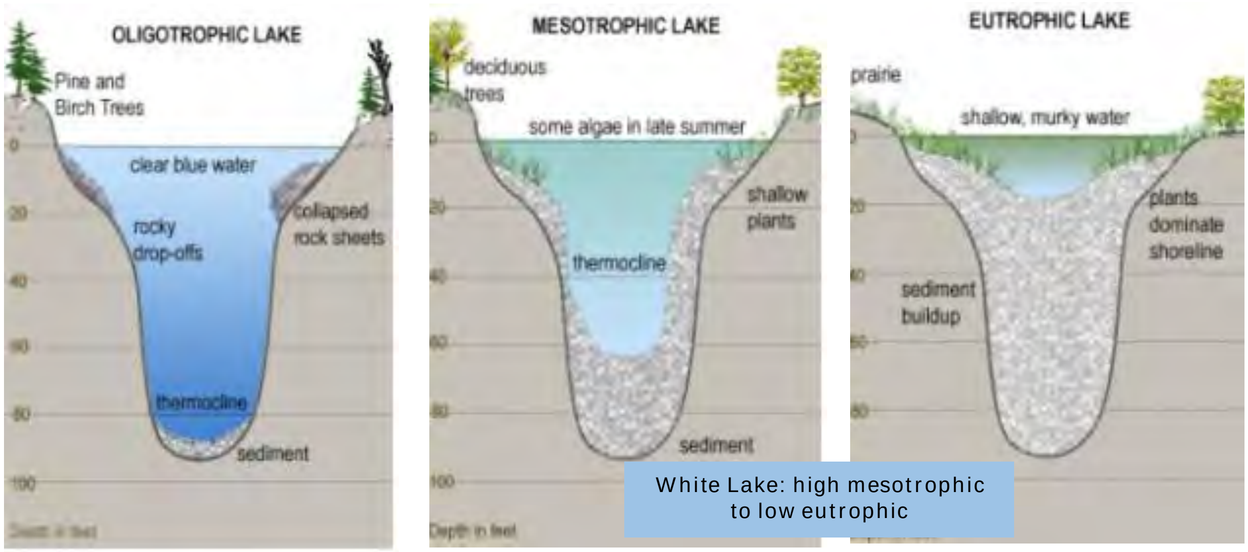
There are at least 15 different types of lakes depending on their origin. There are even more types if they are classified according to factors such as water chemistry, and thermal stratification (layering) to name just two.

White Lake is classified as a Glacial Lake because it was created by the direct action of glaciers and continental ice sheets scraping and grinding across a rocky landscape. The shape of the lake is influenced by the direction of movement of the ice sheet, the hardness of the rocks worn away by the ice and also the presence of geological faults (cracks) in the earth's upper crust.

Many scientists like to classify lakes in another way to make it easier to explain the status of a lake and to compare one lake with another. They do this using trophic states. The word trophic derives from a Latin root meaning *nutrients*. There are three trophic states:

[8] https://basicbiology.net/environment/freshwater/lakes ; A. Purcell in *'Lakes"*

Oligo (meaning very low in nutrients), Meso (meaning mid or average in nutrients); and Eu (meaning very rich in nutrients). These states are graphically described below.



Lake scientists as far back as 1985 have classified White Lake as between high mesotrophic to low eutrophic. This makes White Lake especially sensitive to increases in nutrient inputs and more prone to algal blooms. There has been at least one algal bloom in White Lake in each of the last 9 years.

No lake is permanent. Lakes actually begin filling up with sediment as soon as they are created. Deep lakes however can exist for millions of years. White Lake is a very shallow lake and so is filling up and will eventually disappear. Do we need to worry about this?

The sediments in the main part of White Lake have been measured to be from 5 to 6 metres thick. The rate at which a lake 'fills up' is not a constant and is likely increasing with lake use and as a result of climate change. We do know that since White Lake was dammed, the rate of infill is about 1 mm/year. White Lake is probably about half way through its lifetime, but in only 3 or 4 thousand years, you will likely be able to take your dog for a walk across Three Mile Bay during the summer.

photo credit: Sue Munro

White Lake: Inlets and Outlets

White Lake contains about 75 million cubic metres of water; where does it come from?

One obvious source is rainfall. Each year, an average 0.5 metres of rain falls onto the surface of White Lake. Considering that the average depth of White Lake is 3.1 metres, that would account for about 16% of the water in the lake[9].

The remaining 84%[10] comes from surface runoff, ground water flow, and streams. An extensive study completed in 2018[11], showed that most of the water derived from these sources comes from ground water flow (springs) and a smaller proportion comes from streams and surface runoff. Input from streams is most inportant during the spring melt.

Inlets:

As shown on the map below, there are over a dozen streams bringing water into White Lake. Most of these streams are unnamed because they run only in the spring and are dry for most of the year.

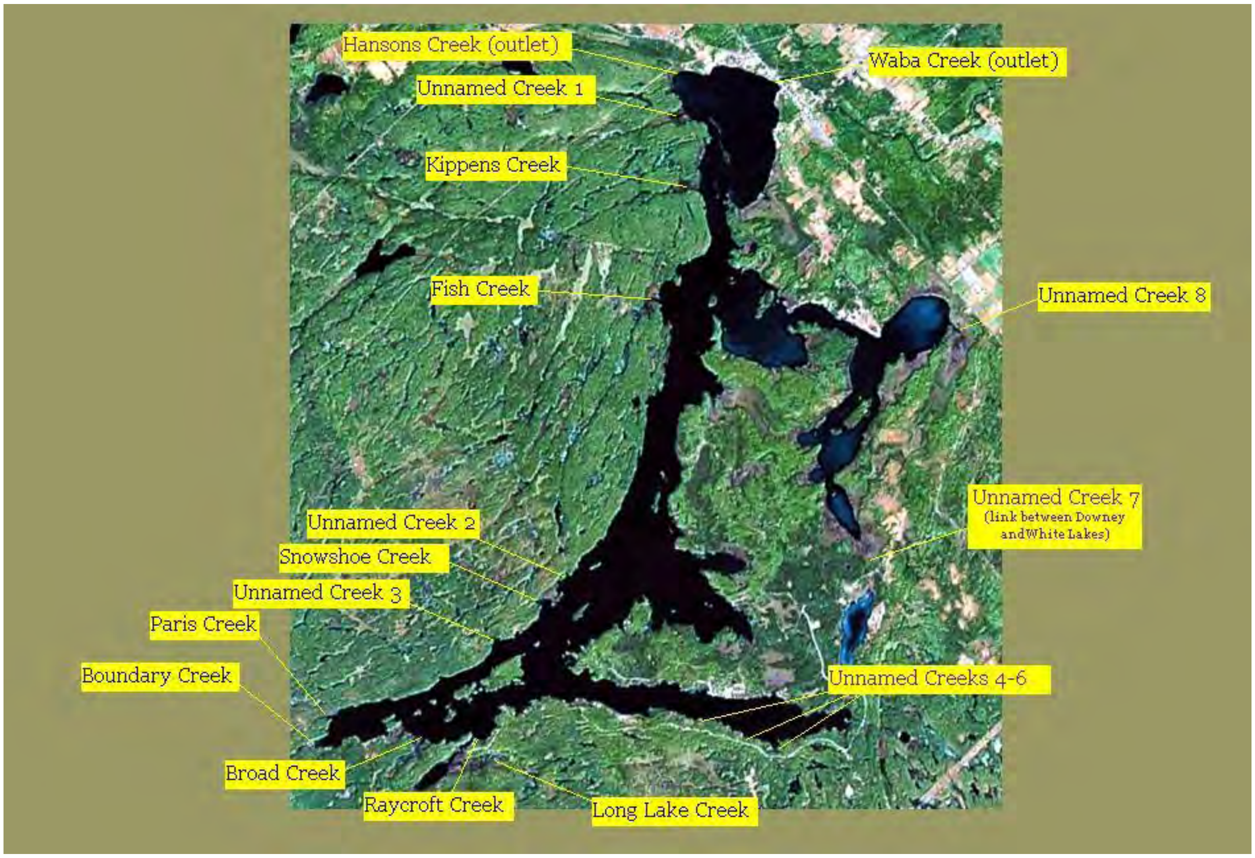
There are five major streams which flow continuously: Long Lake Creek, Raycroft Creek, Broad Creek, Boundary Creek, Paris Creek and Fish Creek. With the exception of Fish Creek, all of the creeks are located on the southern end of the lake.

All of the creeks, with the exception of two, carry waters which are close in compositon to that of the lake. Paris and Fish creeks are exceptional because their waters are very soft and low in dissolved salts, especially calcium. These two creeks, and all smaller ones in between, drain Precambrian Shield and are also soft.

The low calcium contents of Paris and Fish Creeks prevents the growth of zebra mussels. This means that pickerel spawning grounds near these streams are not fouled by the

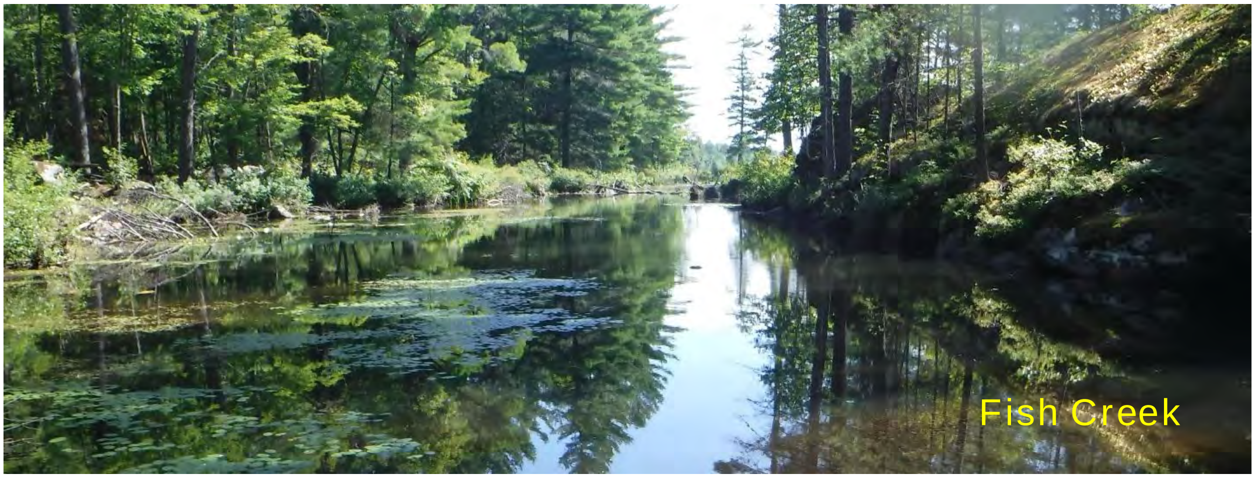
[9] White Lake flushes itself about once per year.
[10] 2017 White Lake Water Quality Monitoring Report, page 71; 2019 White Lake Water Quality Monitoring Report, page 68.
[11] 2018 White Lake Water Quality Monitoring Report

presence of zebra mussels. This may explain why the pickerel fishery in White Lake has not been adversely impacted by this invasive species.



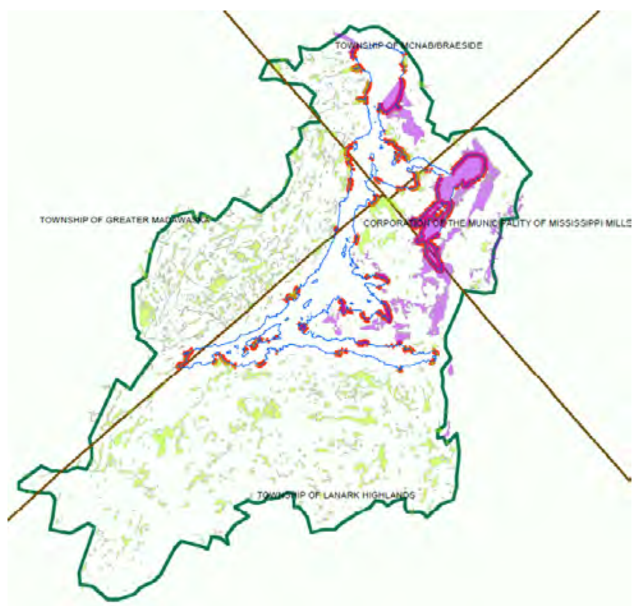
Outlets:

Everyone is familiar with the single active outlet in White Lake at Waba Creek. But in the past, there were two outlets. The second is Hanson's Creek (upper left on map) which is no longer active since the construction of dams at Waba Creek.



White Lake Wetlands

When lake scientists talk about White Lake, they often refer to it as a wetlands lake. A wetland can be defined as a distinct ecosystem that is permanently or seasonally flooded by water. The main factor that separates wetlands from terrestrial land is the presence of plants adapted to both wet and low oxygen conditions.



White Lake has a surface area of 22.7 sq. kilometres and a shoreline of 98 kilometres. 15.9% of the surface area of the lake is classified as wetlands as is 41% of the shoreline (pink and red on map to the right). In addition to this, about 14% of the catchment area of the lake (in light green) is also wetland.

Wetlands are divided into different categories based on variations in soil, landscape, climate, water levels, chemistry, vegetation, and human disturbance. There are four main categories of wetland, each of which can be found in White Lake or its catchment area; 1) A pond has a well-defined basin filled with stagnant water and fringed with vegetation; 2) Marshes are located adjacent to the lake and are subject to periodic flooding and may even dry out; 3) Swamps are essentially flooded wooded areas which support trees, tall shrubs and mosses; 4) Peatbogs are poorly drained areas covered by mats of moss, and are further divided into *bogs*, which are acid, and *fens*, which are alkaline.

Wetlands are so important because they have a number of attributes that benefit people while at the same time protecting water quality. These attributes are called ecosystem services and include: water purification; groundwater replenishment; stabilization of shorelines; storm protection; water storage; storage of carbon, and removal of carbon dioxide from the air. Some nutrients and pollutants are prevented from entering the lake. Wetlands provide a home and nursery for fish, birds, mammals, insects, and microorganisms. Wetlands are reservoirs of biodiversity and have a role in climate change mitigation and adaptation[12]. Since wetlands are so important to the health of White Lake, are these areas protected?

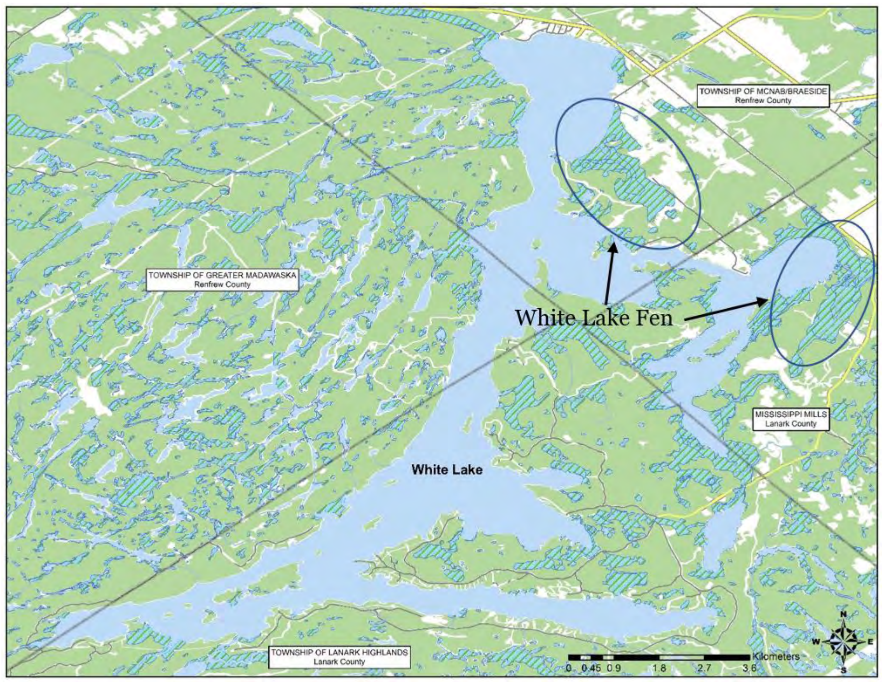
In 2003, The White Lake Conservation Reserve was created in an effort to recognize the importance of White Lake wetlands and at the same time offer some protection against degradation. Unfortunately, in 2017, The Lanark County Council reclassified many of these lands as rural which allows for development and destruction of wetlands. It is now very difficult to protect remnant wetlands because of the small and highly fragmented nature of remaining locations.

We can help by contacting our local and Provincial politicians and let them know that White Lake wetlands need to be protected. We should also start at home and preserve wetlands adjacent to our cottage or home properties. An extreme example of property owner irresponsibility (pictured below) was the wetland cut of a large section of cattail marsh. It was detached and then allowed to drift on the lake. This not only resulted in a serious hazard to navigation, but also compromised the lake bed and shoreline where the cut originated.

Photo Credit: David Overholt, 2015

[12] "Wetlands". USDA- Natural Resource Conservation Center.

White Lake Fen



The White Lake Fen is a special type of wetland which has been designated an Area of Natural and Scientific Interest and a Provincially Significant Wetland. The photo on the right shows the fen divided into two areas: one adjacent to the White Lake Village Basin and the other in Hayes Bay.

Fens are a relatively rare wetland habitat in Lanark and Renfrew Counties. Fens can occur on either marble or limestone bedrock. They are spring fed with waters which are high in minerals but relatively low in nutrients. Part of the White Lake Fen is floating over shallow waters.

The White Lake fen is home to rare plants including several orchids. These include the orchid Pogonia ophioglossoides (left).

The White Lake fen is also one of the few Canadian locations where the Bogbean


Fen at water's edge

Bogbean in full bloom

Buckmoth can be found. This is a species of silk moth that feeds on a typical fen plant, Bogbean.

The Bogbean Buckmoth is a rare moth known to occur in North America in only New York State and in Ontario. In Ontario, it is classified as endangered by the Committee on the Status of Species at Risk in Ontario (COSSARO) due to its habitat specificity and extremely limited geographic range. It is currently found at two sites in southeast Ontario: the Richmond Fen Wetland, and the White Lake Fen Wetland Complex. The actual area occupied by the species in Ontario is less than 3 square kilometers and is thought to support approximately 3,000 Bogbean Buckmoths.

It is remarkable that despite the rarity of fens such as the White Lake Fen and the even greater rarity of its plant and insect life, that this area is not a protected wetland.

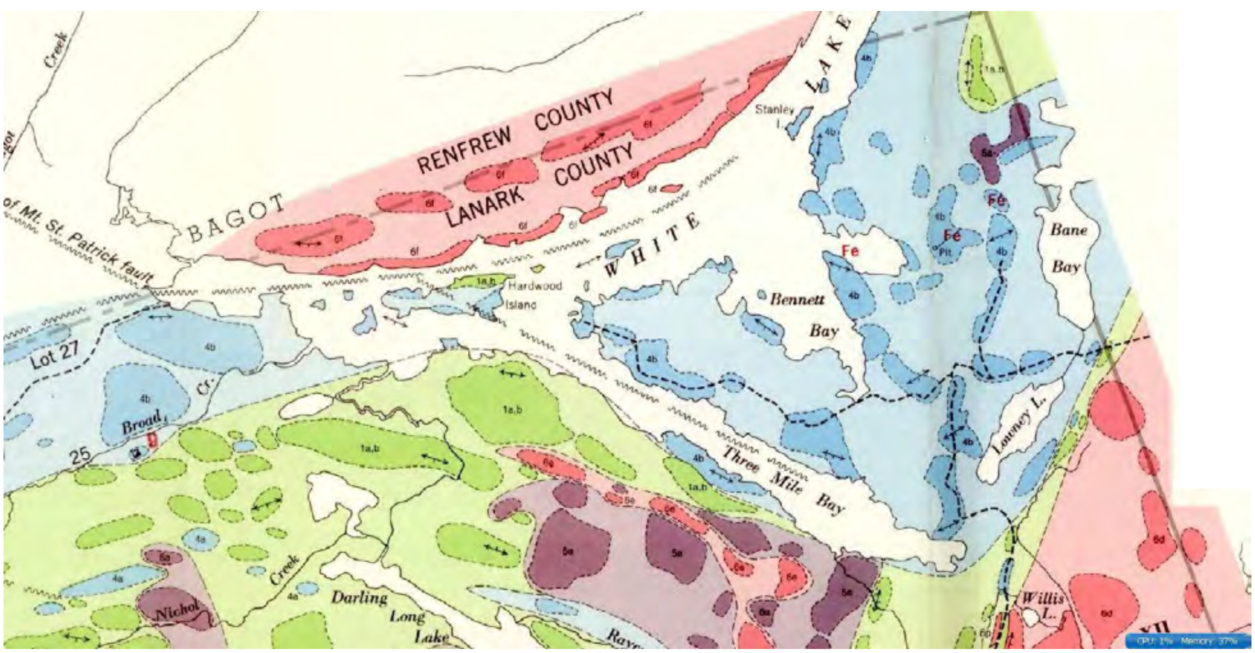
The endangered Bogbean Buckmoth and its caterpillar

It's Our Fault!

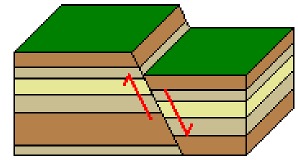
As we stroll out of our cottage or residence towards the lake, how often do we think about the very rocks beneath our feet? What are they? How old are they? How did they get there?

Although the story of Lanark Highlands starts about 4.5 billion years ago when the earth was formed, it's perhaps better to focus on the more recent geological events which led to the formation of what we see today.

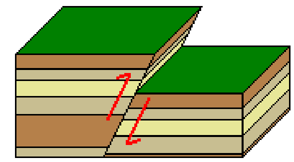
Fast forward to a mere 150 million years ago. By then there was still a lot of geological activity in our region, and Ontario was being stretched and uplifted leading to the formation of the Ottawa Valley. At that time, many cracks formed in the earth's crust including some in the White Lake area.



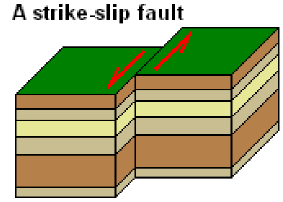
The above map reveals the nature of the surface rocks under and around White Lake today. Geologists refer to these maps as surficial geology maps because they describe the types of rocks anyone can see by just taking a walk.



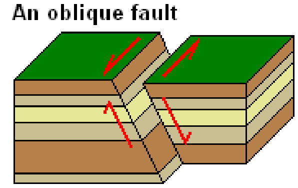
In this map, the pink and red show Precambrian rocks low in calcium and the blue shows rocks high in calcium. We know that the rocks under the lake are also high in calcium. This is what gives White Lake waters a very low acidity and high calcium concentrations. These conditions are perfect for zebra mussels looking for a home.



If you look closely at the map, you will notice a squiggly line running along the western side of White Lake and another squiggly line running down Three Mile Bay and across Hardwood Island. These lines show the course of the Mount St. Patrick fault; our fault on White Lake!



A fault is nothing more than a very large crack in an otherwise solid piece of rock. When nature applies stresses on these cracks, several things can happen. Rock on either side of the crack can uplift or depress or, alternatively, both sides can get further apart.



During the last ice age, the sheer weight of the ice pushed the earth's crust down by about 400 meters. Since the ice sheet has disappeared, the crust is still slowly rebounding. The continent under our feet is rising while at the same time moving westwards at the rate of about 1 centimetre per year. As it moves, stresses are built up between rocks on either side of a fault and at some point, these stresses seek relief in the form of an earthquake.

There is no evidence in the scientific literature to suggest that the fault running down Three Mile Bay has ever shifted, but it is entirely possible that it has widened (oblique fault) over the millennia. More likely though, a normal fault (see diagram above) occurred along the other fault line running north south, resulting in the cliffs we see especially on the west side of McLaughlin's and Hardwood Islands (right).

The geological faults running under White Lake may be responsible for the actual shape of the lake we see today.

We may think we are on solid ground, but at any moment Mother Nature may decide that your cottage lot belongs somewhere else.

