Consolidation of water quality data for the Cisco Chain of Lakes, historical to present.

Cisco Chain of Lakes- Vilas County, WI & Gogebic County, MI

2024

Created for the Cisco Chain Riparian Owners Association
By Many Waters, LLC

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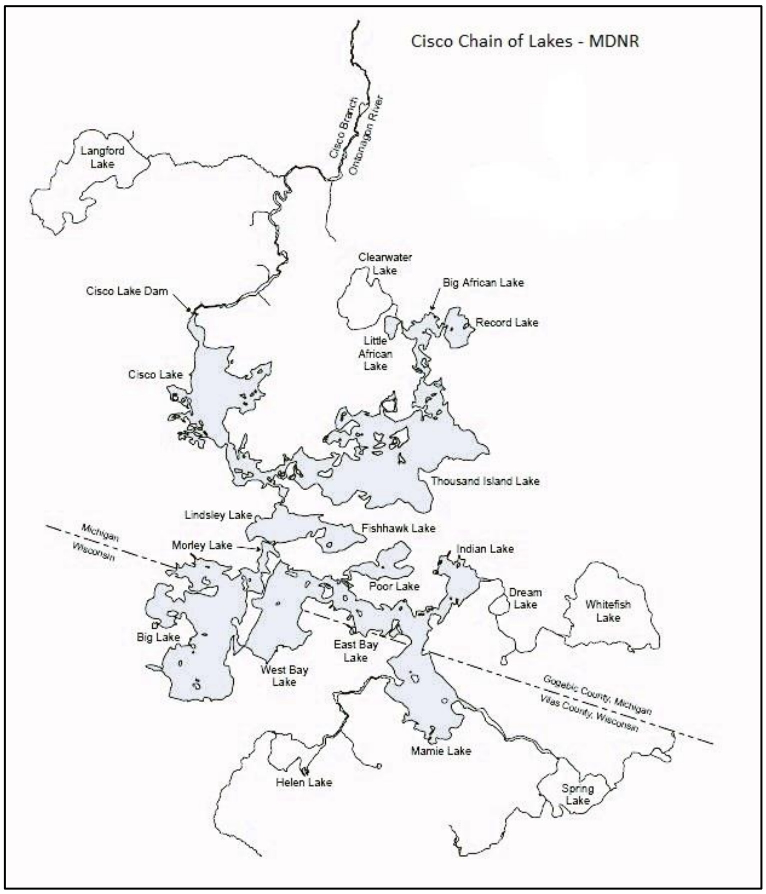
1.0 INTRODUCTION

The Cisco Chain is a system of fifteen lakes, totaling approximately 4,025 acres of water, and 270 miles of shoreline. Riparian ownership includes the Wisconsin Department of Natural Resources (WDNR), Michigan Department of Natural Resources (MDNR), State of Wisconsin Board of Commissioners, University of Notre Dame, USFS Ottawa National Forest, Michigan, and Wisconsin riparians. The lakes are relatively shallow, with Thousand Island Lake being the deepest at 90 feet. The fish community in the Cisco Lake Chain includes species such as walleye, northern pike, muskellunge, and various other fish families. The Cisco Chain is a destination for fishing, boating, snowmobiling, and other outdoor activities. There are five public and one private-pay access sites.



Historical logging operations originally dammed this system at the Cisco Lake outlet to the Cisco Branch of the Ontonagon River, allowing connectivity between the lakes and navigation for floating logs. In the early 1930s a permanent dam was constructed to store water for hydroelectric facilities at Victoria Dam. The dam currently does not serve any hydroelectric purpose but is still owned and maintained by the Upper Peninsula Power Company (UPPCO).

This document consolidates historical water quality data for the Cisco Chain of Lakes, summarizing current water quality condition. Water quality data is useful to resource managers and lake stewards to understand water quality trends and changes that may be occurring within the lake over time. Trends or changes to water quality may not be detectable unless there is a long-term record. For instance, MiCorps, the Michigan run volunteer water quality monitoring program, recommends at least eight years of data to analyze trends. The amount of data varies across the Chain, with the boarder lakes with Wisconsin generally having more data than lakes in Michigan. This difference is likely due to the availability of Wisconsin DNR programs for volunteer water quality monitoring and lake grants funding more data collection versus Michigan. In the past, for volunteers to participate in Michigan's water quality monitoring program they would have to travel downstate when the training was offered. This training now is often offered locally in person or can be completed virtually. Vilas County, Wisconsin also has a robust land and water conservation department with staff that specialize in water conservation and offer training and programs for lake health. Recently Michigan State University Extension has taken interest in the Western Upper Peninsula, providing technical assistance and information to lake groups on lake health and other water quality topics.

2.0 WATER QUALITY DATA OVERVIEW

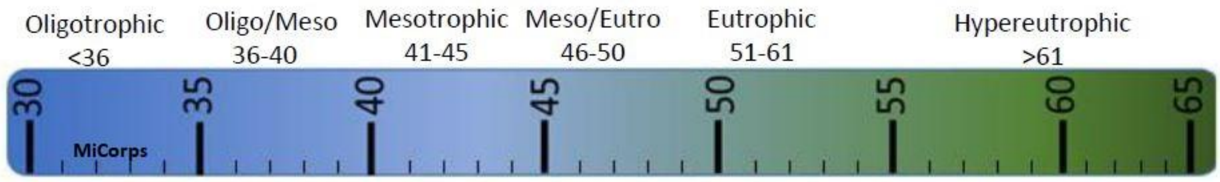
Michigan and Wisconsin, like most states, have statutory requirements to protect water quality, public health and welfare, and natural resources. In Wisconsin, the agency responsible for the State's waters is the Department of Natural Resources (WDNR). In Michigan, this responsibility is the Department of Environment, Great Lakes, and Energy – Water Resource Division (EGLE-WRD). EGLE-WRD and the Michigan Department of Natural Resources are two separate agencies. The mission of EGLE-WRD is to "keep water safe and clean," whereas the mission of MDNR is to "conserve, protect and manage the state's natural and cultural resources."

Both states routinely monitor water quality and both states have designated use criteria, which set the minimum protection status for surface water depending on its designated use. Examples of designated uses include navigation, agriculture, public water supply, aquatic life, or recreation. Depending on the state, designated uses and how they are classified are broken down by the type of surface water, such as a river versus an inland lake, and/or by the designated use. Many of these standards are written into the State's rules or codes, depending on the State.

For inland lakes, the three most common water quality measurements used to assess and track lake health over time are total phosphorus, chlorophyll *a*, and water transparency. These measurements are commonly used by the States in their assessments and are the three most common parameters included in citizen lake monitoring programs.

- **Phosphorous** is the nutrient most responsible for excessive aquatic plant and algae growth. Some sources of phosphorous are natural but many are from human activities on the lake and in the surrounding watershed. Total phosphorous in natural waters is often expressed as a concentration, for example milligrams/liter.
- Algae abundance is difficult to measure directly, so it is common to measure the green pigments or the **chlorophyll *a*** in algae, which is responsible for photosynthesis. Chlorophyll *a* values are also represented as a concentration, similar to phosphorous.
- **Water transparency**, or clarity, is measured using a secchi disc, which is an 8-inch disk painted black and white and attached to a long rope. Measurements are taken by lowering the disk into the water until it just disappears out of sight and then slowly raising the disk until it barely becomes visible. The average of the two depths is recorded, typically in feet. Water transparency is affected by several factors including the abundance of algae, (which can vary throughout the growing season,) and suspended materials such as silt and other particulate matter dissolved in the water.

Using water transparency, total phosphorous, and chlorophyll *a* measurements, a trophic status value for each parameter can be calculated. Based on those values, lakes are divided into three general categories: oligotrophic, mesotrophic, and eutrophic. Oligotrophic lakes are generally deep, clear lakes that are low in nutrients and have relatively few aquatic plants and algae. These lakes may support a desirable game fishery, but because they are low in nutrients, may not support a large fish population. Eutrophic lakes typically have high levels of nutrients, aquatic plants, and algae. Seasonal algae blooms and dense plant growth during certain times of the year are common. Moderate eutrophic lakes often support an abundant fish population, though winterkill can be a serious problem. Mesotrophic lakes fall in between oligotrophic and eutrophic lakes.



2.1 TROPHIC STATUS AND LAKE CLASSIFICAITON - WISCONSIN

Not all lakes are created equal. Lakes vary in size, depth, configuration, chemical properties, the types of fish and other aquatic life present. Drainage lakes have surface water inflow/outflow from a river or stream, whereas seepage lakes do not. Lakes at the top of watersheds generally have less land area draining into the lake, whereas lakes further down in the watershed generally have more land area draining into the lake. All these factors contribute to a lake's natural community type. Using this information, the WDNR will classify lakes with similar characteristics into natural community types. The main factors considered are the lake size, depth, surface water flow in or out and watershed characteristics. Using the natural community type compared to the lake condition or trophic status, the WDNR will describes a continuum of water quality conditions from "excellent" to "poor." Excellent means the water body fully supports designated uses whereas poor would mean a waterbody is not meeting water quality standards for a designated use. The three designated use criteria for the Wisconsin boundary lakes of the Cisco Chain are fish and aquatic life, recreation, and fish consumption.