Glacial Erratics

"The Old Man of the Forest" *photo by David Overholt*

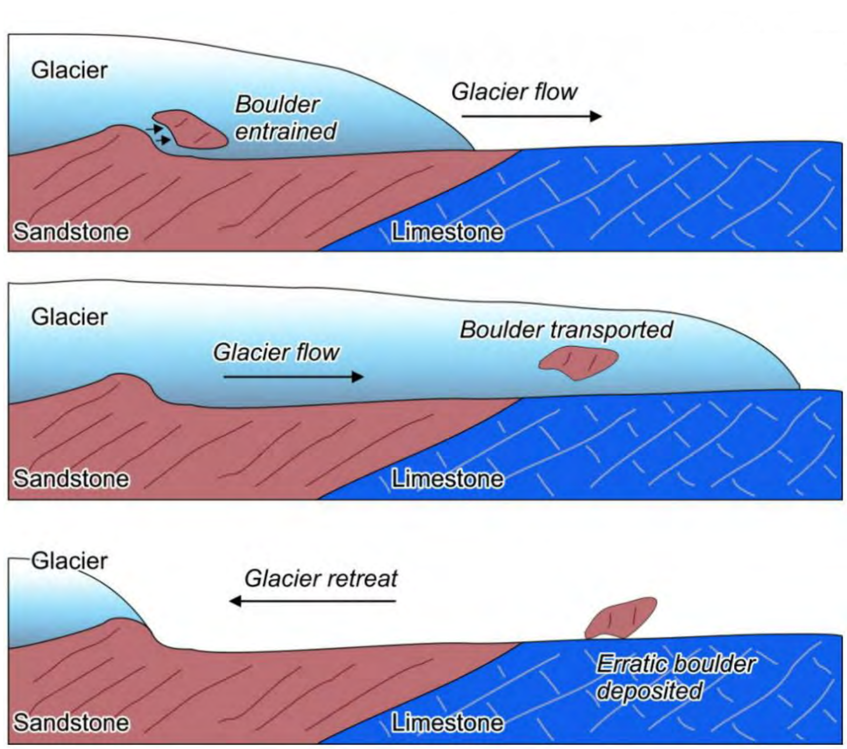
Strewn about the landscape around White Lake are large smooth boulders of varied size and shape. They somehow just don't seem to belong. What are they, where do they come from, and how did they get here?

Boulders, such as the one pictured above, were once considered evidence of a biblical flood. Over time, scientists began to understand that these boulders were connected to an ice age in the earth's past. Their very name, erratics, derives from the Latin word *errare* which means to wander.

Now we know that the erratics we see around us come from glaciers which covered the northern half of North America starting about 79 thousand years ago. At one time, the White Lake area was covered by a layer of ice two kilometres thick.

When glaciers melted away about 11,000 years ago, they left in their wake ample evidence that they were here in the form of gravel eskers and other glacial formations and glacial erratics. Glacial erratics can be very small to as large as a two-story house.

The diagram to the right shows how rocks are broken off by flowing glaciers and carried up to 2000 km from their original locations. As they travel, boulders are ground smooth by contact with other rocks or bedrock.



Erratics can also be carried on top of glaciers when rocks are broken off the sides of mountains by the glacier. These erratics are often more jagged and can also be odd-shaped.

Scientists use the composition of the erratics, their location, distribution, and other glacial markers to show the pathway and direction of flow of the glacier.

Although the start of the next ice age is not talked about very much at present, when it does end, the glacial erratics we are familiar with near White Lake will very likely be found in somebody else's back yard.

For more information on glacial erratics, please consult these references:
https://www.ontariobeneathourfeet.com/ice-age-glacial-erratic https://en.wikipedia.org/wiki/Glacial_erratic
http://fossilslanark.blogspot.com/2013/04/glacial-erratics-and-eskers-in-township.html

Water Levels

White Lake Dam is managed by the Ministry of Natural Resources and Forestry, Kemtpville 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

Dates	Target Levels	
	Decimal Feet	cm
January 1 to March 15	3.5	106.7
April 1	4.0	122.0
April 15	4.5	137.2
May 1	5.0	152.4
May 15	5.2	158.5
June 1	4.9	149.4
June 15	4.8	146.3
July 1	4.7	143.3
July 15	4.6	140.2
August 1	4.5	137.2
August 15	4.3	131.1
September 1	4.2	128.1
September 15	4.0	122.0
October 1	3.8	115.9
October 15 to December 31	3.5	106.7

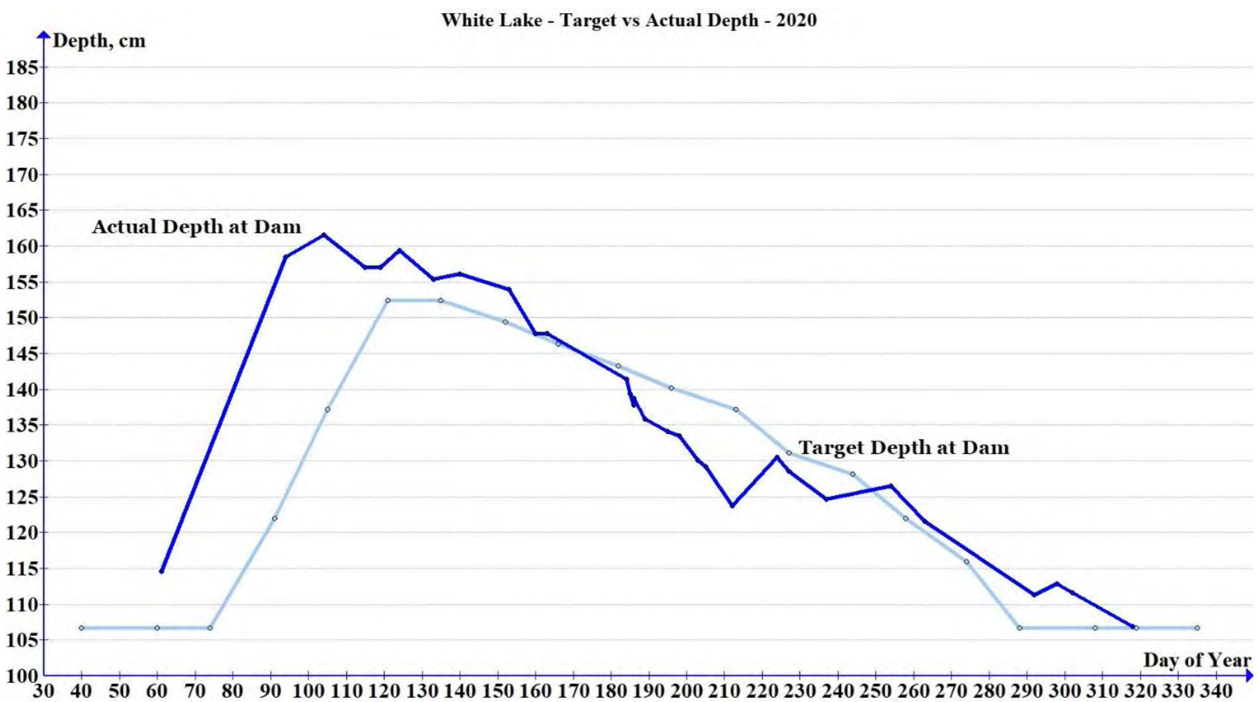
and address other ecological concerns during low flow conditions. A notch will be placed between the second and third log of the middle stop-log bay."

The annual variation of the operating band provides that 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 will bring the lake down to the winter holding level."

During dry years, such as 2016, the challenge is to balance water levels in the lake, with the flow required to maintain the Waba Creek ecosystem. In wet years, such as 2017, the challenge is to reduce the flow into Waba Creek to prevent flooding downstream.

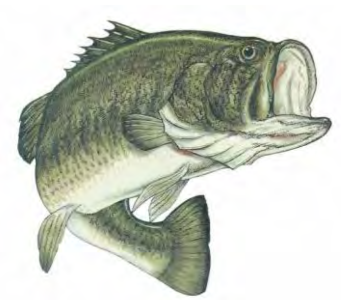
In order to monitor water levels in White Lake, we take regular and frequent readings depth reading at the White Lake Dam using the gauge fixed to the dam structure.

The figure below shows actual depth measurements read at the dam (dark blue line) plotted with the target water levels for the same time period (light blue line).



When comparing the line showing actual depth readings with that for target levels, it is evident that lake levels were high up to mid-May, and thereafter followed the water level plan until early August. Lower water levels at the beginning of August occurred after a period of hot dry weather. Beyond this point, water levels were according to plan.

White Lake Fisheries



The health of the White Lake fishery is important to the economic well-being of area merchants and service suppliers. We report here on the fisheries monitoring work done on White Lake by the Ministry of Natural Resources Forestry.

The Broad-scale Fisheries Monitoring program was created by MNRF to evaluate Ontario's fisheries on a broad level. Broad-scale monitoring includes the collection of detailed information about fish species and fish communities, physical and chemical water characteristics, aquatic invasive species, and fishing effort for each lake surveyed. Once every 5 years, information is collected in a standardized way from a representative number of lakes in each Fisheries Monitoring Zone. The number of lakes included in the program is sufficient for managing and reporting on fisheries in each zone, but represents a relatively small percentage of the total number of lakes in Ontario. For White Lake, the first sampling cycle of the program occurred in 2008, and was repeated in 2014, and, more recently, in 2019.

The Broad-scale Fisheries Monitoring program is designed to:

- describe the distribution, amount, and diversity of fishes in Ontario
- estimate the current state and changes over time of Ontario's fisheries
- identify natural and human-caused stresses affecting fisheries
- provide reports on the state of fisheries and aquatic environments in Ontario

The program provides MNRF biologists with additional benefits and opportunities to gather information on the biodiversity and health of aquatic environments. It includes monitoring the spread of aquatic invasive species, collecting genetic samples for researchers, gathering climate change data, sampling fish for contaminants for the Ministry of the Environment, Conservation and Park's Guide to Eating Ontario Sport Fish, and collecting samples for the monitoring of water quality in surveyed lakes.

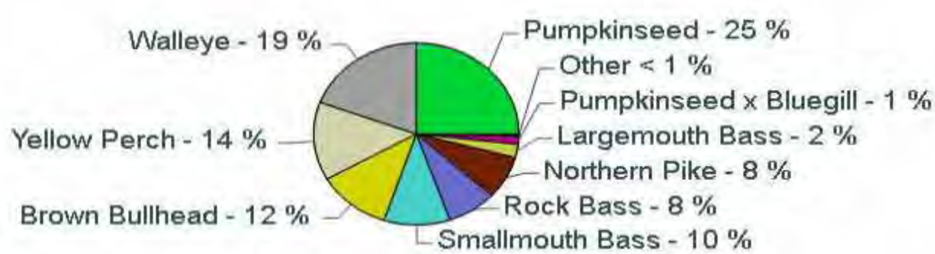
The last full report entitled *Zone Summary for Fisheries Management Zone 18; Cycle 1: 2008-2012* can be downloaded from the White Lake Science and Information website. This 150-page document contains a wealth of information about the fisheries in Zone 18 lakes including White Lake. A lake synopsis data sheet for White Lake was published as part of this effort and is reproduced in our 2020 Water Quality Monitoring Report.

The fish netting results for 2019 are presented below. Summaries for the 2008 and 2014 surveys can also be found on the White Lake Science and Information website.

Fish Netting Results: August 26 to September 5, 2019

Fish species	Total catch %	Maximum length (cm)	Minimum length (cm)	Average length (cm)
Pumpkinseed	25	34.1	1.2	20.7
Walleye	19	63.8	24.1	40.7
Yellow Perch	14	34.9	13.3	22.0
Brown Bullhead	12	37.8	23.5	33.1
Smallmouth Bass	10	46.2	12.6	33.3
Rock Bass	8	23.1	9.8	15.4
Northern Pike	8	66.5	33.6	51.2
Largemouth Bass	2	38.9	11.4	27.5
Pumpkinseed x Bluegill	1	22.4	20.4	21.3
Golden Shiner	< 1	15.9	15.9	15.9
White Sucker	< 1	49.8	49.8	49.8

Proportion of fish caught in large mesh nets



More information on the Broad-scale Fisheries monitoring program can be obtained at: https://www.ontario.ca/page/broad-scale-monitoring-program. Reports for each of the three study years can be obtained on the FishOnline website. In the search box on the site enter the White Lake waterbody ID 18-3808-50183.

WHITE LAKE PROPERTY OWNERS ASSOCIATION ENVIRONMENT VOLUNTEERS

Pollen Storms


Spruce Pollen

Every year from mid-May to mid-June I find myself standing at the end of our dock on the western shore of White Lake looking South. What I see is a yellowish cloud over Sunset Bay which is heading in my direction. Anyone who suffers from allergies has felt the oncoming storm for some time. Dread is in the air!

The oncoming pollen cloud is also a reminder that it is a good time to close the cottage windows and to cover, if possible, any patio furniture.

Much of White Lake is nestled in forests which feature spruce and pine along with deciduous trees such as birch, oak and maple. All of these trees produce pollen in the spring.

The annual pollen storm can be mild or more severe depending on the weather. Cooler temperatures can extend the duration of the storm and rain can function to cleanse the air of pollen and deposit it on land and water.

As far as trees are concerned, one unintended consequence of their reproductive cycle is the loss of huge amounts of pollen to the lake. Some of the pollen ends up floating on the surface of the lake, while most of it slowly sinks to the bottom. On the way down to the sediments, pollen grains become food for small fish and other creatures and also provide added nutrients in support of primary algal growth, the basis of the lake food chain.

What we see on the surface can be easily mistaken as an algal bloom. The wind can act to concentrate the pollen in sometimes very long 'lines' on the surface of the lake, in much the say way we see lake foam lines developing in the fall.

Eventually, the floating mass of pollen will begin to decompose giving off foul odours in the process.

Once pollen sinks and becomes part of the sediments at the bottom of the lake, some of it will decompose and release nutrients, including phosphorus. It has been reported that for some lakes, as much as 10% of the phosphorus entering the lake ecosystem is derived from pollen.

Because there is usually a lack of oxygen in sediments, some of the pollen will be preserved in the sediment. In fact, sediments thousands of years old can be recovered by coring.


Sediment core – Bane Bay

These cores can be divided into slices of one centrimetre or less. The slices can be precisely dated using radiocarbon dating techniques, and analyzed for their preserved pollen content. Scientists (Paleolimnologists) can then use this information to reconstruct the forest cover and even the climate over thousands of years.

A recent study of sediment cores from White Lake, which we participated in, found that the lake is 'filling in' at the rate of about 1 millimetre per year. This means that in about 3,000 years, you will be able to take a walk across Three Mile Bay, in the summer, without getting wet!

Lake Foam

Every year in late summer and early fall we can see lines of white foam streaming in the wind across the lake. Sometimes there are relatively large accumulations of foam along the shoreline.


Hayes Bay, August 30, 2020

Although it is possible that it is pollution, for White Lake that turns out to be very unlikely. We know this because pollution from detergents produce a foam which dissipates quickly and often smells fragrant. Foam from detergents would also be observed throughout the year and not exclusively at the end of summer.

Natural lake foam is long-lasting and even when there is no wind, often emits a fishy smell. This is the kind of foam we have on White Lake which is good news!

What is lake foam and where does it come from?

Lake foam is a natural phenomenon that occurs on many lakes. Foam is produced when organic matter from decaying plants and plankton in the water and sediments decomposes releasing compounds such as fatty acids. These compounds readily dissolve in water and act to reduce the surface tension of lake water in much the same way soap does, hence the foam.

Chemists call this class of compounds surfactants (short for surface active agents). Like soap, these compounds are soluble in both water and oil and can concentrate on the surface of the lake because they are lighter (less dense) than water.

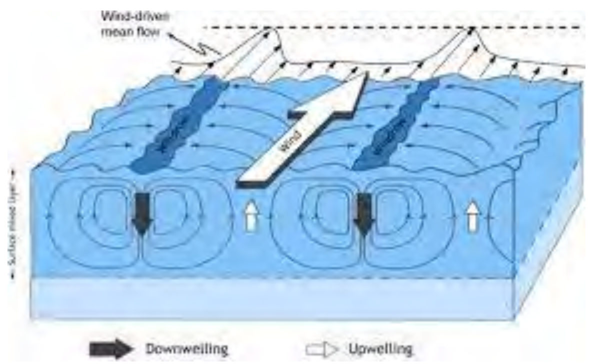
It takes only a very small amount of fatty acids or other foaming agents to produce a large amount of foam. The foam itself is only about 1% foaming agent and 99% water. There is no hazard or danger associated with lake foam.

Why do we see lines of foam forming in the same direction as the wind is blowing?

The lines or streaks of foam visible on the lake in the fall are the natural consequence of how water at the surface of the lake interacts with the wind. These lines are called Langmuir lines, so named after the physicist who first described them mathematically.

The photo on the right shows Langmuir lines on the surface of the lake. The diagram below shows how water circulates and mixes when the wind is blowing. Lake foam forms when the wind causes two streams of rising water to meet and rise to meet the wind.

November 2020




Lake foam along shoreline, Western shore, October 12, 2020

Tape Grass

Tape grass (*Vallisneria Americana*), also known as eel grass, is a very common perennial aquatic plant in temperate and sub-tropical climates around the world. It is native to Canada and can be found in lakes, streams and ponds. It is a common aquarium plant and is an important food for wild ducks.

This plant is easy to recognize because it has long thin leaves that grow in a clustered rosette with its intertwined roots lodged just below the sediment surface. We also know this plant because, during middle to late August in recent years, we see large mats of these plants floating into our waterfronts.

Tape grass can be found almost everywhere along the shoreline of White Lake. It also forms large underwater meadows, and leaves can attain several feet in length. The upper parts of the plant can sometimes be seen floating on the surface of the lake.

The photos below show tape grass growing on the lake floor, and as seen out of the water.

Tape grass plants found along the immediate shoreline are well rooted between rocks and other debris. For this reason, the action of wind and waves seldom displaces them from their positions. It is possible that, since water clarity in the lake has increased and zebra mussels have drawn nutrients to shoreline areas, that tape grass beds have expanded into deeper water where sediments are not very dense giving a poor foothold to tape grass colonies. In these deeper areas, sediments are very fine in texture and do not have the 'holding' power of the rocky shoreline. This situation is made worse by the relatively shallow penetration of tape grass roots into the sediment.

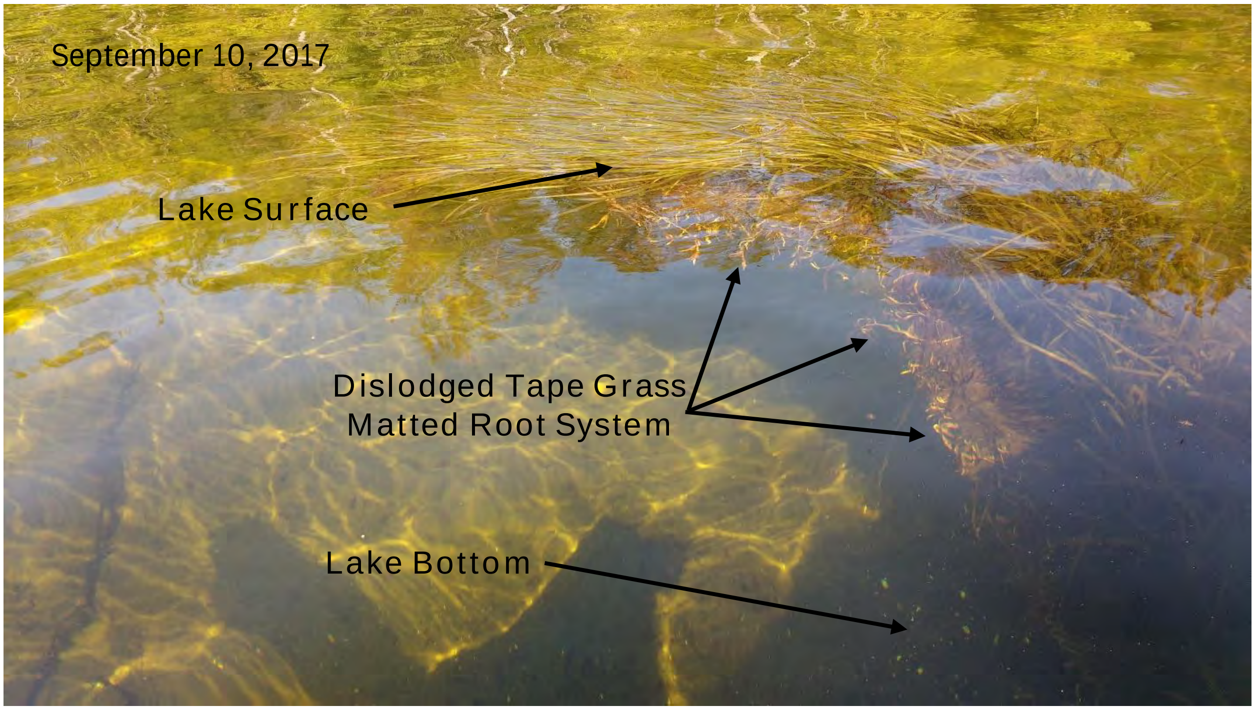
So why are we seeing these rafts of tape grass floating on the lake?

By late summer, tape grass plants in deeper water have grown to lengths of up to three feet and are now close to the surface of the lake. At the same time, water levels in the lake are steadily decreasing as the White Lake dam is adjusted to meet its bi-weekly target levels. Also, fall winds arrive resulting in significant waves which transfer energy to the tape grass beds. An added factor is the wake disturbance produced by powered vessels which send large waves crashing into the shoreline, stirring up the bottom of the lake.

The net result of all of these factors can be seen in the photograph below taken near the western shore of the lake opposite Stanley Island.

As wave action takes hold of the tape grass beds, the root system loses its grip in the fine sediment and begins to peel off like a carpet being lifted at one end. Any sediment adhering to the roots is washed away and the entire plant mat begins to float. Eventually, the tape grass bed becomes completely detached from the bottom of the lake and can now float freely. The same wind that helped dislodge the tape grass mat will now deliver it to a cottage shoreline.

We have observed this phenomenon in a number of locations around the lake and believe it likely that this will become an annual event. The formation of tape grass mats is a natural phenomenon and part of the plant's life cycle.



What can we do about this?

When faced with a large mat of tape grass on our cottage shoreline, one has very few options: 1) leave it there as it will eventually decompose; 2) remove it using a rake; 3) hope that the wind changes direction and the whole thing becomes somebody else's problem!

Wild Rice

Wild Rice[13] found in White Lake is Northern wild rice (*Zizania palustris*) and is native to the Great Lake region of North America, the aquatic areas of the boreal forest regions of Northern Ontario, Alberta, Saskatchewan, and Manitoba. Although very likely a native species in White Lake, there are anecdotal reports that duck hunters seeded the lake during the 1940s[14] to attract ducks to the lake.

Wild Rice near Hardwood Island

Wild rice is Canada's only native cereal. It is a wild grass that grows from seed annually and produces a very valuable grain that has been used as a food source for thousands of years by the First Nation peoples in parts of North America. In September, during the rice-harvesting season, muskrat, fish, ducks, geese, and migratory birds feed on ripe wild rice seeds. Wild rice filters the waters, binds loose soils, provides protection from high winds and waves along the shorelines, and provides habitat for species at risk, such as least bittern and black terns.

The entire wild rice plant provides food in the summer for herbivores such as Canadian geese, trumpeter swans, muskrats, beavers, white-tailed deer, and moose. In addition to this, rice worms and other insect larvae feed heavily on natural wild rice. These then provide a rich source of food for small marshland birds. The stems of wild rice provide nesting material for such species as

[13] Abstracted in part from Plenty Canada website: https://www.plentycanada.com/wild-rice--aquatic-ecosystems.html, and Wikipedia.
[14] Doug Tilley, personal communication.

common loons and muskrats. Every stage of growth of natural wild rice provides food and habitat for wildlife; as a result, wild rice stands provide exceptional breeding and nesting areas for an abundance of species.

The life cycle for wild rice is simple. In the late summer, the ripened seed drops off the stem and sinks to the sediment, where it remains dormant until the following spring. Low oxygen levels and warmth typically stimulate germination, but some seeds may remain dormant for five years or longer, which allows the rice to survive occasional crop failures. After germination, there are three distinct growth phases that occur. The seed first begins to sprout in early May when the water temperature reaches about 7 °C. For the first three or four weeks of growth, the young plants are under water, which is the defining characteristic of the submerged leaf stage. Then, as the long, thin leaves begin to float on the surface of the water, this becomes the floating leaf stage of growth. Finally, the rice will then grow up out of the water into an upright position to reach the growth stage when it is a mature wild rice plant. Wild rice has a growing season of 106 to 130 days.

White Lake has long supported wild rice beds in many parts of the lake. Over the past several years we have documented the presence of wild rice on the lake. During the summer of 2018, we noticed that wild rice beds in the Village Basin area had increased considerably and now covers a significant area in this basin.