Trophic Status Thresholds for Natural Community Types (Wisconsin)

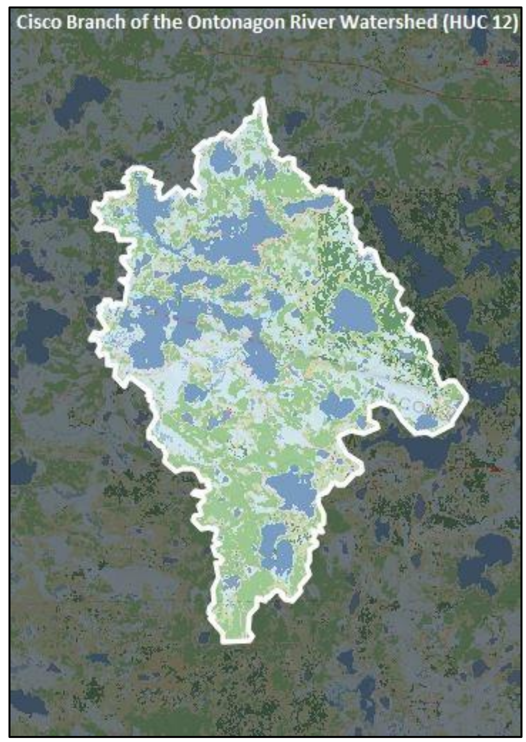
General Assessment Condition Level	Shallow			Deep			
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage	Two-Story
Excellent	<53	<53	<45	<48	<47	<63	<43
Good	53-61	53-61	45-57	48-55	47-54	43-52	43-47
Fair	62-70	62-70	58-70	56-62	55-62	53-62	48-52
Poor	≥71	≥71	≥71	≥63	≥63	≥63	≥53

2.2 TROPHIC STATUS AND LAKE CLASSIFICATION – MICHIGAN

Like Wisconsin, Michigan uses the TSI to assess and classify lakes. Between 2001 - 2010, 730 lakes greater than 25 acres with public access sites were assessed by EGLE and USGS. Over half of the lakes (54%) were mesotrophic, followed by eutrophic (24%), oligotrophic (18%). Four percent of lakes were considered hypereutrophic, with excessive nutrients. [1] Using a 'weight-of-evidence' approach to determine designated use support. Lakes classified as oligotrophic, mesotrophic, or eutrophic "are generally determined to support the aquatic life and wildlife designated use, unless other information exists that may be impaired. If a water body is determined to be impaired, Tier III monitoring is designed to monitor implementation practices designed to improve the water quality.

2.3 INFLUENCE OF WATERSHED ON LAKES AND WATER QUALTIY

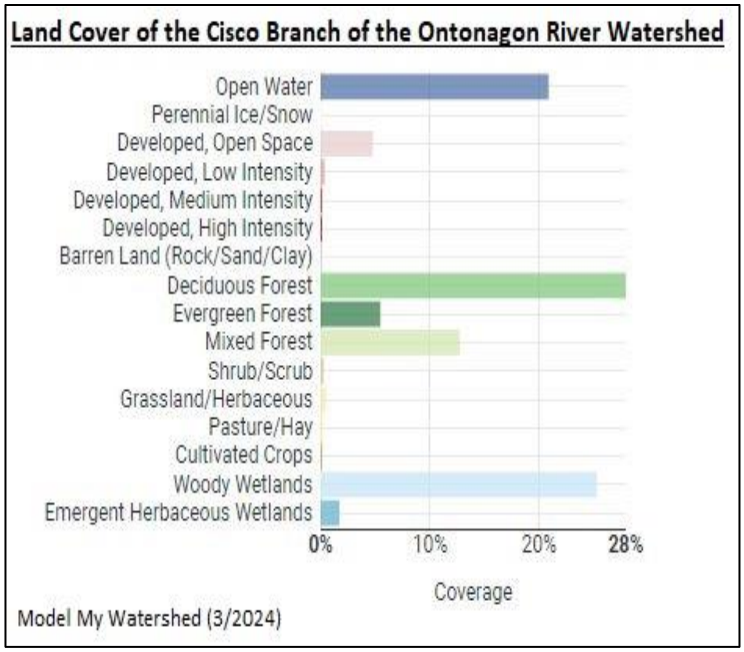
A watershed is an area of land where all water drains and collects at a central location, to a river or lake at a lower elevation. Land use in the surrounding watershed is important to lake health because water flowing across the land picks up pollutants such as nutrients and sediment that may run off into a stream or lake. Pollutants are broadly categorized as point sources and non-point sources. Point sources originate from a distinct location, such as a wastewater treatment plant; they are traceable to the source. Point sources are often monitored with state and federal permit requirements. Non-point sources do not originate from a distinct location. These sources typically come from precipitation and run-off but can come from groundwater. An example of non-point pollution is water running down a driveway or across a lawn into the lake. Heavily forested watersheds infiltrate precipitation better than urbanized or agricultural watersheds due to impervious surfaces and compacted soils, which create more run-off.



Factors that contribute to the amount of nutrients and other pollutants that enter a lake include the size of the watershed and land cover/land use within the watershed. The drainage area to lake area ratio (DA/LA) looks at how many acres of land drains to each surface water acre of a lake. Lakes with large ratios (7-10 acres of land drainage per acres of water) typically have more inflow of nutrients and pollutants than lakes with relatively small ratios (Holdren, 2001). In addition, lakes with large ratios will typically have shorter residence times, allowing nutrients and

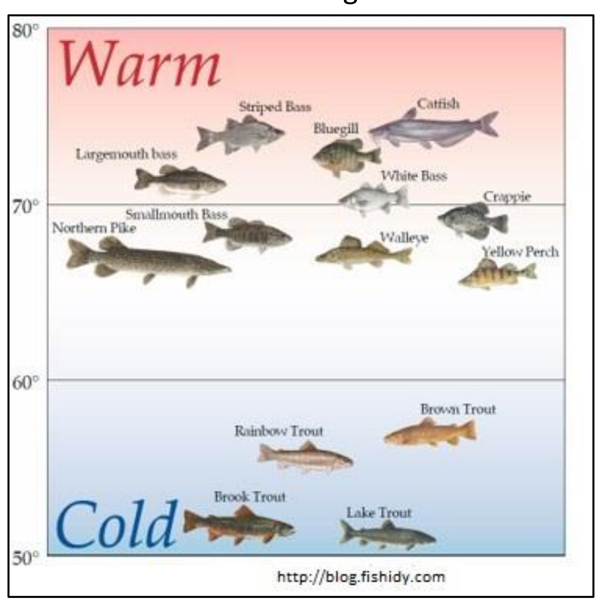
[1] MI/EGLE/WRD-22/001

other pollutants to flush out. Lakes with small ratios typically have much longer residence times, holding pollutants, and other nutrients longer. In these cases, land practice improvements to mitigate water quality issues may take many years to see any change in water quality. In our subject watershed, the Cisco Branch Ontonagon River HUC 12 Sub-watershed, about 8 acres of land drain into the Cisco Chain of Lakes for every acre of surface water. This ratio suggests that land within the watershed <u>does</u> play a significant role in water quality. The Cisco Chain, being a reservoir system, will have shorter residence times. According to the WDNR, Big Lake and Mamie Lake have median summer residence times in days of 220 and 130 days respectively.



2.4 FISHERIES AND WATER QUALITY

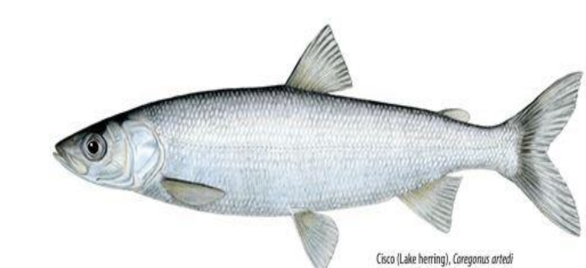
Most aquatic life depends on oxygen, making it one of the most important dissolved gases in a lake. The amount of dissolved oxygen present in a lake is influenced by winds (which mix lake water – exposing it to the atmosphere), groundwater, amount of surface water entering a lake, and biological activity. A deeper lake (e.g. Thousand Island Lake at 88 ft) will thermally stratify, separating warmer surface waters from deeper cooler waters, affecting dissolved oxygen. In lakes that strongly stratify, the water above the thermocline remains oxygenated due to continued mixing with the atmosphere and oxygen production by plants and algae. Below the thermocline, the waters are cooler, and oxygen levels will decline throughout the summer months due to lack of atmospheric input and respiration from organisms that consume oxygen. In shallow lakes (e.g, East Bay and Mamie Lakes), the water continuously mixes, and dissolved oxygen and temperature will remain similar from top to bottom, depending on the time of year.



Cold water holds more dissolved oxygen than warm water and in lakes the temperature and dissolved oxygen will vary over the season. In winter and early spring, the water temperature is low, and the dissolved oxygen is high. In summer and fall, when the water temperature is high, the dissolved oxygen will often be lower. Fisheries will often refer to this oxygen and temperature relationship as the oxy-thermal habitat. Fish that require more oxygen are generally adapted to live and thrive in cool water, think of lake trout or salmon. Whereas other fish can thrive in warmer-less oxygenated waters, such as panfish, bass, and northern pike. A general rule of thumb is for lakes to have at least 5 mg/l of dissolved oxygen to support fish.

You can think of a lake as a fish's home. Some homes are large and some small, some are kept warm and others cool. Other homes may have a lot of furniture and types of flooring, whereas some may be minimal. As homes are different so are the types of habitats that fish reside in. Certain fish have very specific habitat requirements, whereas other fish may be able to live in a wider variety of habitats. Temperature, dissolved oxygen, bottom structure, inlets/outlets and aquatic vegetation all play a role in a fish's home or habitat. For example, northern pike prefer shallow, marshy habitats with vegetation to spawn. Many times, this is near an inlet or outlet to a lake. Whereas walleye will prefer shallow cobble or gravel that is windswept to spawn. The Cisco Chain is a large system of interconnected lakes, providing a variety of habitats for different fish species. Though the Cisco Chain is an interconnected water system, giving fish the ability to move from one lake to another, the MDNR considers the Cisco Chain to have two distinct walleye populations. One population resides on the northern portion of the chain whereas the other, the southern portion. Cisco, Thousand Island, Little and Big Africa, Record, Lindsley and Fishhawk lakes are the waters for the northern population, whereas the remaining lakes are considered the southern population.