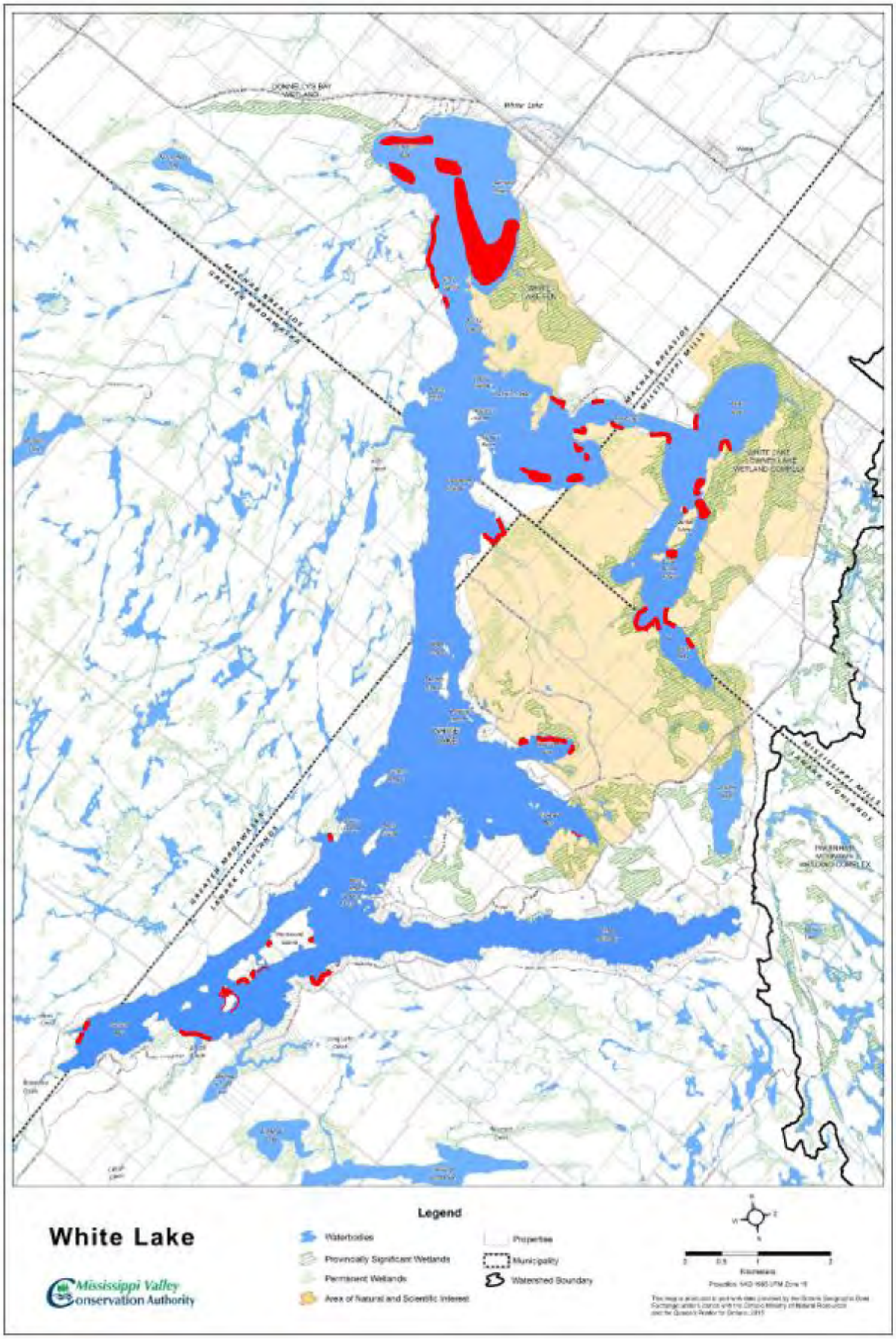
This observation led to a complete study of the entire shoreline and shallow areas of White Lake in order to document the areas of wild rice.

As a result of our survey, we have produced a map showing the locations of wild rice beds. Since 2018, the density of rice beds on the lake has not changed appreciably.

Wild rice was found in most parts of the lake with the exception of Three Mile Bay and most of the western shore except at Sunset Bay, Barry's Island, and the Village Basin.

Clearly there is not enough rice to harvest in quantity and for this reason, it is best to simply allow local wildlife to enjoy this bounty.

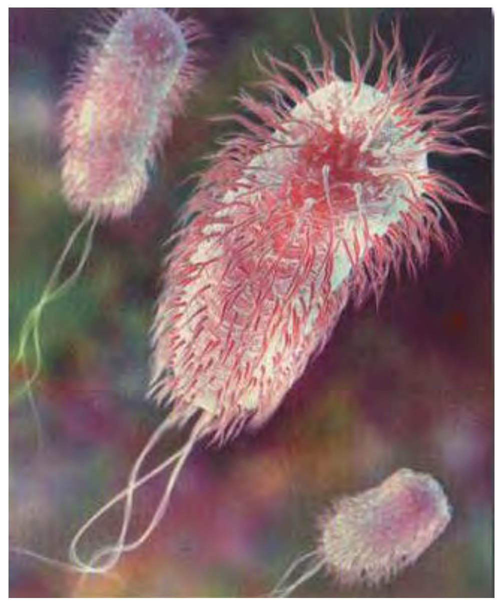
Location of Wild Rice Beds on White Lake



E. coli

What is *E. coli*?

Escherichia coli, commonly called *E. coli*, is one of the most common species of fecal coliform bacteria. It is a normal component of the large intestines in human and other warm-blooded animals including birds, beavers, otters, muskrats, racoons, and other mammals. There are many different strains of *E. coli*, most of which are harmless or even beneficial. Some strains, however, can make you sick. We all carry about one million *E. coli* cells per gram of feces in our guts, and if you are healthy, none of these are capable of causing gastrointestinal illness.



Why do we test for *E. coli*?

When *E. coli* is found in water, it is evidence of sewage or animal waste contamination. Although, on its own, *E. coli* is not likely to cause illness, it is very easy to culture in the lab, making it a useful indicator for other accompanying pathogens or toxins which are much more difficult to detect and quantify.

How and when does *E. coli* get into a lake?

Even in isolated lakes, it is common to find very low levels of *E. coli* in the water. The source of this *E. coli* can be from birds using or overflying the lake, from wild animals and *E. coli* surviving in soils near the lakeshore. When there is a rain event, some of this 'ambient' E. coli is washed into the lake.

Much larger and potentially dangerous levels of E. coli can enter a lake from upstream lakes or rivers which are used by farm animals, or by discharge from, for example, sewage treatment plants. An additional source is from faulty septic systems.

What about White Lake?

White Lake is a headwater lake, which means that there are no significant water sources upstream from the lake, and hence no significant sources of *E. coli*. There are no active farms on White Lake or large point sources such as sewage plants, so it is expected that *E. coli* values would be low for lake waters sampled distant from the shoreline.

Has White Lake been tested for *E. coli* and what were the results?

In 1973, the White Lake Water Quality Committee (which later merged with the WLPOA) measured the *E. coli* concentration at 375 separate locations over a three-day period. Shoreline samples were collected in front of most of the 414 cottages on the lake and at other locations including resorts and marinas. It was a monumental effort requiring dozens of people and a Provincial Government willing to pay the considerable costs associated with the survey. As a result of their work, the Committee found about 30 locations with elevated *E. coli* concentrations. Remedial action was left up to the property owners.

More recently, the WLPOA has also sampled White Lake for *E. coli*. The WLPOA website and documents on file show that samples were collected from 2009 to 2012, 2015, 2016 and again in 2018. These samples were collected in open waters away from the shoreline. Reported *E. coli* concentrations were very low as expected for a headwater lake.

Because the beach at White Lake village is a public beach, the local Health Unit samples beach-water at this site on a regular basis. If high *E. coli* levels are detected, the beach is closed until further testing shows that it is safe to use.

Should the WLPOA be testing for *E. coli* as part of its Water Quality Monitoring Program?

We believe that, for White Lake, testing of open waters away from the shoreline is not required unless there is a reason, such as the appearance of a new large point source, which could affect water quality. Any open water measurement giving high results would have to be followed up by a more detailed testing plan in order to identify the source of contamination. At a cost of about $20 per sample, it would be prohibitively expensive for the WLPOA to test the waterfronts of every or even a significant number of cottages on White Lake.

It is recommended that individual cottagers, residents, resort owners, etc. take responsibility for their own *E. coli* contributions to the lake as a personal health matter. Cottages or residences on the lake which have large lawns, which attract geese during the summer, or anyone who is unsure about the efficacy of their septic systems may wish to conduct private tests. Private cottage or resort beaches should also be tested especially because it is known that *E. coli* can survive in beach sand and be re-suspended by wave action. Samples should be taken where the water is less than 1 metre deep, and after a significant rain event in order to detect *E. coli* washed into the lake.

Sources of Information:

More can be learned about *E. coli* by visiting the websites of the two Health Units serving White Lake:

Leeds Grenville & Lanark District Health Unit

Renfrew County and District Health Unit

If you would like to test your shoreline or beach for *E. coli*, sample bottles and sampling instructions can be obtained from commercial laboratories such as:

Eurofins Ottawa located at 146 Colonnade Road S., Nepean, ON; 613-727-5692

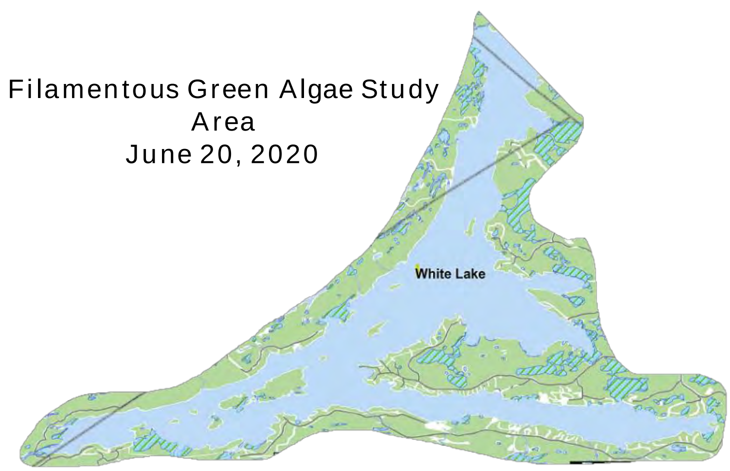
2020 marked 150th anniversary of the birth of Theodor Escherich, the German physician who discovered Escherichia coli, and for whom the bacteria is named. This guy really knew his......errr......stuff!

Green Algae Blooms in White Lake

In early summer we often receive a number of enquiries and have seen some social media posts on green algal blooms in White Lake.

In order to assess the extent of these blooms, we map the occurrences of over a large part of White Lake. On June 20, 2020, we toured the entire shoreline of White Lake south of Fish Creek in order to present a 'snapshot' of algal bloom locations. We also collected samples at each site for microscopic examination. Below is a map of the survey area. This activity is on-going and each year we log the location and intensity of all algal blooms.

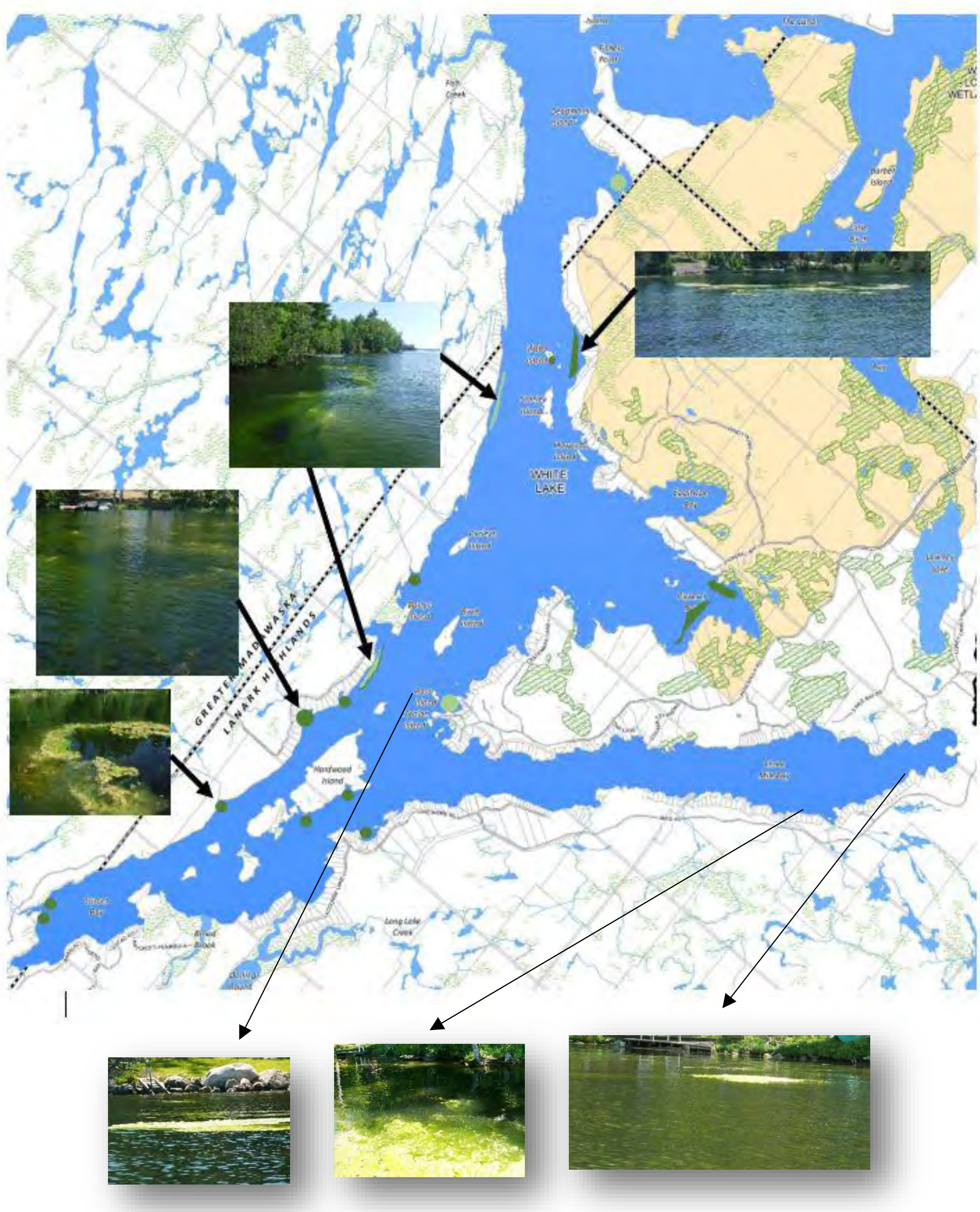
We were not able to examine the entire shoreline of White Lake (~ 97 km) due to time constraints, and so cannot report on other areas of the lake, in particular Hayes and Bane Bays, The Canal and the White Lake Village Basin.



Filamentous green algae of the type we are seeing in the lake has been resident in the lake for likely a good part of the existence of White Lake. Similar algal blooms have been reported in the news, in particular in the Rideau Canal, so the bloom in White Lake is not an isolated event.

Algae bloom when conditions are right for its rapid and uncontrolled growth. These conditions include the presence of excess nutrients (phosphorus), 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 excrete large significant quantities of dissolved active phosphorus-containing compounds which then promotes algal growth. 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 prevent nutrients from entering the lake.

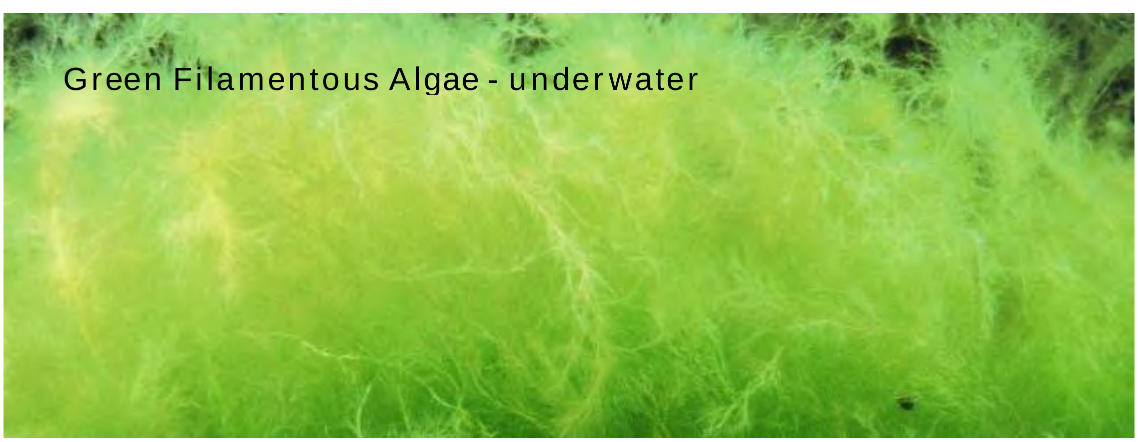
The map below shows the results of the survey:



In the map above, dark green is used to denote surface and submerged filamentous green algae and light green for submerged only. The size of the green dots indicates the relative size of the algal bloom area at each site, as does the length and width of lines for affected shoreline. The photos below provide a visual representation of the algal bloom itself.

All samples collected were of the filamentous green alga mougeotia, which is also commonly goes by the unappetizing name of 'elephant snot'. This alga does not produce toxins in the water and so the bloom is considered a nuisance bloom.

In addition to the blooms shown on the map, we observed numerous free-floating masses of the algae on the surface of the lake in locations where there were no visible fixed blooms. Many of the blooms occurred in bays or small embayments along the shoreline. During its lifetime, this alga produces gases which become trapped in the fine mesh of the



Green Filamentous Algae - underwater

algal mat and serve to raise the bloom from the lake floor to the surface, where it can be affected by the wind.

When large mats of algae die and decompose, the water column can become anoxic (no oxygen) causing the release of phosphorus trapped in sediments. Sediments contain about 200,000 times the concentration of phosphorus found in lake water. The released phosphorus can trigger a secondary bloom which could be larger than the original event.

Although there were large patches of this algal bloom in areas near unaltered forested shorelines, the most serious and largest blooms were found immediately adjacent to newly de-treed and landscaped cottage lots, and areas of severely altered shorelines.

The occurrence and extent of these blooms have increased in recent years which may reflect the growth of zebra mussel populations, climate change and lake overuse.

Although the size and shape of these blooms may change over the summer, they will remain visible and a nuisance until the end of July and could persist into August as they did in 2019.

Blue-Green Algal Blooms in White Lake

Blue-green algal blooms are not benign and so warrant our special attention. When these blooms occur, they can create a public health hazard and anyone using the lake should be apprised of the seriousness of this issue.

In 2021, (shown here for illustrative purposes), White Lake hosted two different blue-green algal blooms. These blooms occurred simultaneously on two occasions. The first on September 16, and the second on October 8, 2021. The two types of algal blooms were: Anabaena (now called Dolichospermum), and Microcystis. The Anabaena bloom occurred in the main body of the lake (deepest water), Pickerel Bay and areas along the Eastern shoreline. The Microcystis bloom was located mainly in Three Mile Bay and adjacent areas.

The simultaneous occurrence of different types of blue-green algae has never been recorded before in White Lake. Prior to the infestation of White Lake with zebra mussels, only *Anabaena* blue-green algal blooms were recorded. Since the arrival of zebra mussels, only Microcystis blue-green algal blooms were observed. In 2021, we observed five algal blooms which is the largest number ever recorded for White Lake.

The occurrence of algal blooms is complicated and dependent on factors including wind, temperature, sunlight, water depth, the presence of different phosphorus and sulphur containing compounds, as well as nitrate and nitrite concentrations, to name just a few.

The figure below shows the extent and intensity of the double blue-green algal bloom on White Lake first observed on September 16, 2021. This bloom lasted approximately 10 days but re-emerged again on October 8, 2021. The second round of blooms were in the same parts of the lake as the blooms observed nearly a month earlier, but of lower intensity. Because the second bloom occurred after the first bloom had disappeared, the second blooms are considered as separate blooms and not a continuation of the initial September 16 blue-green algal bloom

In 2021, only one sample was taken by MOE. The water sample was taken from the western shore of the lake in the zone affected by the *Anabaena* blue-green algal blooms. Although other parts of the lake were not sampled, the MOE advises that every bloom, whether tested or not, must be considered as toxic in the interest of public and personal safety. The Ministry of the Environment, Conservation and Parks reported the following results for the single sample taken: *"The total microcystin concentration was 0.56 ug/L. The microcystin-LR concentration was 0.074 ug/L (Ontario Drinking Water Standard is 1.5 ug/L).*

These results confirm the presence of toxins in the sample taken, but in a concentration not dangerous to human or animal health.

In recent years, an annual pattern of algal blooms on White Lake is emerging. During early summer, we observe widespread nuisance filamentous green algal blooms, and in the fall, we observe blue-green algal blooms in large parts of the lake.

White Lake Algal Blooms: 1977 to 2021

In 1977, the water level management regime was altered to allow gradual summer drawdowns (0.76 m/yr.) to clean spawning shoals and reduce midsummer algal blooms. Fall and winter water levels were stabilized by mid-late September each year. This resulted in increased walleye spawning activity on traditional spawning sites.

Today the nature and causes of algal blooms in White Lake are quite different. These include the change in phosphorus cycling by zebra mussels, climate change, year-round use of cottages as residences, increased boating effects, shoreline degradation, invasive species, and exposed surface runoff. These issues should now be the subject of our attention.

The data contained in the table below tell the story of more recent algal blooms in White Lake. Prior to 2013 and for a period of at least 25 years, there were no reported algal blooms on White Lake. During that time, however, the number of cottages, trailers and commercial tourist units have increased from 475[15] to 1538 (2018), an increase of 324%. Available numbers also show that from 1985 to 2018, permanent homes on White Lake increased by 354% to 209. These trends are continuing today. The table below indicates that White Lake is no longer capable of absorbing and processing additional nutrients coming from any source. The lake is now experiencing multiple algal blooms every year with a record five blooms in 2021.

The table also shows that the arrival of zebra mussels in White Lake resulted in a change in algal bloom patterns. Prior to their arrival, there were no significant filamentous green algal blooms. However, blue-green algal blooms occurred each year from 2013-2015. All these blooms were *Anabaena* blue-green algae.

Following the arrival of zebra mussels, phosphorus cycling in the lake changed. As a result, White Lake now experienced annual filamentous green algal blooms as well as blue-green algal blooms. However, the blue green algal blooms were now *Microcystis*. In

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

2021, White Lake experienced blue-green algal blooms from both *Anabaena* and *Microcystis*.

White Lake is a very shallow (average depth of 3.1 m), productive, warm-water lake, and as such is very susceptible to changes in water quality resulting from human activities. When a lake like White Lake is overused, then the rate at which the lake becomes nutrient enriched (eutrophication) is accelerated.

White Lake Algal Blooms by Year: 1977 to 2021

Year	Green Algae		Blue-Green Algae	
	Summer	*Fall*	*Summer*	*Fall*
1977 to 2012 (25 years)	-	-	-	-
2013	-	-	-	1
2014	-	-	-	1
2015	-	-	-	1
 Zebra Mussel Infestation				
2016	-	-	1	-
2017	1	-	-	-
2018	2	-	-	2
2019	1	-	-	1
2020	1	-	-	1
2021	1	-	-	4

For further reading and to view all photographs and proofs, please read our Special Report entitled *White Lake Algal Blooms: 1860 to 2021* which is currently posted on the White Lake Science and Information Website.

White Lake and the Environment

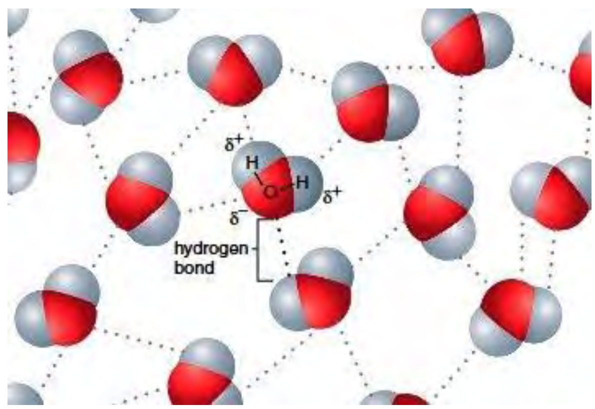
A Little Bit of Science

Water and Ice

WATER

As you look out onto White Lake during the winter months what do you see? Water and ice and lots of it. White Lake contains about 75 million cubic metres of water. If my calculations are correct, that translates to 3×10^{35} molecules of water give or take. Put another way, that's 300,000,000,000,000,000,000,000,000,000,000,000 molecules.

But strictly speaking, this is not true. In fact, there is only one molecule of water in the lake. That's because water is one of the strangest substances in the universe.

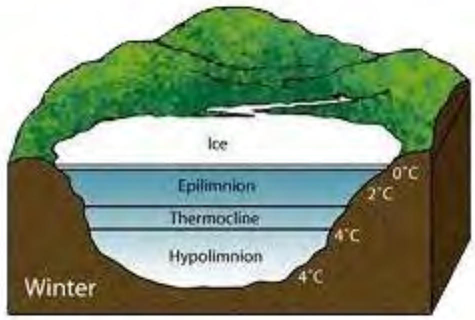


Everybody knows that water boils at plus 100 degrees Celsius. But did you know that for such a small molecule, water should boil at about minus 100 degrees Celsius. It has such a high boiling point because of the hydrogen bond. This bond, in effect, makes each water molecule stick to every other molecule, as in the diagram. And this is why there is only one water molecule in White Lake. Without the hydrogen bond, there would be no life on this planet. All of the water would have evaporated into space or be trapped in our atmosphere as vapour. Earth would be a giant sauna with no one to enjoy it!

ICE

The peculiarities of water don't end with its boiling point. The maximum density of water also occurs at a weird temperature: plus 4 degrees Celsius. Most substances, when cooled, have their maximum density at the freezing point, but water expands at temperatures above 4 degrees, and it also expands when cooled below 4 degrees. Now that is strange!

This is why ice floats and does not sink to the bottom of the lake and it also partially explains why the lake does not freeze solid. So, if ice had its maximum density at 0 degrees, then it would sink to the bottom of the lake as it froze and eventually the entire lake would be frozen solid. There would be no fish or any other living creature in the lake.



In the winter, the temperature of the water immediately under the ice is close to freezing, but at greater depths, it's self-regulated at plus 4 degrees. Any water cooler or warmer than that temperature would rise.

So, we have the peculiar properties of water to thank for our very existence and for ice fishing as well!

McLaughlin's Island from Western Shore

Water on Ice

One of the joys of winter is taking long walks, snowshoeing or cross-country skiing on the lake. For others, it's snowmobiling or ice fishing which is the main draw.

This winter, these activities have been hampered by the wide-spread occurrence of water on the surface of the ice just beneath the snow. What results is a walk in the slush or a snowmobiling ride that feels more like a bumpy boat ride than anything else.

Although this situation occurs almost every year, it was particularly severe during the winter of 2020/2021 Why?

The reason why water seeps onto the surface of the ice is because of a water pressure increase below the ice. This can be caused by several factors. Ice is flexible, like a sheet of paper and when it snows, the ice tends to sag a bit under the added weight of the snow.

Secondly, water can enter the lake from streams and seepage from land. We noticed that much of the water on the surface of the ice on White Lake is brownish in colour. This is a telltale sign of water coming through soils before entering the lake.

Ice cracks when it expands or contracts allowing water to reach the surface. Holes created by ice fisherman serve the same purpose. But why does the water not freeze instantly once it finds its way onto the ice?

First of all, the temperature of the ice itself is close to zero degrees, especially at the ice-water interface. And, even at very cold temperatures, snow is an excellent insulator. Together these two factors keep water in the liquid state resulting in slush. On a cold day, removal of the snow cover would result in ice surface water turning to ice very quickly.

Although one may associate a slushy ice surface with warm weather, this situation can happen anytime during the winter, even in very cold weather. Snow is really the main culprit because of its weight and insulating properties.

As long as there is sufficient ice thickness, it is not dangerous to walk on a slushy lake, just darned inconvenient!

LET'S HAVE SOME CLARITY ABOUT WHITE LAKE

or How Has the Water Changed Since the Arrival of Zebra Mussels?

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 the water clarity has changed differently in different parts of the lake. In areas close to shorelines (where most zebra mussels are found) like Three Mile Bay, water clarity has doubled! At locations further away from shorelines, the Secchi depth (see box below) has increased by about 80%. In the middle of the lake, the increase is only about 60%.

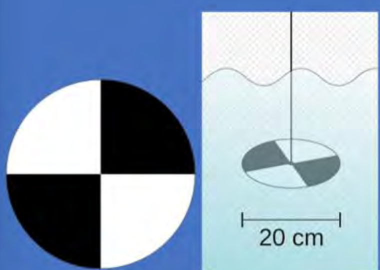
In July of 2015, the Secchi depth in Three Mile Bay was 2.1 metres and by July 2017, the Secchi depth had increased to 4.1 metres. We are now measuring Secchi depths of over 6 metres at some locations. So what?

Water clarity on the surface appears to be a good thing. However, there are some important consequences to consider:

- 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.
- Currently, there are no proven 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 deep.

Secchi Depths at Two Sites

Secchi Depth, metres		
Date	Pickerel Bay	Three Mile Bay
June 7, 2003	2.9	3.0
July 3, 2004	2.9	2.8
July 19, 2006	2.5	2.3
May 27, 2007	2.7	3.0
June 8, 2008	2.6	2.5
May 31, 2009	2.7	3.1
June 8, 2014	2.9	2.8
July 16, 2015	2.7	2.1
July 12, 2016	3.3	3.3
July 15, 2017	4.6	4.1
July 15, 2018	4.9	5.0
July 14, 2019	4.7	4.7

Water clarity measurements taken over the period 2002-2016 consistently show most Secchi disk readings in the range of 2.5 to 3.3m, indicating water clarity on the edge of the mesotrophic/eutrophic level.

Deepest Pickerel Bay	
Year	Secchi Depth, m
2014	4.5
2015	6.0
2016	7.3
2017	7.6
2018	>9.1
2019	7.3

For 2014 to 2019, samples were taken bi-weekly, but sampling sites and dates used in the table were selected to coincide with older data. The maximum Secchi depth measured for years 2003 to 2013 are not available since only a single measurement was made during this period. For later years, bi-weekly measurements were taken and a maximum Secchi depth during the ice-free season was thus obtained. These are presented in table above.

Maximum Secchi Depths by Year for Deepest Pickerel Bay Site

The presence of zebra mussels, confirmed in 2015, became an important contributing factor to increased water clarity, as this invasive species eats the plankton that floats in the water, thereby clarifying the water column. Since 2016, the clarity of White Lake waters has more than doubled.

AQUATIC PLANT SURVEY OF WHITE LAKE

CHANGES IN THE WHITE LAKE AQUATIC PLANT COMMUNITY SINCE 1976

The ability to study change over time in the assemblage of aquatic plants on White Lake was made possible by the efforts of L. J. Bond[1] when he published his findings on the observed occurrence and abundance of aquatic plants in White Lake during the summer of 1976.

A survey in the summer of 2020 was conducted to determine what changes occurred in the White Lake aquatic plant community over the previous 44 years. A total of 174 vegetated aquatic sites were visited. These sites were based on the 98 locations Bond studied covering all parts of the lake.

The table below summarises some of the changes found in this 2020 study. The table is based on the difference in relative frequency of occurrence of aquatic plants. It is evident but not too surprising to see that in 44 years some varieties have disappeared or are in decline while other types have increased their occurrence in the lake. A difference that was less than 5% was regarded as not significant. We were able to add 12 additional aquatic plants to the original Bond list.

Significant changes have occurred in White Lake water quality over the past 44 years. For example, the Provincial Ministry of the Environment, Conservation and Parks states that 100% of phosphorus coming from septic systems within 300m of the lake will end up in the lake.

It is inconceivable that the increase in the number of cottages and permanent homes on White Lake since 1976 would not lead to an increase in nutrients reaching the lake and acting as fertilizer for aquatic plants. In fact, Ministry of the Environment, Conservation and Parks reports on White Lake water quality published 40 years ago warned of 'cultural eutrophication', a term used to denote an increased rate at which the lake becomes eutrophic (filling in) as a result of human activity.

It is natural in our lakes for changes to occur in the species of aquatic plants present over time. These changes are due to several factors including weather and the presence of invasive aquatic species.

CHANGES IN THE WHITE LAKE AQUATIC PLANT COMMUNITY SINCE 1976

COMMON NAME	SPECIES NAME	STATUS and CHANGES SINCE 1976
Richardson's Pondweed	*Potamogeton richardsonii*	The most dominant plant in 2020, major increase
Flat Stem Pondweed	*P. zosteriformnous*	new listing, 2nd dominant type, not seen in 1976
Large Leaf Pondweed	*P. amplifolius*	new listing, low occurrence
Robbin's Pondweed	*P. robinsii*	new listing, low occurrence
Floating Pondweed	*P. natans*	no significant change
White Stem Pondweed	*P. praelongus*	new listing, low occurrence
Variable Pondweed	*P. gramineus*	new listing, low occurrence
Sago pondweed	*Stuckenia pectinata*	severe decline, now rare
Horned pondweed	*Zannichellia palustris*	severe decline, now absent was 2nd dominant 1976
Slender Water Nymph	*Najas flexilis*	no significant change
Northen milfoil	*Myriophyllum sibricum*	decreased occurrence, was most dominant in 1976
Whorled Leaf	*M. verticallatum*	new listing, infrequent occurrence
Eurasian Water Milfoil	*M. spicatum*	new listing, invasive, widely distributed
Wild Celery, Tape Grass	*Vallisneria america*	no significant change
Water Star Grass	*Zosteralla dubia*	no significant change
Canada Waterweed	*Elodea canadensis*	no significant change
Coontail	*Ceratophyllum demersum*	no significant change
Common Bladderwort	*Utricularia vulgaris*	no significant change
Nitella	*Nitella*	new listing
aquatic moss	*Fontinalis*	new listing, in deep water
chara	*chara*	no significant change
White Water Lily	*Nymphaea ordorata*	increased occurrence
Yellow Water Lily	*Nuphar variegata*	no significant change
Star duckweed	*Lemna triscula*	no significant change
Water Marigold	*Megalodonta beckii*	new listing, common occurrence
frogbit	*Limnobium laevigatum*	new listing, rare occurrence
Arrowhead	*Sagittaria spp.*	No significant change
Pickerel Weed	*Pontederia cordata*	new listing
Common Bulrush	*Scirpus validus*	no significant change
Wild Rice	*Zizania aquatica*	increased occurrence

>5% increase occurrence	invasive	>5% decrease occurrence

[1]L.J. Bond, *Ecological Study of White Lake, Renfrew and Lanark Counties 1976*, Lanark District, Ministry of Natural Resources, March, 1977.

Historical and Current State of White Lake Water Quality

"Good" water quality of the lake ranks as the most important value identified by the White Lake community, and maintaining or improving water quality is the most important issue needed to be addressed by any Lake Stewardship Plan. The community's concern has been heightened with the observation of blue green algae blooms in 2013, 2014, 2015, 2018, 2019, and 2020.

The physical characteristics of White Lake have an important influence on overall water quality. White Lake is shallow (average depth 3.1m; maximum depth 9.1m), has a significant amount (90.3%) of littoral zone (shoreline areas with aquatic plants including wetlands), and has a slow flushing rate of only 0.89 times per year. The main basins of the lake are generally isolated, and there are only a few small tributaries that drain into the lake, which contribute to the low flushing rate, and to a lack of mixing of the various bays of the lake. The water column itself does not experience significant stratification that is common to most lakes when temperatures increase following ice-out. These physical conditions must be considered when the lake's water quality is being assessed. The distinct basins and the lack of stratification make it a somewhat complex task to measure and assess the overall water quality of White Lake without multiple samples being taken from the same locations and frequently over the ice-free season.

In its natural state, the water level of the lake would rise and fall with precipitation and seasonal change. From the time the original dam was constructed in 1845, through until the 1960s, water flows were managed such that the levels fluctuated about 1.5 metres per year, resulting in relatively clear waters and healthy walleye spawning grounds. When the dam was rebuilt in 1968, the water management regime was changed to maintain a high stable water level all summer, to accommodate the interests of the property owners at the time. This led to a gradual deterioration of water quality[16]. In 1977, the management regime was adjusted, primarily to benefit fish habitat, and since that time, the lake has undergone annual drawdowns of about 0.5 metres (18 inches). This regime of summer draw-downs has led to the rehabilitation of walleye spawning beds.

Disposal of Crown land for cottage lots and subdivisions began early in the 20th century and continued through until 1966. Today, the shoreline is comprised of a mixture of Crown land and private land developed with cottages, residences, or commercial enterprises. Shoreline development inevitably has an effect on the water quality of any lake. This happens through:

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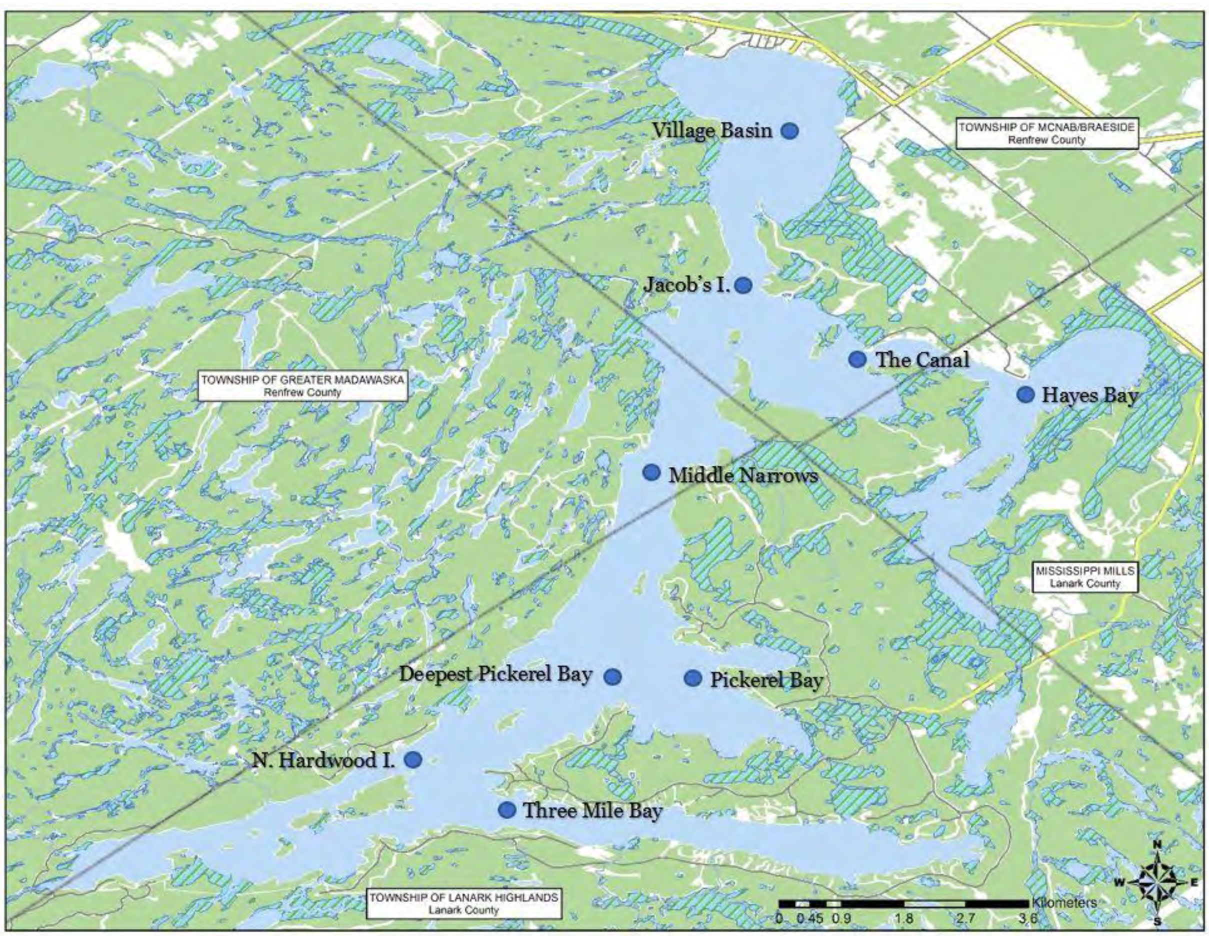
[16] J.P. Ferris, White Lake Integrated Resources Management Plan, Part I, *Ministry of Natural Resources, Lanark and Renfrew Counties, December, 1985.*

- Removal of natural vegetation (and in some cases, planting of lawns or creation of artificial beaches). This allows or increases soil erosion and run-off, including run-off from septic systems, leading to increased nutrients (phosphorus, nitrates) and sediments entering the water;
- Hardening of surfaces (roads, driveways, rooftops of buildings), which allow for increased runoff and potentially increased nutrients entering the lake;
- Use of fertilizers and pesticides;
- Leachate from septic systems that can bring nutrients and bacteria into the lake.
- Faulty or poorly maintained septic systems are more likely to leak bacteria and nutrients than properly maintained systems;
- Increased boat traffic that can stir up sediments in the lake, contribute to shoreline erosion, potentially spill petroleum products, and sometimes disturb fish and wildlife as well as their habitats;
- Intensification of development and redevelopment of cottages to larger all-season dwellings with production of more waste water (dishwashers, washers, multiple washrooms).

Measuring Water Quality and Data Sources

The water quality of White Lake has been monitored and analyzed in various ways since the early 1970s. The Ontario Ministry of the Environment, Conservation and Parks started an active program of measuring water quality in Ontario lakes in the 1970s. From



the beginning, landowners participated in the process. The Cottagers Self-Help Program began in 1971 as a partnership in which cottagers collected samples and took water clarity readings (using the Secchi disk), and MOE performed the analyses for Chlorophyll a, and in later years, total phosphorus. The White Lake Water Quality Committee was established in 1973 to perform sample collection for the program and this committee became a part of the White Lake Property Owners Association (WLPOA) when it was formed in 1987. The Self-Help program continued to operate through the 1970s and '80s, and was replaced by the Lake Partner Program (LPP) which continues today. Since 2005, the White Lake Property Owners Association have augmented these data by collecting water samples at additional locations and having them analyzed at a private lab for a range of additional parameters including: bacteria (Escherichia coli); volatile organic compounds (VOCs); petroleum products/by-products; and herbicides.

Environment Volunteers starting in 2013, added a significant number of new sites to the Lake Partner Program, and sampled for phosphorus on a monthly basis, and water clarity and temperature on a bi-weekly basis, from May through October, rather than only once per season. This expansion of the number of sites combined with monthly sampling has allowed for a better understanding of the lake's condition.

The Mississippi Valley Conservation Authority (MVCA) undertook, under contract to the Township of Lanark Highlands, additional sampling in 2007 (total of 3 sites). In addition to the monitoring of water clarity and phosphorus levels, MVCA included sampling and monitoring for Chlorophyll *a*, dissolved oxygen/temperature depth profiles, and pH. Similar measurements were performed in 2015 and 2016 by the MVCA and again in 2017 with Watersheds Canada. Since 2014, the White Lake water quality monitoring program has expanded to 9 sites with bi-weekly readings for water clarity (Secchi disk depth) and temperature, and monthly sampling for Total Phosphorus with analysis for Total Phosphorus carried out by the Ministry of Environment and Climate Change (Lake Partner Program). Additional studies were completed at dozens of sites in all parts of the lake studying conductivity, pH, temperature, sediments, etc. of the lake including streams and their estuaries.

The Ministry of Environment, Conservation and Parks has established a set of guidelines for desirable or safe levels of a long list of parameters. These guidelines, referred to as the Provincial Water Quality Objectives (PWQOs), will be referenced in the following discussion of water quality results for White Lake, as they provide scientifically-based levels for most parameters that measure water quality.

Although there has been a considerable amount of monitoring of White Lake's water quality since the 1970s, there was not a consistent or systematic approach taken comparable to data sets produced starting in 2014.

Over the past 45 years there have been changes to the locations of sampling, time of year sampled, parameters measured, and methods of collection and analysis all of which make pre-2014 data inadequate for the delineation of long-term trends in water quality. Also, prior to 2002, measurements for total phosphorus in both private and MOE laboratories had a much higher measurement error than the methods used under the Lake Partner Program today making comparisons of modern data with these older data sets of little value.

Historical Overview (to 2016): Lake Trophic Status

Trophic status is a useful means of classifying lakes and describing the general lake process in terms of the biological productivity of a lake. The classification includes three levels of trophic status (Table 1). Low trophic status, or oligotrophic, is typical of the cold-water lakes on the Canadian Shield, with clear waters and low levels of aquatic vegetation and algae. Mesotrophic status is typical of many of the lakes, especially off-shield lakes of Eastern and Southern Ontario; waters are less clear, and moderate levels of vegetation and algae growth can be expected. Eutrophic status is a state to be avoided, typical of highly enriched lakes, often caused by human-induced conditions; eutrophic conditions include heavy growth of vegetation, and frequent algae blooms.

Table 1: Lake Trophic Classification

Lake Trophic Status	Description	Total Phosphorus (µg/L)	Chlorophyll-a (µg/L)	Secchi Disk Depth (m)
Oligotrophic	Lakes with low nutrient levels, limiting biological productivity. Water is often clear and cold with sufficient oxygen levels in the entire water column throughout the year; often supporting cool to cold water fisheries.	< 10 µg/L	<2µg/L low algal density	> 5 m.
Mesotrophic	Lakes with moderate nutrient levels, resulting in greater biological productivity. Water is often less clear with greater probability of lower oxygen levels in the lower water columns; often supporting cold to warm water fisheries due to a variable range of nutrients.	11 to 20 µg/L	2 to 4 µg/L- moderate algal density	3.0 - 4.9 m
Eutrophic	Enriched lakes with nutrients in higher concentrations. Water has poor clarity, especially in summer months when algae blooms and plant growth peaks. Oxygen levels are greatly reduced in lower water columns throughout the year due to excessive decomposition of aquatic vegetation; often support warm water fisheries.	≥21 µg/L	> 4 µg/L- high algal density	< 2.9 m

Three parameters that are used to establish the trophic status of a lake are:

- **Phosphorus** is the limiting nutrient for the growth of aquatic plants and algae. Phosphorus is present in a healthy lake, as it is needed to allow the growth of the algae and plants that sustain life in the lake. The level of phosphorus, measured as total phosphorus, is an important measure of the productivity of the lake, and high phosphorus levels usually contribute to more and larger algae blooms, and heavier growth of aquatic plants.
- **Water clarity**, as measured by use of a Secchi disk. The Secchi disk is a black and white metal disk that is lowered into the water until it can no longer be seen, at which point the measurement is taken. This is a measurement of the clarity of the water, and is determined by the amount of material that is suspended in the water (algae, phytoplankton, suspended soil sediments, and other materials). These materials are naturally found in our lakes, but if their levels are high, light will not be able to penetrate to deeper levels of the lake, reducing the photosynthesis rates of aquatic vegetation, which reduces oxygen levels, affecting the health and survival of fish and other aquatic life. The Secchi disk reading represents half the distance through which light penetrates the water column.
- **Chlorophyll *a*** is the green pigment contained in algae and aquatic plants that is used in the process of photosynthesis. The Chlorophyll *a* concentration is used to measure the abundance of algae and potential plant growth in the water, and is directly related to the amount of nutrients available. If the concentration of Chlorophyll *a* is high, then it can be assumed that the nutrient levels in the water are high as well, promoting growth of the algae. High concentrations of algae and vegetation can also cause oxygen depletion in the lake. As the algae and vegetation die off, the decomposition uses up available oxygen; if there are more organisms the amount of oxygen needed for decomposition increases.

Trophic classification offers a handy guideline for approximating the productivity level of a lake. These levels have been used by MOECC in the past as benchmarks beyond which water quality should not deteriorate. For example, if a lake measured total phosphorus at mesotrophic levels (between 11 and 20 µg/L), the water quality objective was to maintain levels below 20.

The figures for total phosphorus (in Table 1) and how they relate to the trophic status of a lake need to be read with the following points in mind. They were developed in 1979, as a part of the Provincial Water Quality Objectives (PWQOs). In 1994 it was recognized that the figures were being used "despite incomplete knowledge of relationships between total phosphorus concentrations in water and the corresponding algal growth in lakes and rivers" so their status was changed to "interim". The 2010 Lakeshore Capacity Assessment Handbook points out that "these numeric objectives fail to protect against the cumulative effects of development...." and that the numeric objectives for total phosphorus "ignores fundamental differences between lake types and their nutrient status...". Further, the presence of zebra mussels in a lake, like White Lake, renders traditional trophic level determinations inappropriate because zebra mussels greatly increase water clarity, while at the same time increases the growth of aquatic plants, while fostering algal blooms at very low total phosphorus levels (<10 ppb).