The MDNR considers Thousand Island a Cisco Lake. Only about 156 lakes in Michigan can support cisco. Cisco require deep, clear lakes providing optimal oxythermal habitat, including high oxygen concentration and cool water. These lakes, sometimes referred to as two-story lakes are generally deep, stratify, and provide cool water that maintains adequate oxygen in the deeper to support cold-water fish species, while the warmer upper layers of water support warm water fish.



Michigan Sea Grant - Cisco Restoration in Lake Michigan

Cisco (Lake herring), *Coregonus artedi*
ILLUSTRATION: EMILY DAMSTRA

Another important fish consideration is habitat. Bottom habitat such as cobble, gravel, or large woody debris have a direct effect on the protection of developing eggs and young plus adult feeding success and protection from predators for survival. Aquatic plant structure is also an important part of habitat. Habitat changes can be natural, such as the gradual filling in of shallow bays. However, it is most often exacerbated by human activities. Loss of habitat can occur in many forms. The filling in of marsh areas bordering lakes and streams destroys critical spawning habitat and diminishes the filtering capacity of the wetland, resulting in poorer water quality. Increasing shoreline development, sea-wall construction, and in-lake modifications, such as benthic barriers and the removal of aquatic vegetation, greatly change or destroy the near-shore areas of our lakes and streams. These shallow areas, known as littoral zones, are important for egg deposition, nursery and hiding areas for newly hatched fish, and as food production areas for juvenile fish and their prey items.

3.0 SUMMARY OF WATER QUALITY FOR THE CISCO CHAIN OF LAKES

3.1 SOURCES OF DATA

For each point of data included in this report, the source and date of access is recorded. Most of the recent data from the Michigan lakes came from the MiCorps volunteer water quality monitoring program. Older data collected for Michigan came from a variety of sources including MDNR fisheries, USGS Storet, and hired contractors. Data for the boundary water lakes with Wisconsin includes MiCorps, hired contractors, and the Wisconsin SWIMS (surface water integrated monitoring systems) database. Most of the data for Wisconsin lakes came from SWIMS.

3.2 LAKE NATURAL COMMUNITY TYPE AND CONDITION

Though Michigan does not use a natural community type designation, a summary of what the natural community for Michigan lakes might be is outlined below. Stratification status is determined by using an equation developed by WNDR that considers the depth and size of the lake. Lakes with values equal to or less than 3.8 are predicted to be mixed or shallow lakes. Whereas lakes with values greater than 3.8 are predicted to be deep and stratified. Some lakes that hover near the 3.8 value may intermittently stratify. Being a reservoir, all lakes on the Cisco Chain are considered drainage lakes. These lakes have surface water inflow and/or outflow. Headwater drainage lakes have a watershed area greater than four square miles draining into the lake, whereas lowland drainage lakes have 4 or less square miles of watershed drainage. Thousand Island, being a cisco lake, is a unique natural community and will receive an additional classification of two-story fishery. These lakes have the potential to support cold-water fish species with cool well oxygenated water. Most lakes on the Cisco Chain, using the Wisconsin lake natural community classification, are considered excellent to good.

Lake Name	Lake Size (Acres)	Max Depth (Ft)	Stratification Status	Natural Community Type (Wisconsin)	Condition Level Based on TSI Thresholds for Natural Community Types (Wisconsin)
Little Africa Lake	22	12	Mixed-shallow	Shallow Lowland	Excellent
Morley Lake	59	17	Mixed -shallow	Shallow Lowland	Excellent
Big Africa Lake	65	27	Deep-stratified	Deep Lowland	Good
Record Lake	68	20	Deep-stratified	Deep Lowland	Excellent
Fishhawk Lake	77	22	Deep-intermittent stratified	Deep Lowland	Good
Poor Lake	106	41	Deep-stratified	Deep Lowland	Excellent
Indian Lake	129	16	Mixed-shallow	Shallow Lowland	Excellent
Lindsley Lake	155	28	Deep-stratified	Deep Lowland	Excellent
Clearwater Lake	176	14	Mixed-shallow	Headwater Lowland	Excellent
East Bay Lake	252	12	Mixed-shallow	Shallow Lowland	Good
Mamie Lake	337	15	Mixed-shallow	Shallow Lowland	Excellent
West Bay Lake	417	31	Deep-stratified	Deep Lowland	Good
Cisco Lake	506	20	Mixed-shallow	Shallow Lowland	Good
Big Lake	780	30	Mixed -shallow	Shallow Lowland	Excellent
Thousand Island Lake	1078	88	Deep-stratified	Deep-Lowland/Two-Story Fishery	Excellent

3.3 LAKE DATA AND CLASSIFICATIONS

Most lakes on the Cisco Chain fall within the mesotrophic to meso-eutrophic classification for productivity. The graph below represents the average TSI for all parameters for all year where data is available. Poor Lake, being the most nutrient limited of the lakes on the Chain, sits along the oligotrophic end, whereas East Bay Lake is at the upper end of eutrophic.