Since the development of the PWQOs some fifty years ago, changes have been taking place: the climate has warmed, and there are longer ice-free periods; there is a major increase in development on the Lake; zebra mussels have invaded the lake and their population has expanded explosively since 2016; and plant growth appears to be increasing, especially Eurasion milfoil. White Lake has experienced a significant number of both green and blue-green algal blooms and increased plant growth. Also, water clarity has doubled, chlorophyll-a concentrations have collapsed, making determination of trophic level impossible using the criteria given in Table 1.

In addition to the generalized guideline of trophic levels, MOECP has established a set of water quality guidelines, referred to as "Provincial Water Quality Objectives." These offer specific levels for a large array of chemicals and compounds – levels that are set based on public health and aesthetic criteria.

Table 2: Trophic Status 1973-2015

DATE/Source	Water Quality Measurements			TROPHIC STATUS
	Secchi disk (m)	Chlorophyll *a* (µg/L)	Total Phosphorus (µg/L)	
1973[17]	Min 1.5 Max 4.5	Min 1.1 Max 14.0		Low Eutrophic
1975[18]	Min 2.4 Max 4.9	Min 1.8 Max 8.5	Max 38.0	Low Eutrophic
1972-1987[19]	Min 1.8 Max 3.2	Min 3.3 Max 9.6		Low Eutrophic
1987[20]	Min 1.8 Max 4.5	Min 1.3 Max 7.6		Low Eutrophic
2007[21]	Min 3.3 Max 4.7	Min 3.3 Max 5.3		Mesotrophic
2015[5]	Min 2.1 Max 5.0	Min <0.5 Max 3.9	Max 21.3	Mesotrophic

[17] Robinson, MOE, 1974. Enrichment Status of White Lake, Renfrew and Lanark Counties, Ontario

[18] Doyle, MOE, 1975. Cottage Pollution Survey of Three Mile Bay and Pickerel (Bennett) Bay on White Lake, Renfrew and Lanark Counties

[19] Ministry of the Environment, January, 1989. Cottagers' Self-Help Program, Enrichment Status of Lakes in the Southeastern Region of Ontario.

[20] Mississippi Valley Conservation, 2007. State of the Lake Environment Report 2007: White Lake.

[21] White Lake Preservation Project, 2015. Water Quality Monitoring Program 2015 Report.

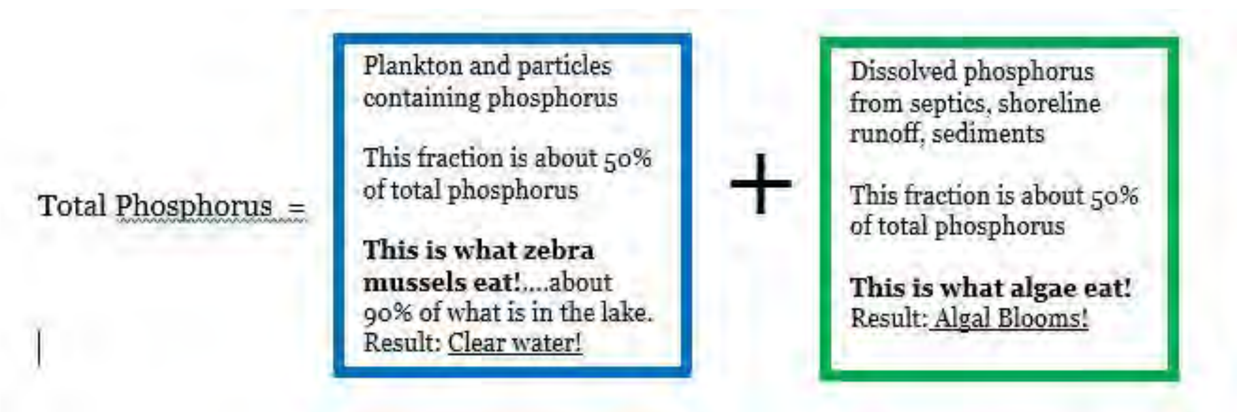
Since the 1970s, when measurements of the lake's trophic status were first established, White Lake has measured in the mesotrophic, or low eutrophic status (Table 2). A Canadian ban on phosphates in detergents significantly reduced the amount of phosphates entering our surface waters in the 1970s and 1980s. As a result, many of our lakes saw some improvement in water quality after that. Changes in dam management in the 1970s also had an effect on water quality of the lake.

Observations - Historic Trophic Status

- There have been various approaches to monitoring and measuring water quality on White Lake over the past 45 years, but not with the consistency needed to provide reliable trends through time.
- Since the 1970's the available data indicate that White Lake has been a moderately productive lake, falling into the category of mesotrophic or low eutrophic.
- The sampling regime for the lake has been broadened to monthly samples taken at locations representing the various distinct basins of the lake, starting in 2015.
- Since the arrival of zebra mussel, the tropic status of White Lake cannot be determined using traditional guidelines.

What is Total Phosphorus?

Total phosphorus is the sum of a number of different phosphorus-containing components including plankton and other particulate matter plus phosphorus compounds dissolved in water.



The total phosphorus level is a very important measure of water quality in our lakes and rivers. Phosphorus is the nutrient that is most influential in controlling the growth of algae and aquatic plants. Higher levels of phosphorus lead to higher levels of algae and plant growth. Phosphorus levels above 20µg/L indicate a highly productive (eutrophic) state; when levels approach or exceed 20µg/L, there is a greater likelihood of excess algae blooms and growth of aquatic plants. Phosphorus is a naturally-occurring element in our surface waters, and is necessary for plant growth in a healthy ecosystem. However, phosphorus levels can be elevated as a result of shoreline development, land clearing and agriculture.

Phosphorus moves into the water from different sources including natural, human-induced, and internal loading from phosphorus released from sediments, which have concentrations of phosphorus about 200,000 times greater than that of the water column above it.

Table 3: Sources of Phosphorus Entering Waterbodies

External Natural Sources	· Decay of organic material. · Weathering of rocks/minerals containing phosphorus. · Erosion of soils. · The atmosphere during rain and snow events. · Groundwater.
Man-made Sources	· Erosion and runoff from exposed agricultural lands. · Application of fertilizers and manure. · Septic systems, particularly aging systems that have not been upgraded. · Erosion and runoff from hardened surfaces and roads. developed areas (including lawn Application fertilizers, animal waste, detergents from car washing. · Erosion and runoff from construction sites or logging (exposed soils are prone to higher erosion that vegetated areas).
Internal Natural Sources	· Lake sediments: phosphorus that is held in the lake sediments can be released into the water column if conditions permit. Sediment in the shallow sections of the lake may be stirred up by high winds, waves, or motorboats. Internal loading of phosphorus can be accelerated by low oxygen levels at the lake bottom (<2µg/L), which allow chemical reactions to occur that release phosphorus otherwise locked in the lake sediments. · Presence of zebra mussels – as zebra mussels filter feed from the phytoplankton of the lake, they remove phosphorus that is tied up in the phytoplankton, and deposit this phosphorus into the lake sediment of near-shore areas. · Aquatic macrophytes draw phosphorus from sediments into their stems and leaves. Upon senescence this phosphorus is released into the water column

The sources of phosphorus inputs to White Lake would include all of the above-noted categories. Estimates of the levels of phosphorus entering a lake from different sources can be done through applying the Lakeshore Capacity Model.

White Lake receives phosphorus from each of these categories; and data shows that sediment release is an important source of phosphorus, particularly late in the season when low oxygen levels may be present and water temperatures are high.

Recent studies done on sediment cores from White Lake[22] provides a historical record of nutrient loading in White Lake over the past 150 years. The authors of this study

[22] M. Murphy, C. Grégoire and J. Vermaire, Ecological response of a shallow mesotrophic lake to multiple environmental stressors: a paleolimnological assessment of White Lake, Ontario, Canada., *Lake and Reservoir Management, in press.*

concluded that for the sediments of White Lake, the top layers indicated a higher nutrient enrichment in recent years, suggesting that there has been increased phosphorus added to the lake during this time resulting in a degradation in water quality.

Historical Trends in Total Phosphorus Concentrations in White Lake: 1975 to 2015

In 1975, the Ministry of the Environment (Ferris, 1985) completed a study of total phosphorus concentrations at three locations on White Lake. Single samples were collected at approximately two-week intervals starting in mid-May and ending in mid-September. Samples were collected at Three Mile Bay, Pickerel Bay and the Village Basin at the North end of the lake.

Unfortunately, the analytical uncertainty associated with total phosphorus data was approximately ±30%, which was typical for measurements obtained using a now outdated analytical method[23]. This method had a limit of detection (LOD) of 5 ppb (±100% at the LOD) and for this reason was abandoned by the MOE in 2001. Further, prior to 2002, samples were not filtered allowing unwanted large zooplankton to be accidentally included in samples for analysis. This resulted in abnormally high results which were not representative of the actual total phosphorus present. It also gave erratic results because of the particulate nature of the contamination entering the water sample collected.

Since 2002 and up to 2015, the last pre-zebra mussel year, a number of total phosphorus determinations for White Lake were completed. Unfortunately, with the exception of the 2014/5 data, none of the samples were collected in a systematic way, but rather were taken as 'grab' samples at various times of the year and at various locations. It is important to note that all of the sampling sites were located in Zone 1, (see Appendix for Zone Map) the Main Water Body of White Lake, and that all analyses were completed at MOE Laboratories in Dorset, Ontario. This data is presented in the graph below where total phosphorus concentrations are plotted by day of year.

We know from hundreds of measurements made during the last seven years[24], 2015-2020, that the total phosphorus values are not identical at all sampling sites in this zone, but are normally no more than a few ppb difference from one sampling location to another. This allows us to plot this data on a single graph for illustrative purposes.

Figure 1 shows that total phosphorus concentrations were low in the spring, increased until mid-July and then decreased to lower levels in the fall. The largest number of points were taken in the spring which, for shield-hosted lakes, would give the highest total phosphorus concentrations. For off shield lakes, like White Lake, better data would be gained if sampling dates had been more evenly distributed over the ice-free season,

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[23] B.J. Clark, Assessing variability in total phosphorus measurements in Ontario Lakes., Land and Reservoir Management, 26:63-72, 2010.
[24] D.C. Grégoire and D. Overholt, White Lake water Quality Monitoring Reports, 2015 to 2020.

because the minimum TP value occurs in the Spring. The maximum TP value occurs later in the summer, which is needed to evaluate water quality. The best fit line (light blue) on the graph was calculated using a second order polynomial. This line indicates that statistically, total phosphorus concentrations can be in excess of 20 ppb (Provincial limit) from day 188 to day 230 or about 42 days during the ice-free season.

Figure 1: Lake Partner Program Total Phosphorus Data 2002 to 2015

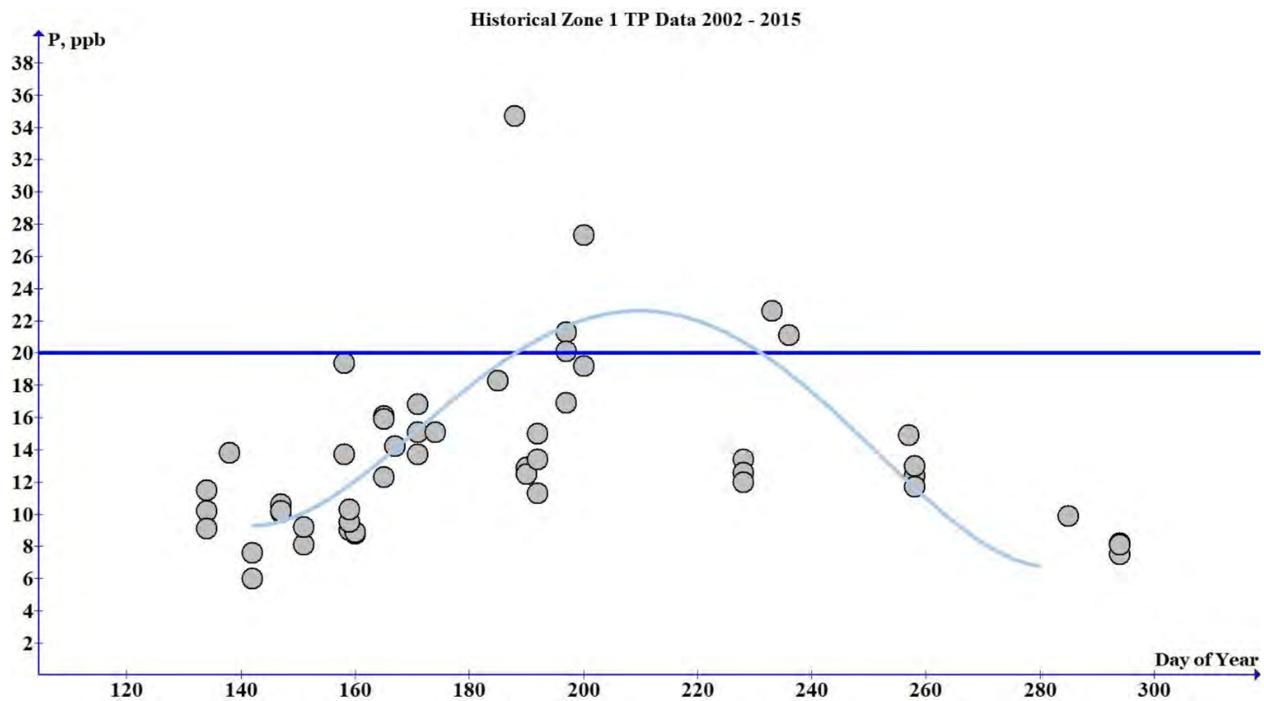
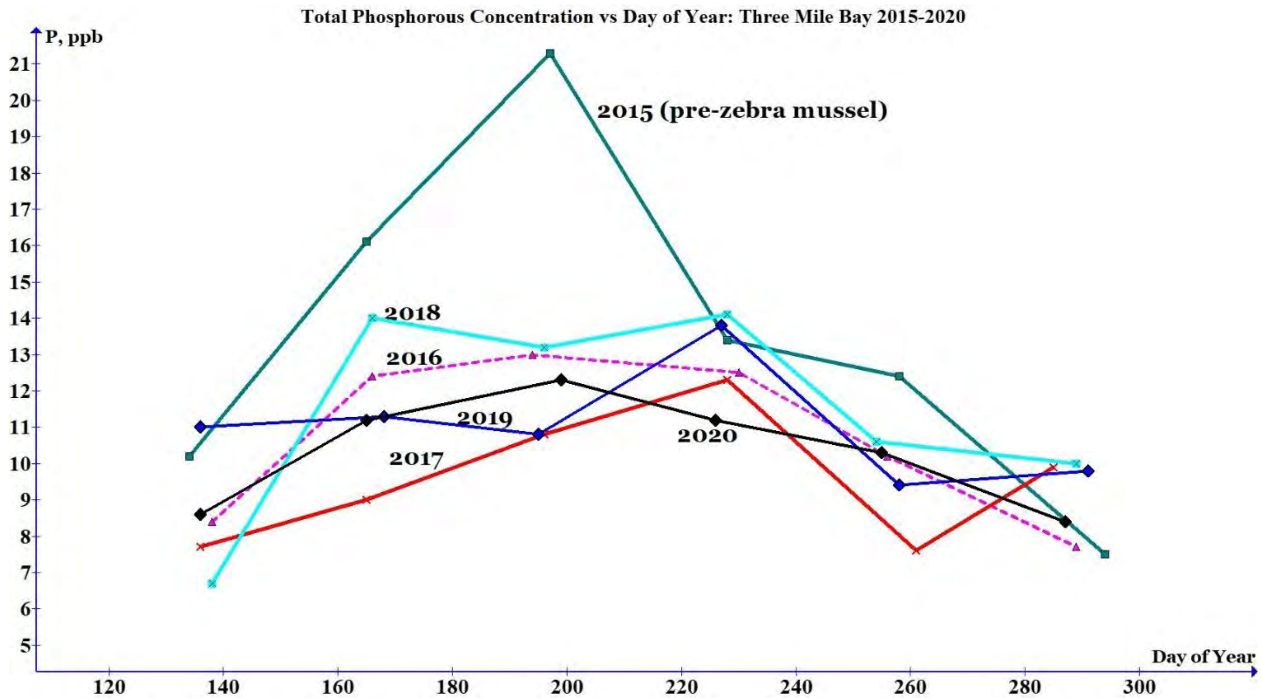


Figure 2 below graphically shows the change in total phosphorus values (Lake Partner Program) for the Three Mile Bay site during the ice-free season for 2015 to 2020. Note that the 2015 curve represents the last year prior to the infestation of White Lake by zebra mussels.

Figure 2: Total Phosphorus by day of year for Three Mile Bay sampling site; 2015 - 2020



Observations - Total Phosphorus – Historical Perspective

- Study of historical total phosphorus levels for White Lake show as far back as 1975, that total phosphorus concentrations may have exceeded the 20 ppb limit set by the MOE.
- The quality of analytical data has to be taken into account when comparing results from different analytical methods.
- The highest total phosphorus levels were measured in mid-July.
- Shield vs non-Shield Lakes. For lakes on the Canadian Shield, a single sample in the Spring will usually suffice as this is the time when shield-based lakes will show highest readings for phosphorus and lowest for Secchi disc. White Lake is predominantly underlain by limestone rock, which gives the lake the chemical properties of a non-shield lake. In this case, sampling needs to be done on a monthly basis to provide reliable results.
- The use of means or averages for the interpretation of total phosphorus data for an off-shield lake is not accepted practice and leads to erroneous conclusions.
- Up until 2014, the quality and quantity of total phosphorus data collected for White Lake were not good enough to be used in determining long-term trends, although we know that maxium values remained high and above the 20 ppb Provincial limit.

Changes in Maximum Total Phosphorus Levels Since the Arrival of Zebra Mussels: 2016 to the Present

When White Lake became infested with zebra mussels in 2016, the chemistry of the lake changed dramatically. Perhaps the most significant change was in the way phosphorus was cycled in the lake. Rather than being relatively evenly distributed in the volume of the lake and then finding its way to the sediments below at the end of the summer, much of the phosphorus is now consumed by zebra mussels and deposited on and in near-shore sediments. This significant increase in phosphorus in the near shore environment is what is responsible for the explosion of aquatic plants along White Lake shorelines as well as promoting the growth of filamentous green algae and microcystis, a blue-green algae which is potentially toxic.

Total phosphorus is not a single compound, but rather a complex mixture of both particulate (living and dead) and dissolved sources of phosphorus. By definition, total phosphorus is the amount of phosphorus derived from all sources (particulate and chemical species) which will pass through an 80-micron filter.

The easiest way to think of total phosphorus is the sum of: 1) particulate phosphorus; and 2) dissolved phosphorus. The scientific literature on lake chemistry suggests that the two 'types' of phosphorus occur in lakes like White Lake in approximately equal parts. Why is this important?

Zebra mussels are filter feeders and are capable of removing from water all particles as small as one micron (a millionth of a metre). Because there are literally hundreds of millions of zebra mussels in White Lake, and because they can each filter up to 1.5 litres of water per day means that they can together remove most of the phosphorus containing particles in the lake over the summer. In other words, they can remove 50% of the total phosphorus which is that portion found in lake particulates. This is why the clarity (see water clarity section below) of the lake has more than doubled since the arrival of zebra mussels.

To illustrate this, the table below gives the maximum total phosphorus concentrations for samples taken from three deep water sites in Zone 1 of White Lake, the Main Water Body.

Table 4: Maximum Total Phosphorus (ppb) by Year: 2015 to 2020

Location	Year						
	2014	2015	2016	2017	2018	2019	2020
Three Mile Bay	-	21.3	13.4	12.3	14.2	13.9	12.3
N. Hardwood I.	21.2	20.1	14.1	12.0	14.1	12.9	13.0
Middle Narrows	-	16.9	12.7	11.3	12.6	13.8	12.2

Shaded areas denote maximum TP in mid-July; unshaded areas denote maximum TP in mid-August. The data for 2014 and 2015 (pre-zebra mussels) show total phosphorus concentrations ranging from 16.9 to 21.3 ppb. Once zebra mussels infested the lake (2016+), the concentration of total phosphorus decreased by about half and have remained relatively low since that time. The shaded area in the table indicates that for these location and dates, the maximum value for total phosphorus occurred in mid-July. Since 2017 and for the unshaded data, these maximum values occurred in mid-August, approximately one month later. TP maxima for 2020 occurred in mid-July. The graph below is a more dramatic presentation of the same data.

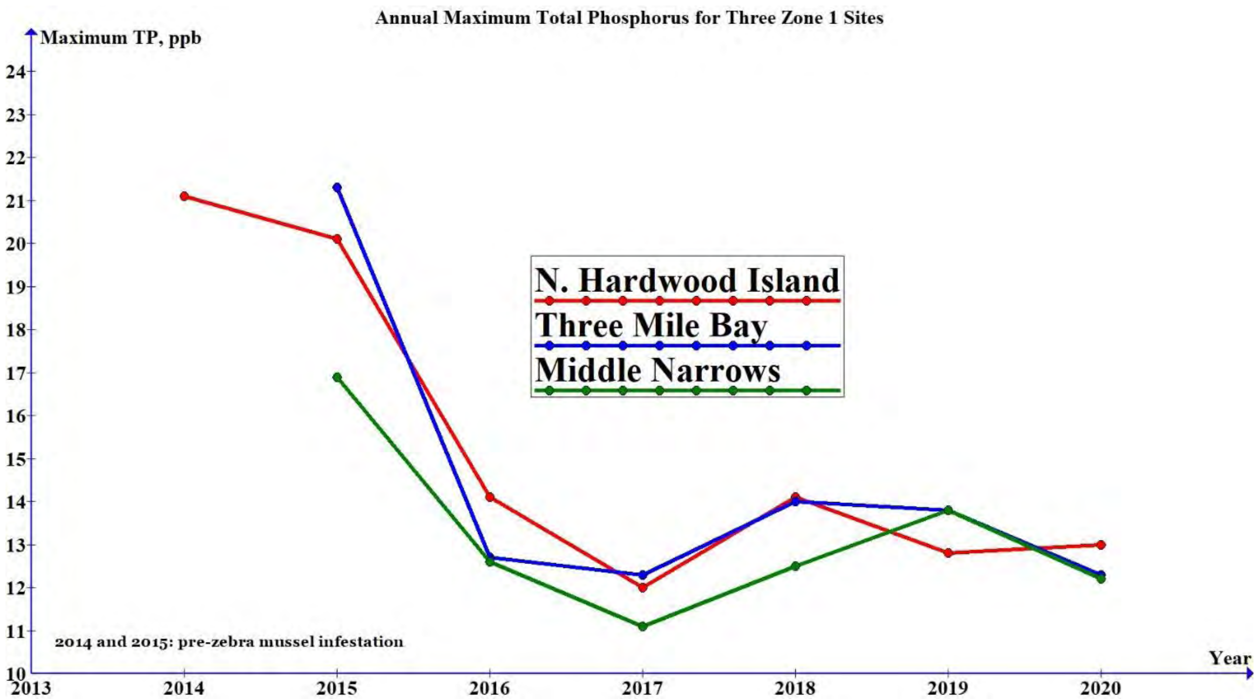


Figure 3: Change in Maximum Total Phosphorus Levels: 2015 to 2019

The phosphorus budget for White Lake is complex. White Lake has an internal[25] load meaning that some of the phosphorus found in sediments is released into the water column above. This can happen because of low oxygen or iron levels in the sediment and by increased warming of the sediments as a result of more sunlight reaching the lake floor. This may explain the shift in total phosphorus maxima from mid-July to mid-August since the invasion of zebra mussels. Also, the health of the zebra mussels, their numbers and size as well as other parameters can all effect the efficiency of lake water filtration by mussels. Taken together, this may be responsible for shifting the date on which the maximum total phosphorus concentration occurs.

[25] D.M. Orihel et al., Internal phosphorus loading in Canadian fresh waters: a critical review and data analysis., Can. J. Fish. Aqat. Sci. 74: 2005-2029 (2017)

Consequences of Changes in Phosphorus Cycling Due to Zebra Mussels

One often repeated goal by lake managers is to take steps to keep total phosphorus levels below the 20 ppb Provincial limit. At total phosphorus concentrations at or above this limit, it is said that the possibility of algal blooms increases significantly. Reaching this limit while experiencing frequent and extensive algal blooms is a clear sign that the lake has reached shoreline development capacity.

It is clear from the above discussion that White Lake has frequently exceeded the Provincial limit in years dating back to at least 1975 and is currently still doing so. In addition to this, since at least 2013 White Lake has been experiencing blue-green algal blooms, some of which were toxic. In 2018, there were two extensive blue-green algal blooms in White Lake, one of which was certified toxic and the other presumed to be so[26]. In 2019 and 2020, blue-green algal blooms occurred in Three Mile Bay, but were not tested by the MOE for toxins.

Since 2016, the highest total phosphorus concentration measured in White Lake was 14.2 ppb, well below the Provincial limit. As it turns out, the fraction of total phosphorus remaining in open water after zebra mussels have fed is composed of dissolved phosphorus compounds. This is the phosphorus that algae feed upon. This means that the potential to have an algal bloom is undiminished by the activity of zebra mussels. As far as algae are concerned, the available phosphorus for growth is unchanged from that available before zebra mussels arrived[27].

Now that zebra mussels are present, the proliferation of a species of noxious blue-green algae (cyanobacteria) is favoured: *microcystis aeruginosa*[28,29]. This species of blue-green algae thrives in waters containing low concentrations of phosphorus. Additionally, zebra mussels selectively filter out and excrete undigested *microcystis* further adding to its competitive edge against other algae, which the mussels will consume. During the last two years, White Lake has experienced three significant *microcystis* blooms. At the time when each bloom occurred, the total phosphorus concentration in lake water was less than 10 ppb. Of great importance is the realization that the Provincial target of 20 ppb total phosphorus <u>no longer applies</u> to lakes, like White Lake, which have been invaded by zebra mussels.

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[26] J.G. Winter, A. M. DeSellas et al, Algal blooms in Ontario, Canada: Increases in reports since 1994., *Lake and Reservoir Management,* 27:107-114, 2011

[27] T.M. Higgins et al., Effects of recent zebra mussel invasion on water chemistry and phytoplankton production in a small Irish lake, *Aquatic Invasions (2008) Vol 3, Issue 1: 14-20*.

[28] D.F.Raikow et al., Dominance of the noxious cyanobacterium *Microcystis aeruginosa* in low-nutrient lakes is associated with exotic zebra mussels*., Limnology and Oceanography, 49(2), 2004, 482-487.*

[29] L.B. Knoll, et al, Invasive zebra mussels (Dressina polymorpha) increase cyanobacterial toxin concentrations in low-nutrient lakes, *Can. J. Fish. Aquat. Sci., 65: 448-455 (2008).*

Observations - Total Phosphorus – 2015 to 2019

- Since the arrival of zebra mussels, total phosphorus concentrations in the lake have been reduced by about 50%. The cycling of phosphorus in the lake is now permanently changed.
- The reduction in total phosphorus in lake waters is entirely due to the presence of zebra mussels and not from any human intervention.
- In addition to phosphorus entering the lake by other means (pollen, rain, etc.), phosphorus released from sediments is now being transferred to the near shore environment rather than finding its way back to the lake bottom at the end of the season.
- The increased clarity of White Lake is due to the removal of particulate matter in the water column by zebra mussels.
- Transport of phosphorus to near shore areas by zebra mussels encourages growth of aquatic plants and an increase in algal blooms.

Water Temperature

Temperature is one of the most important parameters 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 would also increase the release of phosphorus (internal loading) from sediments into the water

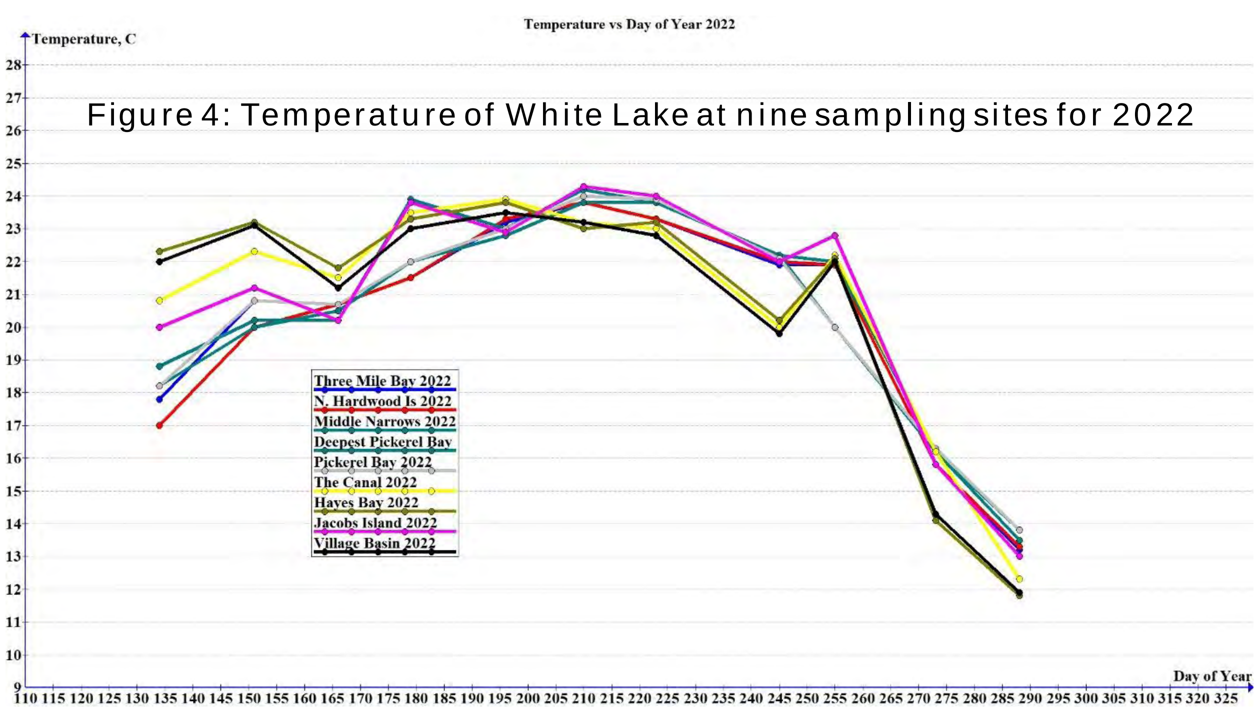


Figure 4: Temperature of White Lake at nine sampling sites for 2022

column. All temperatures reported were taken at the Secchi depth using a thermometer calibrated against a secondary standard mercury glass thermometer.

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 (see below). 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 and surface runoff. Not evident in the figure above, are differences in temperatures at 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

Table 5 gives the Zone location for both the low and high lake temperatures recorded for each lake sampling date in 2019. Data highlighted in yellow are for shallow sites.

Table 5: Lake zone location for low and high-water temperatures for White Lake, 2019

Zone 1[30] = Main Water Body; Zone 2 = Hayes and Bane Bays; Zone 4 = Village Basin

Date	Low Temp.	Zone		High Temp.	Zone	**Difference, ◦C**
May 16	10.4	1		12.0	2	1.6
May 31	15.0	1		18.7	2	3.7
June 17	17.8	1		18.7	2	0.9
June 27	21.5	1		23.5	2	2.0
July 14	23.6	1		24.8	2	1.2
Aug. 1	24.3	4		25.5	1	1.2
Aug. 15	22.1	1		23.2	1	1.1
Sept. 1	16.2	4		21.5	1	5.3
Sept. 15	16.2	2		18.0	1	1.8
Sept 30	14.1	2		17.7	1	3.6
Oct. 8	8.0	4		11.5	1	3.5

This data shows that the largest differences in temperature occur at the beginning and again at the end of the ice-free season with a maximum difference of 5.3 ◦C. Starting in June and until September, the range between low and high temperatures in White Lake is close to 1◦C.

It is not surprising that, depending on the date, the high and low water temperatures are either found in Zone 1 or Zones 2 and 4 of White Lake. Zone 1 comprises the deepest parts of the lake which would both heat up and cool down more slowly than shallower parts of the lake. Zones 2 and 4 comprises the shallowest parts of the lake with an average depth

[30] For an explanation of the White Lake Zone Map, see Appendix 1 on page 91 of the 2021 WLPOA Water Quality Monitoring Report.

of approximately 1.5 m. At this depth, waters in Hayes Bay and the Village Basin would both cool and heat up more quickly than in Zone 1 or any deeper location on White Lake.

Annual Trends in Lake Water Temperatures

Although there is 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. 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.
For example, the 2022 data presented in the graph below shows that lake water temperatures were several degrees warmer at the beginning of summer and about the same temperature in the fall when compared to previous years.

We now have nine consecutive years of water temperature measurements for the deeper sites (Zone 1: Main Water Body) on White Lake. The figure below gives temperature measurements obtained at the North Hardwood Island site for the years 2014 to 2022.

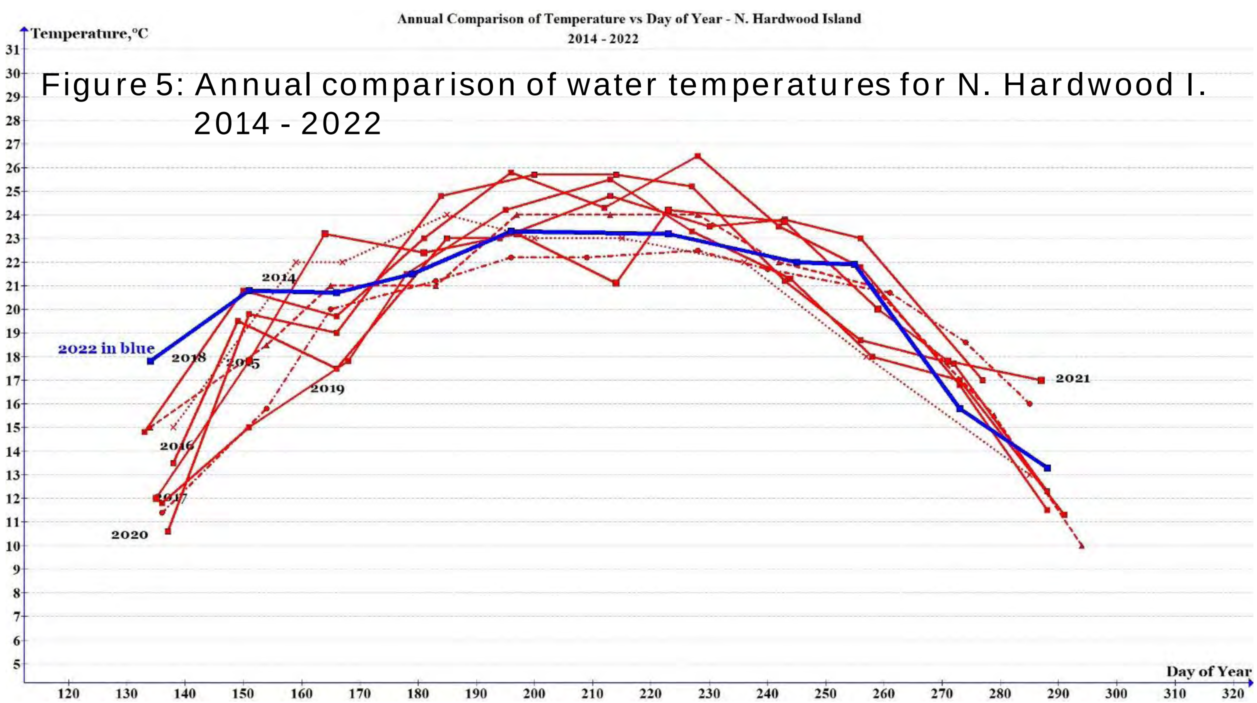


Figure 5: Annual comparison of water temperatures for N. Hardwood I. 2014 - 2022

The table below gives maximum temperatures recorded for White Lake during the past nine years. The year 2018 had the highest temperature and 2017 the lowest giving a range of 4.0 ◦C over the period.

Table 6: **Maximum Temperature, ˚C**

Year	Day of Year	Maximum **Temperature, ˚C**
2014	199	24.1
2015	213	26.0
2016	213	24.7
2017	196	22.8
2018	196	26.8
2019	213	25.5
2020	214	26.0
2021	223	26.1
2022	210	24.4

Observations – Water Temperatures

- Water temperatures are governed by weather and ambient temperatures and may vary from year to year.
- Maximum temperatures are achieved in mid-August.
- Deeper parts of the lake respond to changes in air temperature more slowly than shallower areas.

For More Information on White Lake Water Quality

- For a more complete discussion of measured water parameters including calcium, chloride, chlorophyll a, conductivity, etc. please refer to the complete report, which is abstracted here for the sake of brevity. This and all other reports are available for downloading at the White Lake Science and Information website at www.wlpp.ca

Lakeshore Capacity

This section provides you with information on the concept and approach used to define, calculate, and assess lakeshore capacity. In addition, this chapter[31] provides information on the purpose, use and importance of assessing lakeshore capacity. This concept has been applied to White Lake and relevant data is presented showing that White Lake has reached lakeshore development capacity. This result requires the attention of The Ministry of the Environment, Conservation and Parks, Municipal Councils and all those who wish to preserve the integrity of White Lake.

White Lake - 2015

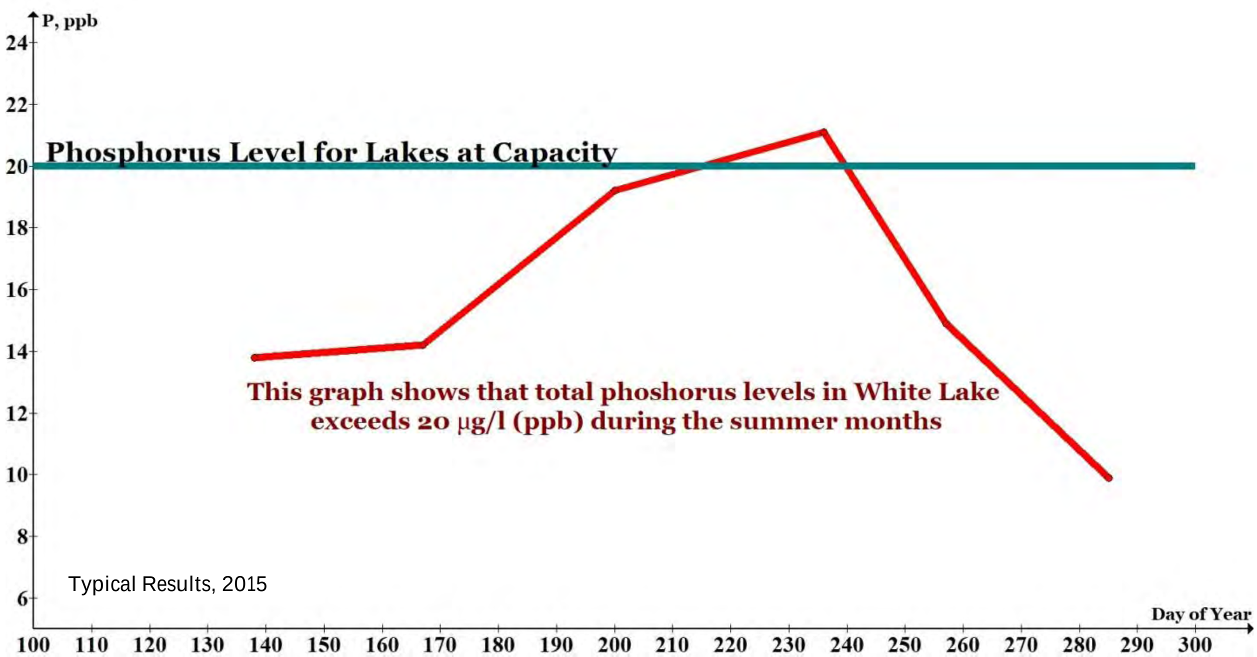
[31] Co-authored with Jane Taylor

1. What is lakeshore capacity?[32,33] Lakeshore Capacity refers to the level of shoreline development a lake can sustain without degradation in water quality.

2. What is water quality? Water quality for this discussion focuses only on algal blooms and total phosphorous (TP), the nutrient that is the main driver of algal blooms. There are many other elements that impact water quality that are not included in the official definition of Lakeshore Capacity.

3. When is a lake at capacity? A lake is at capacity when there is a deterioration in water quality as evidenced by:

- observations of regular extensive algal blooms (blue green, toxic and non-toxic, filamentous green etc.)
- measured phosphorous over 20 μg/l (ppb), which has been shown to be the level at which algae starts to appear regularly



4. What is the Source of phosphorous? In recreational lakes that do not have a large point source of phosphorous e.g. sewage treatment plant, and no significant agriculture along the shoreline, domestic waste from septic systems is the largest human source of phosphorous. The concentrations of phosphorous in septic waste waters as they exit the system are from 200 to 300 times higher than the concentrations which stimulate algal growth in lakes. Other sources of phosphorus in a cottage or lake setting include: fertilizers, animal feces, detergents (especially

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[32] *Lakeshore Capacity Assessment Handbook: Protecting Water Quality in Inland Lakes on Ontario's Precambrian Shield*, May 2010, Ontario Ministries of Environment and Climate Change, Natural Resources and Forestry, and Municipal Affairs and Housing.

[33] *Lake Capacity Assessment*, July 2014, and *Protecting the Water Quality of Ontario's Inland Lakes*, Sept., 2014, Federation of Ontario Cottagers Associations, Crystal Hyatt, Dorset Environmental Science Centre, Dorset, Ontario.

those used to wash vehicles, boats, windows and other outdoor surfaces), and contaminants from paved surfaces. Even grass clippings, leaf litter and household compost can be important sources of phosphorus.

5. How does phosphorus from all of these sources get into the lake? The most important vehicle for transporting phosphorus to the lake is storm water run-off.

6. How can we slow the rate of contaminated storm water reaching the Lake? Anything that impedes the rate of storm water run-off helps protect the lake from excessive phosphorus loading. Especially Important are:

- substantial building setbacks (30 metres plus)
- buffers of natural vegetation along the shoreline; e.g. 15 metres minimum (lawns do little to impede the rate of storm water flow)
- limiting hard surfaces near the water; e.g. boat launches, boat houses, parking lots, etc.

Before and After Shoreline Restoration

7. How does phosphorous get into the lake from septic systems? Domestic septic systems do not filter out phosphorous. Phosphorous migrates from septic systems to lakes. The amount and the time it takes varies according to:

- design and maintenance of system (the newer the better)
- distance from the water (the farther the better)
- soil type (certain soils are more effective than others in holding back the phosphorous)
- characteristics of underlying rock
- slope of the land to the water (impacts storm water run-off)
- vegetation between the septic system and the water (grass is not effective)

8. Can we determine how much more development can take place on a lake before **it will be** "at **capacity"?** Calculations can be carried out to estimate how much more development might be possible before water quality starts to deteriorate. This is done using the Lakeshore Capacity Model.

9. What is the Lakeshore Capacity Model (LCM)? This is a computer model developed by the Ministries of the Environment, Natural Resources and Municipal Affairs and Housing.

10. What does the Lakeshore Capacity Model do?

Lakeshore Capacity Modelling is designed to be a preventative tool, to give planners an idea of how much more development can take place before:

1. algal blooms occur
2. the level of phosphorous rises to the point where blooms are likely to occur regularly.

11. What are the steps in modelling?

1. *Estimate the pre-development load of phosphorous* for a watershed i.e. how much phosphorous was in the watershed/lake before buildings started to appear on the Lake.
2. Factor into the model the current figures for development[34] to arrive at an *estimate of the current load of phosphorous* in the Lake.
3. Compare the *estimated current load* of phosphorous to the *measured current load of phosphorous* in the lake. For the modelling to be valid the estimated and measured levels of phosphorous must be within 20% of each other.

12. What are the objectives of performing a lake capacity assessment?

- Keep the level of phosphorous in lakes below the modeled (or estimated) predevelopment level plus 50% e.g. a lake with a modeled predevelopment phosphorous concentration of 10 μg/l (ppb) would have a water quality objective of not exceeding 15 μg/l (ppb)
- Arrive at an estimate of how much more development and what kind can occur before the water quality objective is exceeded
  Note: In the absence of a model the fall back objective is not to exceed a phosphorus concentration of 20 μg/l (ppb).

13. When is a good time to carry out a Lakeshore Capacity Model calculation?

The provincial government advises carrying out a Lakeshore Capacity:

- When developing or updating official plans[35]
- If significant improvements to road access to a lake are being considered, or have occurred increasing the use of residences from seasonal or extended seasonal to permanent
- If development is being considered within 300 metres of a lake or a permanently flowing stream within its watershed
- If significant unusually large amounts of development are proposed for a lake beyond the 300 metre boundary
- If water quality problems are noted i.e. elevated levels of phosphorous, loss of water clarity, or algal blooms are noted

[34] Type of shoreline residence (seasonal, extended seasonal, permanent), resorts, trailer parks, campgrounds (tent trailer and RV parks, youth camps), vacant lots of record.
[35] Official Plans are required by the Province to be in place for each municipality. They are to reflect the Provincial Policy Statement and contain policies to guide Councils on how land in a municipality should be used.

- If cottagers or year-round residents raise concerns about the effects of development on water quality

14. What information is used in the Lakeshore Capacity Model?

- lake surface area
- catchment or watershed area
- mean depth of the lake
- percent forest and wetland in the watershed
- the number and types of shoreline developments[36] within 300 metres of the water
- observed or measured total phosphorous concentrations to evaluate the model's performance

15. How are the results of the model used?

The Province of Ontario recommends that the results of Lakeshore Capacity Assessments be incorporated into the Official Plans.

16. What about White Lake; is it at capacity now? Measurements of phosphorus concentrations above 20 μg/l (ppb) have been recorded *and* blue green and green algal blooms observed; both are criteria meant to be avoided by the timely application of the Lakeshore Capacity Model. The detailed model calculations described above have been completed (by an external consultant) and also show that White Lake is at capacity.

∞

A report by Hutchinson from 2014[37] indicated that capacity tools have been used as a part of the approach for managing shoreline development by the District Municipality of Muskoka, Seguin Township, City of Elliot Lake and City of Kenora (Black Sturgeon Lake) to determine the maximum amount of development that could occur on a lake without exceeding certain attributes, one of them being levels of phosphorous.

Closer to this part of Ontario Tay Valley Township[38] has used the Lakeshore Capacity Assessment to determine that Silver Lake has reached capacity meaning no new waterfront lots will be created. For all warm water lakes in Tay and Big Rideau Townships, the creation of 3 or more new lots within 300 metres of the lake will require an Environmental Impact Assessment.

Townships which have used the modelling approach also use a variety of tools which are generally described as "Best Practices" in an effort to prevent erosion, protect the riparian zone and limit the migration of phosphorous to water.

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[36] Type of shoreline residence (seasonal, extended seasonal, permanent), resorts, trailer parks, campgrounds (tent trailer and RV parks, youth camps), vacant lots of record

[37] Review and Analysis of Existing Approaches for Managing Shoreline Development on Inland Lakes, 2014, Hutchinson Environmental Sciences Ltd, prepared for the Ontario Ministry of the Environment and Climate Change

[38] Tay Valley Township Official Plan, § 2.24 Water Quality and Quantity; § 2.24.1 Lake Capacity, p. 58.

White Lake Q & A

Every year we receive questions from cottagers and others about White Lake. Questions range from enquiries about specific issues such as algal blooms, to questions about the lake itself and why we are studying it. In this section, we answer some of these questions and solicit our readers to forward to us any questions they may have. We are happy to answer them.

1. What kind of lake is White Lake? White Lake is a very shallow warm water lake. Scientists refer to lakes like White Lake as wetland lakes because it has so many very shallow bays and lots of marshes. The average depth of White Lake is 3.1 metres or about 10 feet. The deepest spot is 9.1 metres or about 30 feet.

   One of most important characteristics of White Lake is the chemistry of its waters. Because the lake itself sits on top of limestone (rock containing calcium) and its entire south shore is largely made of the same material, the lake is high in calcium and also has a high pH, which means that there is almost no acid in the lake.

   All of this makes White Lake a very productive lake which is good for fish, loons and all of the other creatures that live in and around the lake.

2. What about the surrounding land (watershed) which supplies water to the lake? White Lake has a watershed which is about 10 times the surface area of the lake, which is relatively small. We are very lucky that most of the land draining into White Lake is relatively pristine forest and small lakes. There is very little agricultural input, especially in the southern part of the lake.

   This means that what enters the lake, such as any nutrients or pollutants, etc. comes from us and not from anybody upstream. This also means that we have control of what enters the lake and that we can take responsibility for its present and future condition.