TSI Scale	Oligotrophic	Oligo/Mesotrophic	Mesotrophic	Meso/Eutrophic	Eutrophic
	<36	36-40	41-45	46-50	51-61
Poor Lake		■			
Record Lake			■		
Thousand Island Lake			■		
Lindsley Lake			■		
Clearwater Lake				■	
Fishhawk Lake				■	
Big Africa Lake				■	
Indian Lake				■	
West Bay Lake				■	
Morley Lake				■	
Big Lake					■
Little Africa Lake					■
Cisco Lake					■
Mamie Lake					■
East Bay Lake					■

Using a combination of 2023 MiCorps individual lake report summaries and data available for the three TSI parameters, a Pearson's correlation coefficient (α 0.05) measured the strength of the linear relationship. This analysis sought to identify potential water quality trends and does not take the place of a robust statistical analysis, which is outside the scope of this report. Only data with significant results have the Pearson's *r* value reported.

Thousand Island Lake

In the 2023 MiCorps individual report for Thousand Island, the summary indicates a "slow movement toward lower nutrients" in Thousand Island Lake over time. Lower nutrients usually correlate to increases in water clarity, which is evident in the graphs below.

While not seen in other lakes in the Chain, cisco, members of the trout and salmon family, are present in Thousand Island Lake and are considered a refugium species. Refugium species are living in a location that supports an isolated or relic population of a once more widespread species. It is believed cisco may have arrived here from a pre-glacial connection to Pacific Northwest waters and are now living in the midwater (pelagic) regions of the Great Lakes and high- quality inland lakes. Cisco spawn in the late fall, about the time surface ice forms. Eggs fall to the bottom and develop over winter to hatch in the spring. During the 19th and 20th centuries, cisco made up a significant part of the Great Lakes commercial fishery, but their numbers have dropped drastically, at least partly due to the introduction of invasive alewives and rainbow smelt, which deplete the zooplankton upon which cisco feeds.

During the summer months when Thousand Island stratifies, cisco will need cool oxygenated water, located deeper in the water column. Their oxy-thermal habitat preference is water cooler than 60 ˚Fahrenheit and dissolved oxygen levels above 3 mg/l.[2] Cisco will rarely be found in water temperatures greater than 68˚ Fahrenheit and dissolved oxygen levels below 3 mg/l.[3] According to the MDNR Status of the Fishery Resource Report for Thousand Island Lake, the mid-summer thermocline occurred at approximately 17 to 26 feet, with dissolved oxygen levels too low to support fish below 50 feet during the sampling period[4]. More recent dissolved oxygen and temperature monitoring, though limited, suggests that 5 mg/l of oxygen, typically the lower end of the dissolved oxygen level needed to support most fish species, is reached at 20 to 23 feet of depth in Thousand Island Lake.

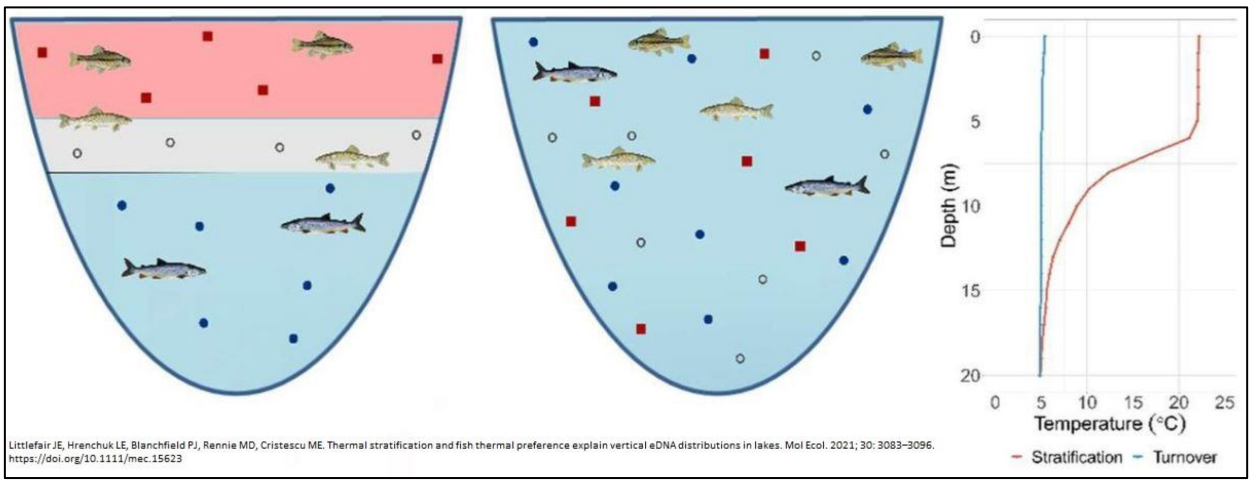
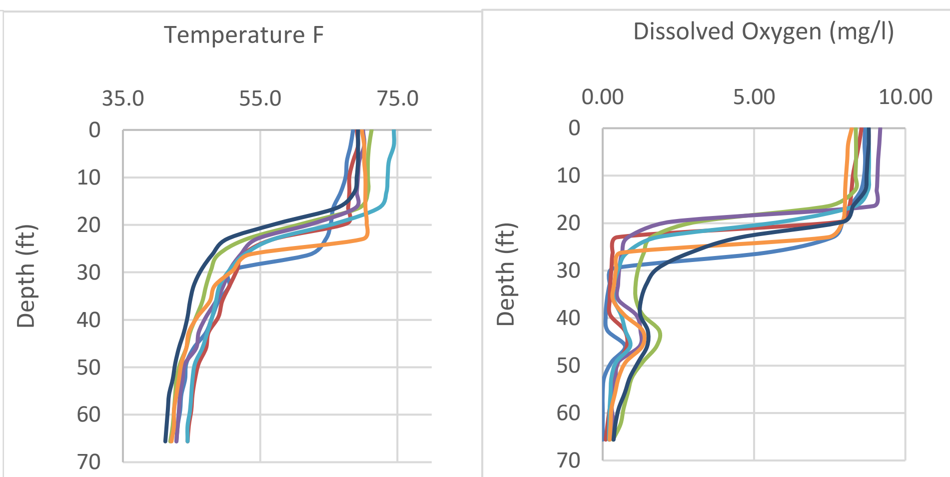