3. **What is water quality?......is it the same as the 'health of the lake'?** There are many definitions of water quality, but a good one is: "a measure of the condition

of water relative to the requirements of one or more biotic species [fish, etc.] and or to any human need or purpose'.

The health of the lake is harder to define but generally refers to a number of biological, physical, and aesthetic parameters as well as value considerations. To assess the health of White Lake, a multidisciplinary approach is required to collect data and observations so that changes occurring in the lake can be tracked over time.

This means that it is possible to have acceptable water quality for fishing, swimming, etc. at the same time that the health of the lake is deteriorating or becoming more sensitive to stresses imposed on it.

4. **Can we assign a one 'word' or one 'letter' grade to characterize White Lake water quality?** This can be done, but to do this we need to use a relatively large number of parameters to asses water quality. The Ontario Ministry of the Environment, Conservation and Parks uses 20 separate parameters which have to be measured several times during the year in order to assess lake water quality. The final results are obtained using a complex calculation.

   Conservation Ontario, the body which oversees Conservation Authorities, produce watershed report cards based on at least five measured parameters.

   A simplified version of Conservation Ontario's approach has reduced the number of parameters to three: total phosphorus, e-coli and a calculated factor reflecting the diversity and health of invertebrates in stream and lake waters. There is no information available on invertebrate species living in the White Lake watershed.

   White Lake is not part of any conservation authority, so it is not assessed or graded by any certified body or organization.

5. What is Total Phosphorus? There are many types of phosphorus in White Lake, but these can be divided into two categories: phosphorus contained in suspended particles like pollen and plankton, and phosphorus dissolved in the water much like sugar is dissolved in a cup of tea. Total phosphorus is the sum of the two. In White Lake, as in many other lakes, about half of the phosphorus is found in each type. Phosphorus is essential to all life, but too much can cause algal blooms and other problems.

6. Why are we measuring Total Phosphorus in the lake every month rather than just once a year in the spring as is done for most Ontario lakes? Most Ontario lakes are located on Precambrian Shield rocks, and, for those lakes, the highest total phosphorus levels are in the spring. Levels usually go down a little bit after that and remain relatively constant through the summer. For these lakes it is appropriate to take average values for interpretation.

White Lake is not a shield lake and spring values for total phosphorus are at the lowest levels. After that, the total phosphorus can increase by about 300% during the summer and decline again in the fall. For this reason, Provincial and other scientists do not use averages or individual values, but use the *maximum values* for interpretation.

For the past 7 years, the Ministry of the Environment's Lake Partner Program has been supporting our work on White Lake by providing the equipment and the chemical analysis of 126 separate water samples for a number of parameters such as total phosphorus, calcium, chloride, etc. Because White Lake is an off-shield lake (see Q1), the Lake Partner Program requires that the lake be sampled monthly so that the maximum value for total phosphorus can be determined. Reports are submitted to the Ministry annually as part of our agreement.

7. Is White Lake changing? Is it getting better or worse? White Lake is changing and not for the better. Starting abruptly in 2016, total phosphorus levels dropped by about 50%. This reduction was not because less phosphorus was reaching the lake, but because zebra mussels, which are mostly located along the shoreline, were transferring particulate phosphorus (which they eat) from the lake in general to the shoreline zone.

Now, rather than the particulate phosphorus eventually sinking and reaching the bottom of the lake, or being flushed out during the year, it is now being concentrated along the shoreline.

The amount of the second type of total phosphorus, the dissolved type, remains the same as before in the rest of the lake. Dissolved total phosphorus levels have not changed in the lake, and this is the phosphorus which algae feed on.

8. Is it still our goal to have total phosphorus at or below the Provincial recommended level of 20 parts per billion? Before White Lake was infested by zebra mussels, the Provincial level of 20 parts per billion applied and was important not to approach or exceed. At higher levels, algal blooms were more likely.

Once zebra mussels invaded the lake, everything changed. Algal blooms at much lower total phosphorus levels could now occur. The 2018 toxic blue-green algal bloom in Three Mile Bay occurred when the total phosphorus concentration was only 9 parts per billion. Unfortunately, we can no longer use the 20 parts per billion total phosphorus level as a guide, because this level applies only to lakes not infested with zebra mussels.

9. What are some effects of having zebra mussels in White Lake? Zebra mussels change the way phosphorus is cycled in the lake. Each zebra mussel can filter about 1 litre of water per day and there are hundreds of millions of mussels in White Lake. This has the effect of concentrating phosphorus along the shoreline

of the lake because zebra mussels are constantly eating particulate phosphorus and excreting it onto and into the bottom of the lake near the shoreline.

The net result of the action of zebra mussels is to promote the growth of aquatic plants near our docks and along our shorelines and at the same time encourage the growth of a specific blue-green algae (*microcystis*) which blooms at very low total phosphorus concentrations. Another effect is encouraging the growth of filament-like green algae, which is not dangerous but unsightly.

10. White Lake has had algal blooms before in the 1940s and 1970s. Why are we concerned about them now? Algal blooms during the past were the result of water levels being kept too high in White Lake and also because of the use of now banned phosphate detergents and other products. Since late 1970s, total phosphorus levels have decreased significantly because of the use of safer and more environmentally friendly products.

    There are no official records of algal blooms occurring on White Lake during the over thirty-year period of 1980 to 2013. In 2013 White Lake experienced its first ever documented blue-green algal bloom and since that time, there have been several more, some of them toxic. Before the arrival of zebra mussels, maximum total phosphorus levels exceeded the Provincially recommended limit of 20 parts per billion.

11. Should we worry about a blue-green algal bloom even if no toxins were found when analyzed? The official Provincial policy on this subject is stated in this way: 'The Ministry of the Environment, Conservation and Parks regards any cyanobacterial [blue-green algae] as potentially toxic, whether or not toxins are detected in the water upon testing'. This policy prompted the Peterborough Health Unit to say: 'Even experts cannot tell which blooms are harmful just by looking at them, *so waterfront residents will have to be cautious anytime that they have any dense algal bloom.'*

12. What can we do to help? One of the main things we can do to maintain or even improve the health of White Lake is to preserve or restore our shorelines to as close to pristine condition as possible. We can ensure that our septic systems are functioning properly. We can work together and demand that the four municipalities enforce their by-laws and encourage the use of well-known best practices when it comes to any development projects affecting shorelines and nutrient inputs to the lake.

    We also have to be concerned and take action to prevent new invasive species from entering the lake and doing everything we can to minimize the impact of those invasive species already here.

White Lake and the Environment

Invasive Species

MURDER IN THE MARSHES

The Plant That Destroys Wetlands

INVASIVE PHRAGMITES: Pine Tree Corners 2018

There is an advancing column of an aggressive plant making its way along our roads. It has one objective: to take over our plentiful and diverse wetlands. This invader is well known to a group of White Lake residents who engaged it at Pine Tree Corners during the summers of 2017-2019. We know from that experience just how tenacious this invader can be. As a lake community we should take this plant very seriously. It is Canada's #1 invasive plant and it poses a foremost threat to all Ontario wetlands.

A common name for this plant is the European Common Reed (*Phragmites australis australis*). As indicated on the map below, this invasive plant has progressed beyond our roadsides. It can now be found on the shores of White Lake. There are seven known locations on Three Mile Bay and another cell near an ATV trail. If these cells are ignored they will eventually spread beyond our ability to control them.

LOCATIONS OF INVASIVE PHRAGMITES ON THREE MILE BAY

EDDMapS. 2022. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed March 19, 2022.

WHY DOES IT MATTER?

Ecologists have a long list of reasons why invasive phragmites is a problem; here are some of them:

1. The reduction or elimination in the diversity of plants in wetlands.
   - *Native plants cannot defend themselves against chemicals released from phragmites rhizomes.*
   - *Lower plant diversity reduces the resilience of pollinators during times of drought.*

2. A reduction or elimination of animal habitat in wetlands.
   - *Species-at-risk such as Blandings Turtles are displaced from their habitat.*

3. The reduction in insect populations discourages birds and other insect eaters from living in the affected wetland.
   - *Swallows avoid wetlands dominated by phragmites as there is no food resource for them.*

4. The long term buildup of dead plant material results in permanently drying out wetlands.
   - *Dried out wetlands created by phragmites become a fire risk.*

5. Dense cells of invasive phragmites restrict accesss and the enjoyment of lakeside properites.
   - *The dead and living stalks of invasive phragmites can totally block out the view of the lake.*

As property owners we can look for solutions to prevent this plant from spreading farther. More can be learned about phragmites at:

EDDMapS Ontario Species Distribution Maps
Phragmites - Ontario Invasive Plant Council (ontarioinvasiveplants.ca)
Ontario Phragmites Working Group (opwg.ca) Invasive Phragmites | Georgian Bay Forever

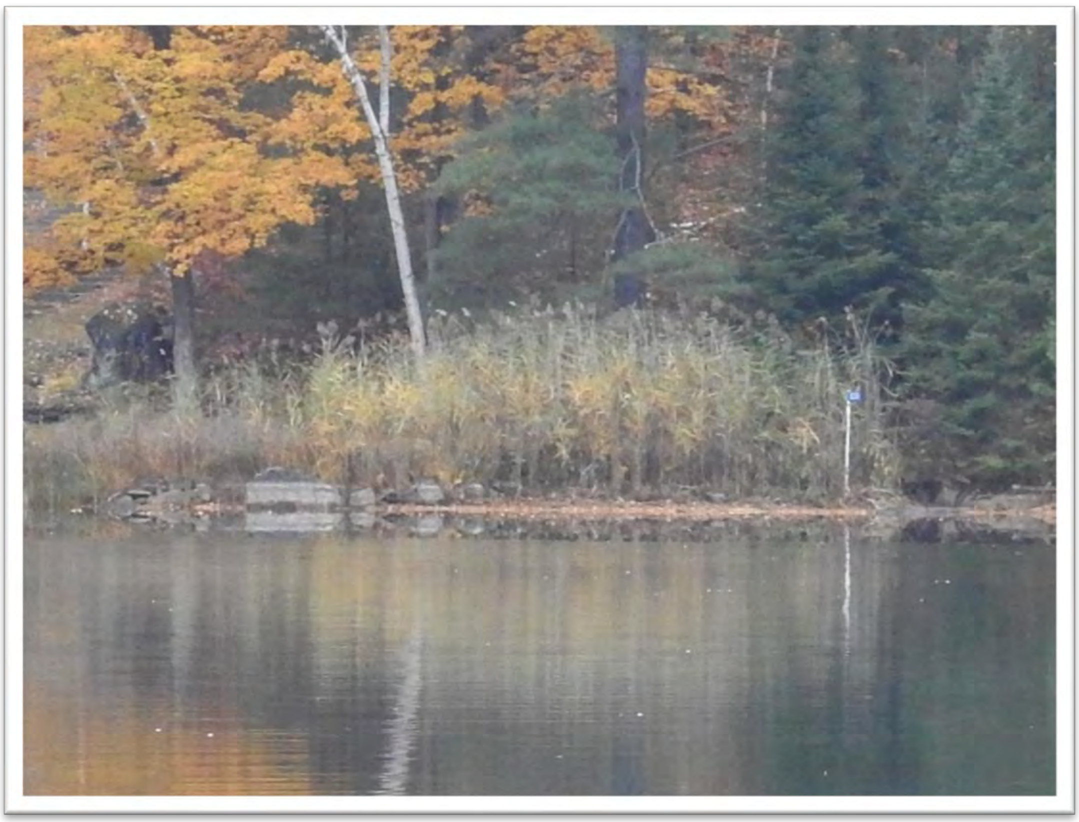
If you need help or advice, please contact us at whitelakescience@gmail.com or visit the White Lake Science and Information Website .

May 15, 2022

Invasive Phragmites

One Cottager's Approach

Bruce Waddell, Three Mile Bay, White Lake



Invasive Phragmites on our shoreline 2015

I realized I had an infestation of invasive phragmites on a portion of my shoreline only after our property owner's association talked about the issue at an Annual General Meeting four or five years ago. Until then I viewed these tall grasses with their feathery plumes of seed waving in the breeze as aesthetically appealing. When I learned this was an invasive species, my enjoyment of the tall fronds was curtailed and I started my quest for a practical, cottage-owner friendly way to manage the small infestation on my property.

Invasive Phragmites on our shoreline 2016

I have been asked to share with you my approach to managing invasive phragmites. My intent is to provide other cottage owners with a practical way to deal with small infestations on their properties. The strategy I have developed through trial and error is two-pronged ... first, manually harvest actively growing invasive phragmites to rob the plants of the opportunity to build up energy reserves (starve the plant) so native species can better compete; and, second, prevent the plants from reproducing (seeds or vegetative spread).

Where does one start? First you need to determine if you have invasive phragmites growing on your property by using this guide.

Timetable

As soon as plants have grown enough to be identified I start to cut off the invasive phragmites stalks, usually in late May. I keep an eye peeled for renewed growth and cut back discernable stalks of invasive phragmites, usually in July and in September.

Harvesting

The most effective overall method I have found to harvest phragmites selectively is to use bypass pruning shears to cut the plants growing onshore near ground level, carefully leaving other native species of plants undisturbed. In addition, where possible I pull plants in the water along the shoreline sometimes removing rhizomes as well as the stalk. This manual harvesting is hard on my knees and back, so I don't do it all at one time but spread it out over several days. As noted above I harvest three times during the growing season which has gradually reduced the size and density of the cell.

I wear protective clothing (long pants, boots, long-sleeved top and gloves) and apply insect repellent and work carefully so as not to disturb native plants some of which have cutting leaves and/or spines that can abrade or puncture your skin, even with protective clothing, or that can cause skin irritation (poison ivy). My wife kindly checks me for deer ticks after I change and clean-up after harvesting.

I am careful to ensure none of the harvested material falls into the water and floats away. Some literature talks about 'spading', cutting the rhizomes with a sharp spade. My shoreline is rocky so attempts at spading resulted in damage to my spade and sore joints for the 'spader' with minimal impact on the phragmites.

native plants at shoreline September 2019

Disposal

I have an area of exposed bedrock within 10 meters of the shoreline. I pile all harvested material on the bed rock and leave it undisturbed to decompose naturally. I have not observed any regrowth there or nearby.

I have not eliminated the invasive phragmites from our cottage shoreline but have significantly reduced them, allowing native plant species to flourish and I have prevented or at least limited the spread of invasive phragmites from our property to other areas of the lake. The picture above shows our shoreline without any visible invasive phragmites and with a healthy growth of native plants.

A forager among native plants May 2021

This picture of our shoreline clearly shows that white-tailed deer feed on these native plants. We have never seen them eating the invasive phragmites.

Zebra Mussels

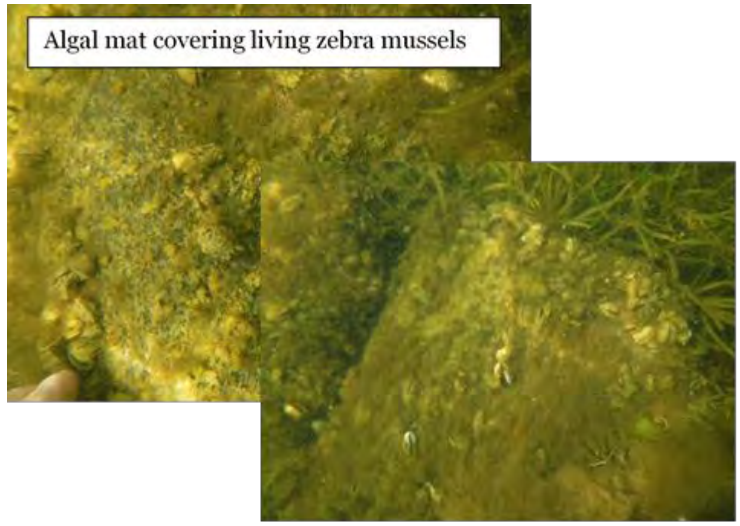
Zebra mussels live from 4 to five years and in 2019, the first generation infecting the lake began to die off. In 2020, the remainder of this 'first' generation of zebra mussels died. As part of a study we were completing, members of the scientific team visited and snorkeled dozens of sites in all parts of the lake. It was apparent that there had been a significant die off of zebra mussels at many of the rocky sholes we visited. Pictured (at right) was a common underwater sight at many places on the lake.

This photograph shows that virtually all of the large adult zebra mussels clinging to the rock have died. The shells are open and empty. Further, there are very few or no smaller zebra mussels, as would normally be observed on the surface of submerged rocks.

The loss of so many zebra mussels in White Lake has somewhat reduced water clarity and total phosphorus values are on the rise. These changes are significant, but these parameters are not that much different than they were before the zebra mussel die-off.

In addition to old age, there is a second force resulting in smaller numbers of zebra mussels. In most parts of the lake, we observed a marked increase in the extent and thickness of an algal mat, called periphyton, covering surfaces including rocks and other materials such as submerged trees and branches. It is important to note that this algal mat covered only the upper surfaces (facing the sun) and not the underside facing the lake bottom.

Periphyton is a complex mixture of algae, cyanobacteria (blue-green algae), microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems and has likely been present in White Lake for centuries. Its existence has been noted in other studies of White Lake[39].



Below are photos of periphyton covering the surface of rocks. Shown are some zebra mussels completely covered by the matting.

It is possible that the presence of the algal mat covering zebra mussels, could have resulted in death for two reasons. Firstly, the algal mat could prevent the zebra mussel from effectively feeding by preventing particulate matter from reaching its feeding siphon. Secondly, the zebra mussel could perish from asphyxiation resulting from anoxic conditions (hypoxia) during periods of algal respiration[40].

The chemistry of White Lake is perfect for indefinitely maintaining healthy populations of zebra mussels. The observed decrease in zebra mussel numbers is likely temporary as conditions change over time. Many healthy zebra mussel colonies were spotted on the underside of rocks and other materials since the algal mat does not live out of range of direct sunlight.

It is clear from these observations that the number, or perhaps more accurately the biomass, of zebra mussels in White Lake will vary with time. Changes in population density of zebra mussels are linked to changes in lake chemistry and biology. The cyclical nature of zebra mussel populations in lakes has been reported in the scientific literature[41], and it is possible that cycles will vary with water body. Zebra mussels have been in White Lake since at least 2015 and it is reported that it takes from 7 to 12 years before populations become stable[42].

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[39] J.P. Ferris, *White Lake Integrated Resources Lake Plan*, Lanark and Renfrew Counties, Ministry of Natural Resources; December, 1985.
[40] J. Kobak, *Behaviour of Juvenile and Adult Zebra Mussels (Dreissena polymorpha)*, in *Quagga and Zebra Mussels, Biology, Impacts and Control*' T.F. Nalepa and D.W. Schloesser, Eds., CRC Press, Chapter 21, pp. 331-344, 2014.
[41] D.L. Strayer et al., *Long-term population dynamics of dreissenid mussels (Dreissena polymorpha and D. rostriformus): a cross-system analysis*; Ecosphere, *Vol 10(4), Aticle e02701, April 2019.*
[42] M. Millane et al, *Impact of the zebra mussel invasion on the ecological integrity of Lough Sheelin, Ireland: distribution, population characteristics and water quality changes in the lake;* Aquatic Invasions, Vol. 3, issue 3, pp. 271-281, 2008.

Nice Lake! 'Mind if we Mussel In?

White Lake is the home for some very unwelcome guests. Since 2015 White Lake has been afflicted with millions of zebra mussels. Their great numbers have brought changes to White Lake. Some of these changes are obvious but others are more subtle.

<u>This is what we have seen to date</u>:

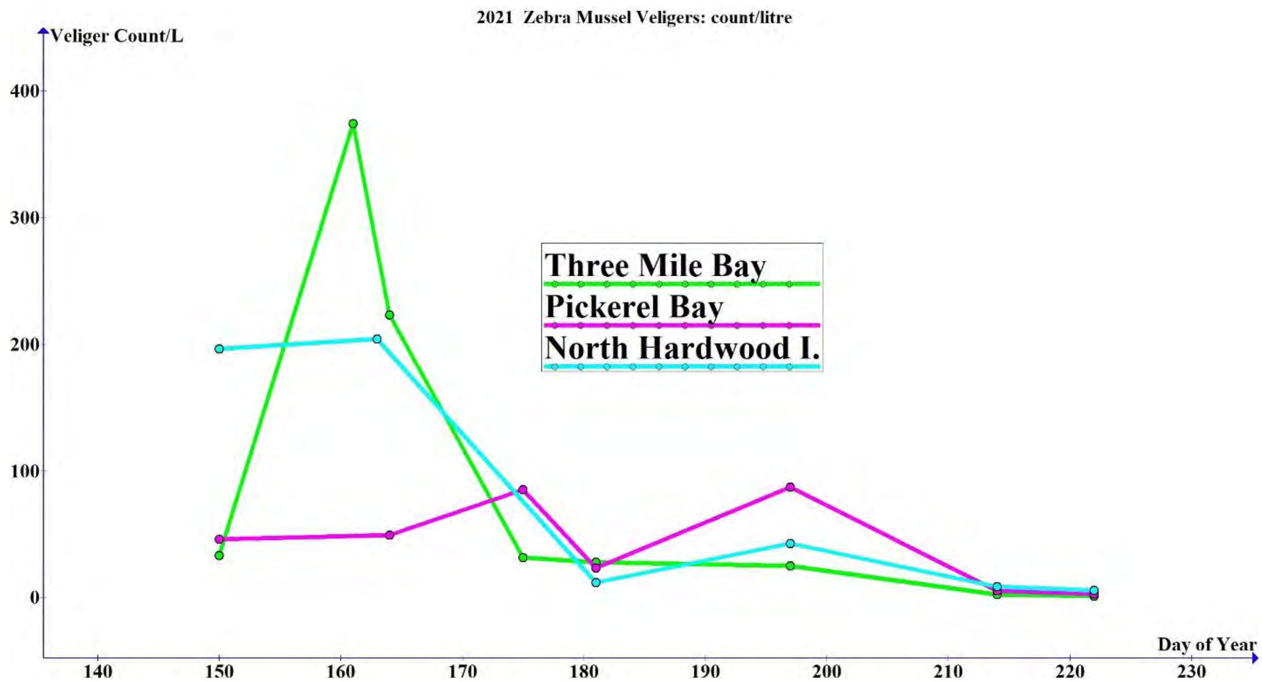
1. *Clear lake water promoting dense and deeper aquatic plant growth.*
2. *Threats of extinction for White Lake native clam species.*
3. *Increase in bottom growing filamentous algae.*
4. *Increase in potentially toxic blue green algae in the water column.*
5. *A change in the occurrence of some plankton species.*
6. *A cycle of die-off and recovery in the zebra mussel population.*

We have been monitoring zebra mussels for the last seven years. During that time zebra mussels have died off in large numbers as their first-generation approached its past-due date. Zebra mussels live for three to five years. The large die-off we observed in 2019 gave some hope that these invasive characters were willing to behave themselves. In 2019 they occurred in fewer numbers and were composed mostly of immature individuals averaging 4mm in shell length.

Last year (2021) the zebra mussel population returned with a vengeance. Mussels were produced that in their first year of growth achieved adult size and occurred in large numbers similar to their 2016 predecessors.

One might think that zebra mussels spread by attaching to surfaces such as boat hulls and boat trailers. This does happen but this is only one part of the story.

A major contribution is the spread of microscopic free-swimming larvae and early stage pediveligers (larvae with a foot). Pediveligers begin to grow a foot used to attach to a hard surface while they are still in a free-swimming state. In 2021 we sampled for these larvae expecting them to be present periodically, perhaps occurring only once or twice during the summer. We discovered zebra mussel larvae present in all of our samples and at all sampling sites from May 31st to August 10th. There were also major 'peaks' in their numbers on June 13th and June 30th.



WHAT CAN WE DO?

It is impossible to do anything about zebra mussels in our lake. But there is one thing we should do. We should institute a clean boat policy. Boat owners need to clean their boats before they leave our lake. This will ensure we do not spread this destructive invasive species to other lakes. If you have family and friends that bring their watercraft to White Lake, please take the simple precaution of cleaning these boats by removing any traces of aquatic plants and rinsing with uncontaminated water before taking it elsewhere.

Clean boat information is available from Ontario's Invasive Species Awareness program: Zebra and Quagga Mussels | Ontario's Invading Species Awareness Program

You can also read our full 2021 Zebra Mussel Report which tracks zebra mussel populations from 2016 to 2021. This and other reports along with a wealth of knowledge can be found on the White Lake Science and Information Website.