Figure 3.4.1: Summer temperature and dissolved oxygen profiles for Thousand Island Lake, 2015 – 2023.



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[2] Distribution and abundance of lake herring (*Coregonus artedi*) in Michigan. Michigan Department of Natural Resources. Fisheries Research Report No. 2014, 1995.

[3] MI/EGLE/WRD-22/001

[4] *Michigan Department of Natural Resources Status of the Fishery Resource Report 93-10, 1993.*

Table 3.4.1: Summer temperature and dissolved oxygen profiles for Thousand Island Lake, 2015 – 2023. (Blue shades indicated thermocline with 1˚ C or greater change in water temperature.)

	8/30/2015		8/24/2017		8/26/2018		8/23/2019		8/26/2021		8/29/2022		8/26/2023	
Depth (ft)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)	Temp (F)	DO (mg/l)
0	68.5	8.67	69.1	8.55	71.2	8.36	70.0	9.17	74.5	8.77	69.8	8.23	69.3	8.79
3	68.2	8.65	69.3	8.47	70.9	8.37	70.2	9.14	74.5	8.79	70.2	8.11	69.3	8.79
7	67.6	8.67	68.5	8.37	70.7	8.37	69.4	9.10	73.8	8.80	70.2	8.08	69.3	8.75
10	67.5	8.64	68.0	8.27	70.7	8.35	69.3	9.08	73.6	8.79	70.3	8.04	69.1	8.72
13	66.7	8.53	68.0	8.22	70.7	8.33	69.1	9.05	73.4	8.76	70.3	8.01	68.7	8.67
16	65.7	8.19	67.8	8.15	69.4	7.46	68.9	8.94	72.3	8.33	70.3	8.00	66.2	8.27
20	65.3	7.93	67.6	7.90	61.3	3.14	62.8	2.28	66.0	5.94	70.5	7.92	57.6	7.95
23	64.6	7.60	57.0	0.48	53.1	1.61	54.5	0.84	57.0	1.81	70.0	7.45	50.2	4.57
26	62.2	5.37	52.5	0.33	48.9	1.36	52.2	0.64	52.7	0.80	53.4	0.60	48.0	2.88
30	50.7	0.36	51.6	0.29	47.8	1.18	50.5	0.55	50.5	0.53	51.1	0.45	46.4	1.82
33	50.5	0.23	50.5	0.25	47.1	1.09	49.6	0.51	49.1	0.38	48.4	0.38	45.3	1.45
36	48.9	0.14	49.5	0.23	46.6	1.10	48.6	0.51	48.6	0.37	47.7	0.34	44.8	1.27
39	48.0	0.10	48.9	0.25	45.7	1.33	47.1	1.11	48.0	0.61	45.9	0.72	44.4	1.24
43	47.1	0.16	47.5	0.73	44.8	1.87	46.0	1.25	47.3	0.75	44.6	1.32	43.9	1.49
46	45.3	0.74	47.1	0.80	44.2	1.78	45.7	1.22	46.6	0.91	44.2	1.31	43.2	1.47
49	44.2	0.30	46.0	0.52	43.3	1.33	44.1	0.52	45.5	0.45	43.5	0.77	42.6	1.18
52	44.1	0.05	45.5	0.37	42.8	0.97	43.7	0.43	45.1	0.29	43.2	0.53	42.3	0.90
56	43.5	0.00	45.1	0.30	42.6	0.83	43.3	0.35	45.0	0.26	42.8	0.41	41.7	0.73
59	43.3	0.00	45.0	0.23	42.4	0.69	43.2	0.30	44.8	0.23	42.4	0.29	41.5	0.53
62	43.0	0.00	44.6	0.16	42.3	0.59	43.0	0.36	44.4	0.22	42.4	0.26	41.4	0.42
66	42.8	0.00	44.4	0.10	41.9	0.34	42.8	0.23	44.4	0.21	42.1	0.23	41.2	0.36

Figure 3.4.2: Thousand Island Lake - trophic status indices by year.