Spongy (Gypsy) Moth Infestation

If you were strolling through the woods over the last ten days or so, you would have heard what sounded like very light rain falling on leafy trees. But the sun was shining and there were no clouds in sight! What you were hearing were not the sounds of thousands of caterpillars chewing on tree leaves, but of a gentle 'rain' of spongy moth larvae droppings finding their way to the forest floor, your deck, or car. These droppings are called frass by entomologists.

The spongy moth is an invasive species native to Europe and Asia, and introduced to North America in the 1860's. Since that time, they have spread from the Boston area and now are common in southern Canada. They were first detected in Ontario in 1969 with major defoliation events occurring starting in 1981.

Spongy moths have a varied menu and thrive on a number of tree species including oak, birch, aspen, sugar maple, American beech, white pine and blue spruce. Although they prefer oak trees, these moths will eat over three hundred species of trees and shrubs.

Spongy moth outbreaks occur every 7 to ten years. The larvae chew holes in leaves and can completely defoliate its host tree. During severe outbreaks, trees and shrubs are completely defoliated. Trees are capable of producing a new crop of leaves, but tree growth is limited and weak or stressed trees may not survive.
Spongy moth caterpillars hatch in the spring and find their way to nearby food sources by finding a tree trunk or branch to climb. Mature caterpillars are 50 mm long, dark coloured, hairy, with a double row of five pairs of blue spots, followed by a double row of six pairs of red spots, down the back. Feeding is

completed in July at which time the caterpillars search for protected areas to pupate. This could be the underside of a piece of bark, under your deck, soffits, or even the wheel wells of your car parked behind the cottage.

The moths emerge from the pupae in mid-to late July. Male moths (left below) are light brown and slender-bodied, while females are white and heavy-bodied.

Curiously, the females have wings, but do not fly. The males fly up and down vertical objects in search of females. After fertilization, the female with lay about 500 eggs in a spongy mass which are covered with a peach-like fuzz. (see below)

Once laid, the eggs enter what is called 'diapause' and become dormant. The eggs will overwinter for eight to nine months before emerging once temperatures reach about ten degrees Celsius.

Control of this pest is difficult because during an infestation, caterpillars are numerous and their distribution is extensive. When caterpillars are within reach, it is practical to gather these and drop them into a jar containing some isopropyl (rubbing) alcohol. The moths can also be collected and disposed of in a similar manner. Finally, any egg mats found on any surface can be scraped off into the same jar to join its predecessors. Caution: There are reports that the furry egg mats can cause skin irritation for some individuals.

The next opportunity to control spongy moths comes in the Spring. Vulnerable trees near your cottage can be treated with a sticky natural resin called tanglefoot. This substance, with resembles caramel in colour and texture, can be spread on a layer of gauze, duct tape, etc. girding the tree as shown below.

When young caterpillars leave the egg mass, they search for trees to climb, and they become stuck onto the sticky layer of tanglefoot. This will not eliminate all of the caterpillars reaching the crown of your trees, but could very well reduce the quantity of frass in your morning coffee as you sit on your deck to welcome a new day!

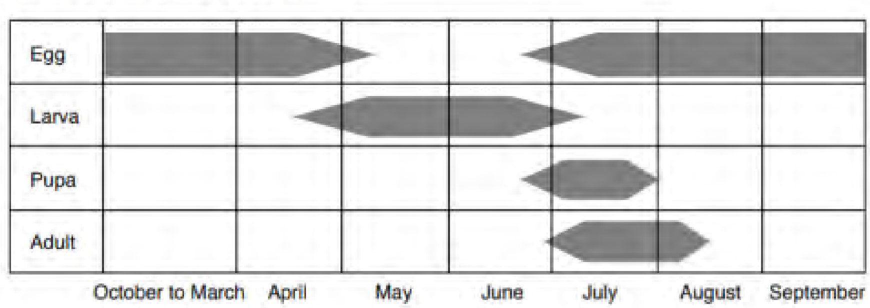
Control of Spongy (Gypsy) Moth Infestation

In 2020 we issued a report on the current spongy moth infestation in the forests surrounding White Lake. It is apparent from our observations of trees during the fall and through the winter that the situation may be even worse in 2021. We have found trees hosting as many as 100 egg masses waiting for warm weather to hatch and wreak havoc on emerging foliage. Many trees will not survive two to three years of foliage loss. Coniferous trees are especially vulnerable because these trees retain three years of pine needle growth which can all be lost in a single year from the ravages of spongy moth caterpillars. These trees can die during a single infestation season.

Spongy moth numbers rise and fall during an approximately 10-year cycle so they will eventually (almost) disappear and then return in threatening numbers. Cold winter temperatures of below -20C for extended periods can kill a percentage of the eggs waiting to hatch. However, winter has not been severe, and with the effects of climate change steadily changing our seasons, we can expect even more trouble from spongy months.

Is there anything we can do to prevent the loss of trees on our cottage and home lots? The

Life Cycle of the Gypsy Moth



answer is yes, but a concerted effort is required over more than one year to achieve success. The actions we can take are centered around the life cycle of the spongy moth as illustrated by the diagram below.

1. From September to late April: *Remove and/or Destroy Egg Masses*.

During this time period, the spongy month is in the egg stage and masses can be found on tree trunks, branches, buildings, rocks, and even your car. Egg masses are often found at the base of a tree, but also can be found all the way up a tree trunk, especially for badly affected trees. One egg mass contains about 300 eggs.

Scraping egg masses; assemblage of egg masses; single egg mass

The easiest way to eliminate and destroy these eggs is to scrape them off into a container using a narrow putty knife or a small spatula. The collected eggs can be killed by soaking them in a soapy solution for a couple of days. The soap and water combination wets the eggs mass and deprives it of oxygen.

A word of caution: The egg masses are covered with protective hairs and these can irritate your eyes and throat. We recommend wearing glasses and a mask to prevent adverse effects.

A second approach to eliminating egg masses is to use a spray of natural insecticide oil or vegetable oil such as soya oil. By simply mixing one cup of soya oil with one cup of water and a quarter cup of liquid dish soap, one can produce an effective spray that coats egg masses and leaves a layer of asphyxiating oil on the surface of the eggs (see Appendix 1). Shake well before using. This approach can be also be used in concert with scraping as a way to kill eggs tightly lodged into the cracks and crevices of tree bark, especially oak.

Additionally, products as pictured below, can be purchased on the internet by searching their brand names. Any household sprayer which can produce a 'jet' can be used for this purpose.

A third approach cited in the literature is removing egg masses with the use of a vacuum cleaner. Proper disposal of the filter bag is essential to prevent caterpillars from escaping back into the wild.

2. From late April to early May: *Place sticky barriers or bands on the trees.*

Wrap duct tape or other suitable material (sold at hardware stores) around the trunk of a tree about 5 feet off of the ground. This band is then coated with a sticky material called tree tanglefoot which serves to capture hatchling caterpillars as they make their way up the tree trunk from lower down or from areas such as buildings or objects.

Tree tanglefoot is a plant-derived resin which resembles caramel in colour and texture. In order to make spreading of this material easier, especially in cooler weather, the resin can be thinned by adding 25% acetone and applying the mixture using a paint brush. Note that acetone, available at hardware stores, is the only solvent we have found that dissolves tanglefoot. Once applied, the acetone evaporates very quickly.

3. From late May to August: *Replace sticky barriers with burlap bands.*

Caterpillars feed at night and hide during the day in places to protect themselves from the heat and predators. In doing this, they often crawl down the trunk of the tree to seek shelter.

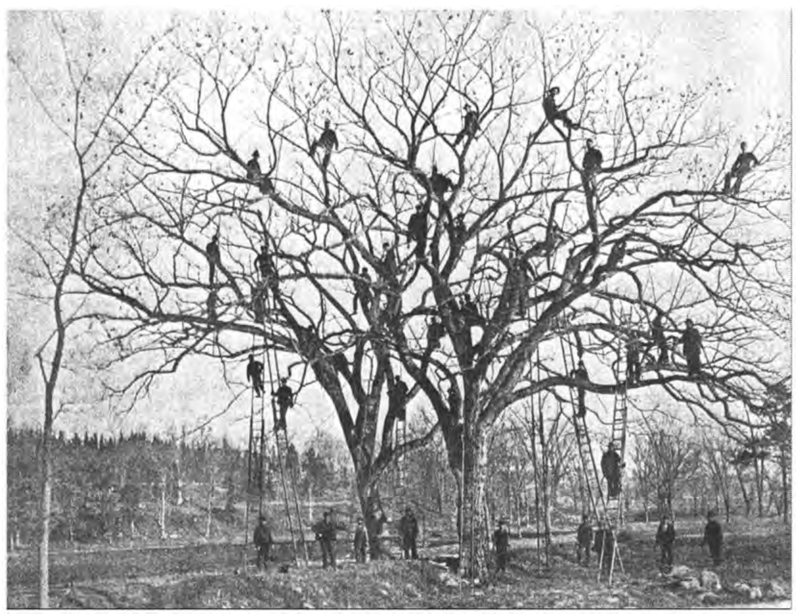
At this point, they can be captured by placing burlap cloth bands on the trees as shown below:

Wrap burlap that is about ½ to 1 metre wide around the tree trunk. Tie it at the middle with a length of twine. Then fold the top halt of the burlap wrap over the lower half. Simply collect and destroy the caterpillars that emerge from under the burlap. The best time to 'harvest' your catch is during later afternoon before they rouse themselves and crawl back up to the crown of the tree.

From late June to early August, caterpillars will pupate in the same location and can also be harvested. Both caterpillars and pupa can be destroyed by placing them in a soapy solution for a day or two. Your challenge may be finding someone in your family who is willing to do this.

4. Involve your family and your neighbours.

One approach to getting this work done is to make it a family affair. The collection of spongy eggs, larva and pupa can be a multi-generational activity carried out all year long. Make this year's easter egg hunt of a different kind!



Ridding spongy moths from your property does not guarantee that caterpillars will not find their way to you from your neighbours. It's a good idea to get them involved as well, and if they are not interested, perhaps they will let you treat the most affected trees on their property and save you work later on.

5. Aerial spraying.

One additional option available to White Lake residents and cottagers is engaging a licensed crop-duster to overfly properties and apply an insecticidal spray. Aerial spraying for spongy month is often done using a commercial product called Foray 48B®.

Foray 48B® is a water-based product containing a bacterium called Bacillus thuringiensis variety kurstaki (Btk). Btk is found naturally in the soil and is known to cause illness in many insect larvae when ingested, including caterpillars of pest species such as the spongy moth. Larvae are most susceptible to Btk when they are in the early developmental stages.

Foray 48B® is not toxic or harmful to people, dogs, cats, fish, birds, reptiles, or insects such as honeybees, beetles, or spiders. Pest control products containing Btk have been registered for use in Canada for about 40 years. It is now the most widely used pest control product in the world.

Aerial spraying of Foray 48B® for spongy moths is usually done in the spring between April and June and takes place between 5:00 a.m. and 7:30 a.m. Three separate applications are done every 7 to 10 days. These applications are usually required to treat the spongy moth larvae, which hatch during the treatment period.

Depending on the size of the treatment area, the aircraft used and any weather delays, it may take several mornings to complete 1 application.

For aerial spraying to occur, everyone in the area would have to agree to have it done as well as to share in the cost. It is not possible to spray individual properties and so universal buy-in from everyone on a shoreline is required before proceeding. The fact that we cannot spray on public lands, which is only done by the province when warranted, means that the efficacy of spraying only on private land is somewhat compromised by the large pool of moths located on nearby public land.

Suggestion: If you are planning to implement any of the measures outlined above, be sure to buy your supplies early to avoid disappointment.

Female and Male Spongy Moths

Appendix 1

The efficacy of two different solutions for killing spongy moth egg masses

An experiment was conducted to determine the efficacy of two different preparations reportedly used to kill spongy moth eggs. Samples were collected in mid-February by scraping egg masses off of tree trunks. Three separate samples were made by placing 5 egg masses in each of three 250 ml canning jars. A piece of cheese cloth was used rather than the sealing disk to allow oxygen to enter the jars.

The three samples, shown below in the photo were:

1) No treatment
2) Solution made from 10% dish (Sunlight) soap and 90% water by volume.
3) Solution made from 10% dish (Sunlight) soap, 45% vegetable (rapeseed) oil and 45% water, by volume.

After saturating the second and third samples with their respective solutions, the three samples were placed together in front of a south facing window. Eggs hatched in about 14 days.

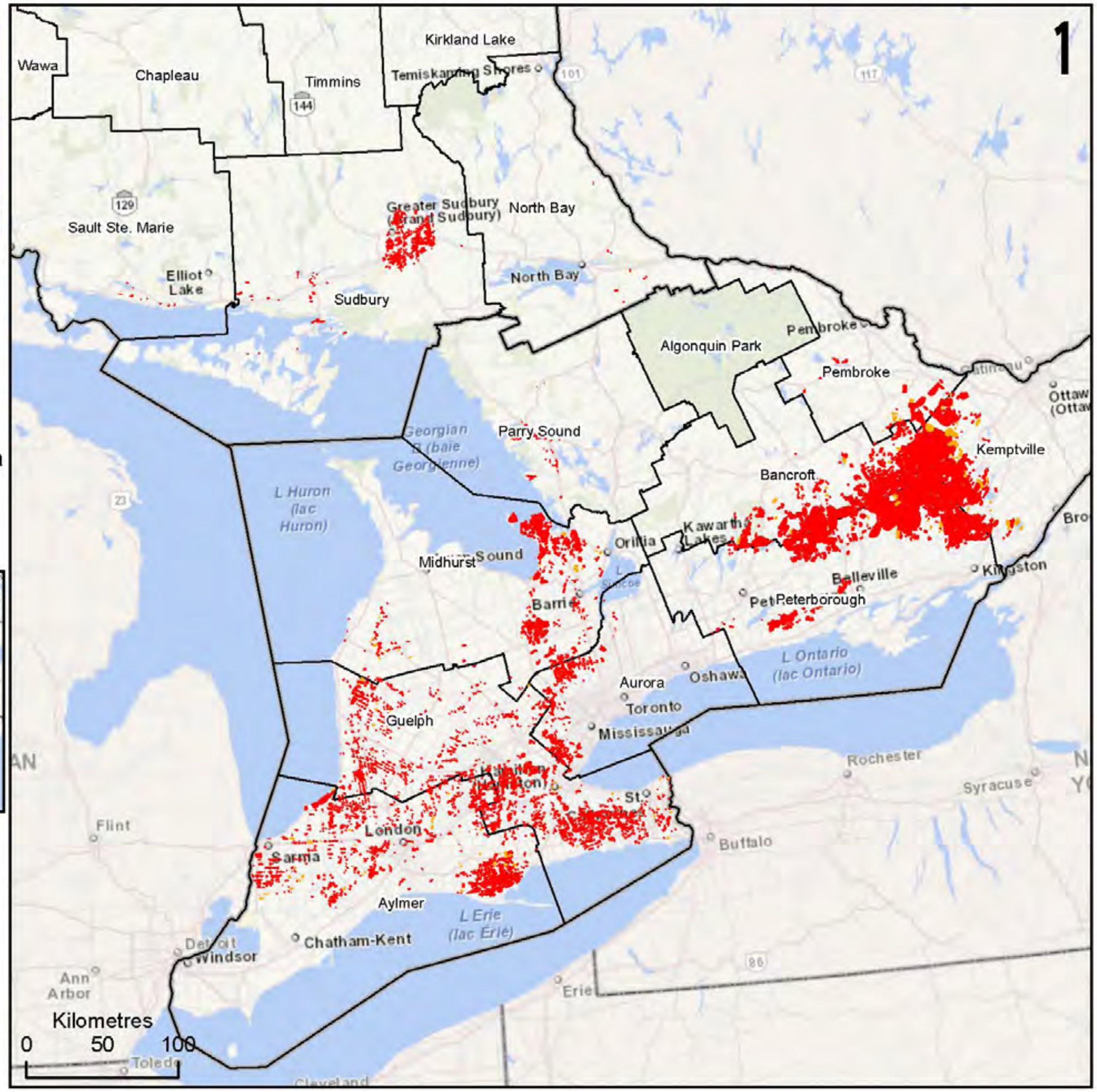
Results: It is apparent from the photo below that a simple soap solution was not effective in killing spongy moth eggs. The relative number of newly-hatched caterpillars from untreated eggs appear to be about the same as for those eggs treated only with a soap solution. The third sample, treated with the soap/water/oil emulsion, did not produce any hatchlings. When the egg mass was saturated with a spray this emulsion, effective control of this pest was achieved.

Gypsy moth 2020

Areas in Ontario where gypsy moth caused defoliation

Light = 17,002 ha
Moderate to severe = 569,384 ha

- Area of light defoliation
- Area of moderate to severe defoliation



Disclaimer:
This map is illustrative only. Do not rely on this map as being a precise indicator of routes, locations of features, nor as a guide to navigation. This map was produced by the Ministry of Natural Resources and Forestry.

Ontario

White Lake and the Environment

Keeping Count

Loon Surveys: 2013 to 2022

Because of the ongoing Covid-19 pandemic, boat traffic has been relatively light on White making it easier to carry out loon and chick counts.

In 2020, it was not only humans who were facing an existential threat. The loons on White Lake were on their own dealing with a very serious issue.

Photo credit: Joyce Benham

Early on during the survey, it became evident that 2020 was a difficult year for loons. There were fewer adult looms to be seen and very few chicks.

An article appearing in the Ottawa Citizen reported that the issue which resulted in poor loon reproduction was an infestation of a species of black fly (Simulium annulus) which only attacks loons and not humans. In the article, Dr. Piper who is a loon researcher from California, said that these black flies are “active in May, when the adult fly needs a meal of blood in order to reproduce. And clouds of the tiny flies (smaller than the kind that go for humans) swarm around each loon, just as they are sitting on eggs. In years when fly numbers are low, the loons put up with it. But in years with many flies, loons can be driven off their nests and the eggs don’t hatch. It has been a dreadful first round of nests for most breeding pairs”. The article further states: “Typical pairs in the study area in Michigan abandoned their first nesting attempt in early May because of the clouds of flies that descended upon them, and have only just begun to re-nest or think about doing so”.

"Based on what we have seen, it appears that 70 to 80 per cent of all pairs could not stand to incubate the first clutch of eggs they laid in early to mid-May, making 2020 even more devastating a black fly year than 2014, the previous worst year on record".

The only way to escape black flies is to dive and stay underwater. Loons can leave their eggs uncovered for a couple of hours, but if they completely abandon the nest, then the eggs do not hatch. We did not observe any loons on White Lake trying a second nesting. It could be that the black flies plaguing them we high in numbers into the summer months.

For more information on loons and their struggle with black flies, please click here

The table below summarized the results of loon surveys for seven years starting in 2013. It is clear that 2020 and 2021 were difficult years for loons. When compared to 2019, the total adult loon population and consequently the number of chicks has declined very significantly. Preliminary results for the 2022 season indicate that the number of chicks has rebounded significantly. A total of 15 chicks were counted in 2022

OBSERVATION	2013	2015	2016	2017	2018	2019	2020	2021
Number of Adults	23	40	32	45	44	38	25	27
Number of Nesting Pairs	7	10	11	19	10	12	2	5
Number of Chicks	16	17	16	21	18	23	4	5

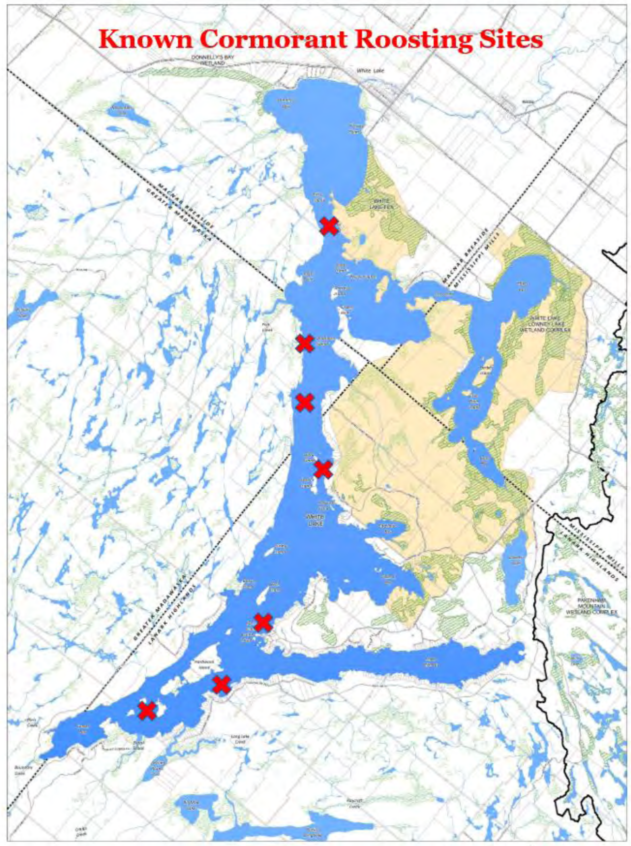
Double-Crested Cormorant Count

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."*



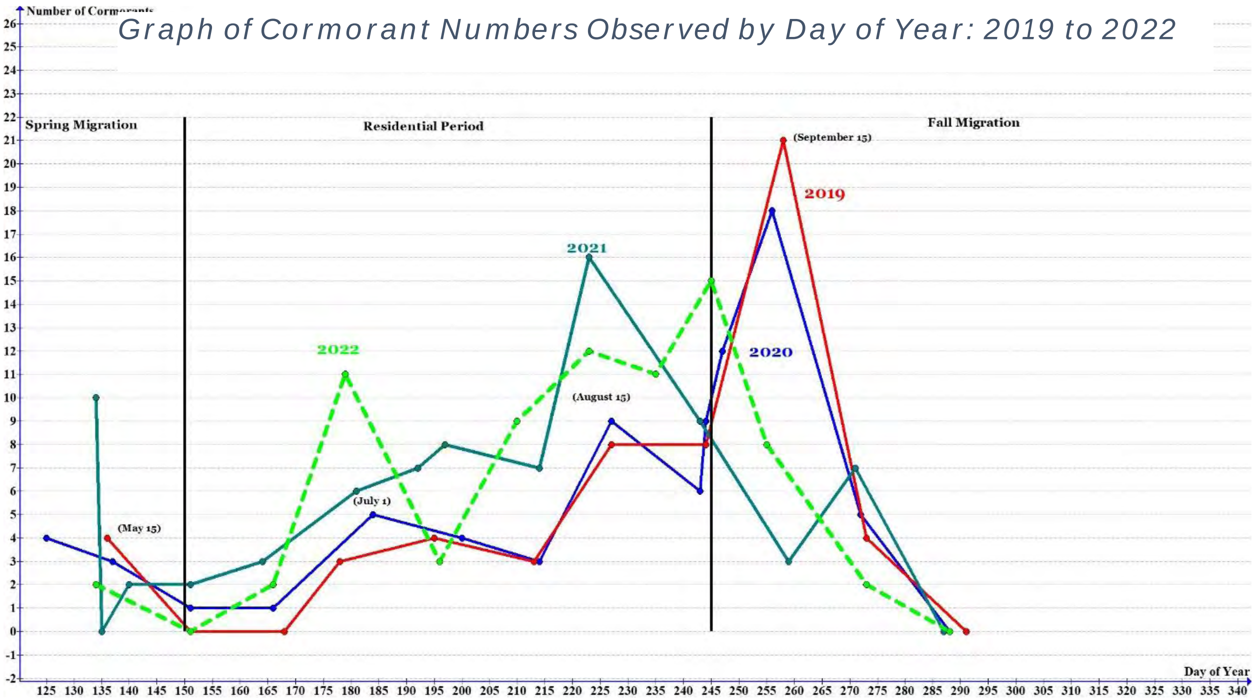
Nobody is calling for the extermination of cormorants, just control of populations 'where cormorant numbers are high'. The goal of our annual cormorant count is to establish baseline population numbers so that we can, in fact, determine when and by how much populations on White Lake are increasing.

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. Also, their roosting habits have changed and they now prefer sites in the southern part of the lake.

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 three consecutive years.



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. In 2021, we did not observe the higher numbers usually seen during the fall migration. It is possible that non-resident cormorants did not use White Lake this year, or they arrived and left during the two-week interval between counting dates.

Of greater interest are bird counts taken during the residential period. 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 about 10 to 12 cormorants making White Lake their home. This translates to a minimum of 5 to 6 nesting pairs producing less than 10 offspring, as reflected in the total cormorant count taken in mid-August.

It is clear from the above graph that cormorant numbers may be slowly increasing. 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.

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 and Information 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.