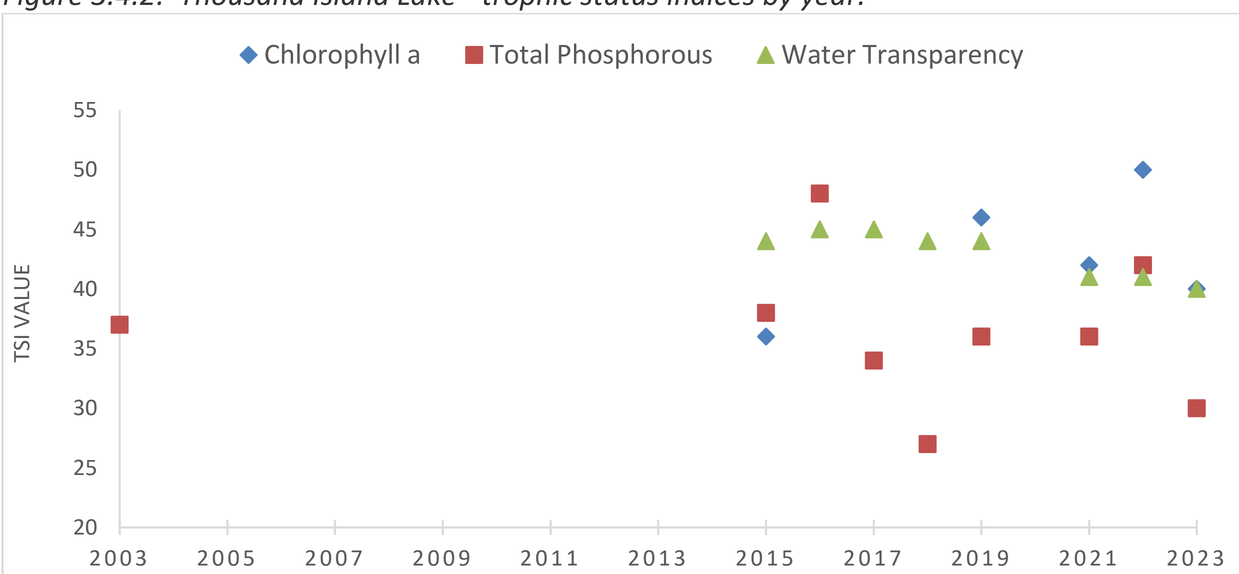


Figure 3.4.3: Thousand Island Lake – secchi depths by year.

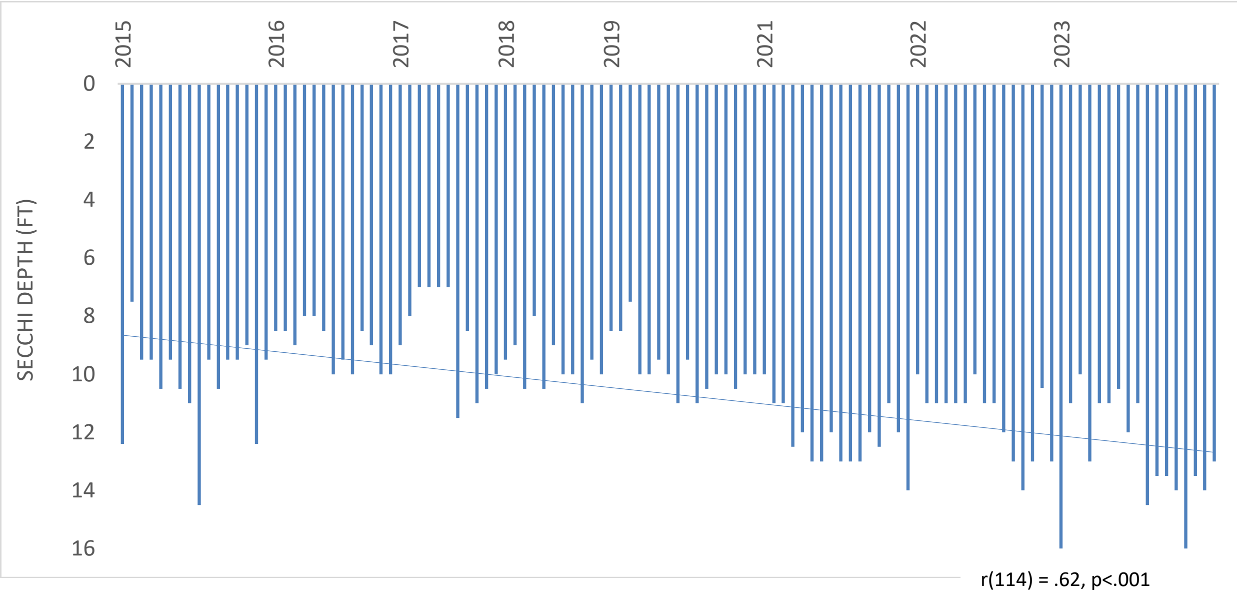
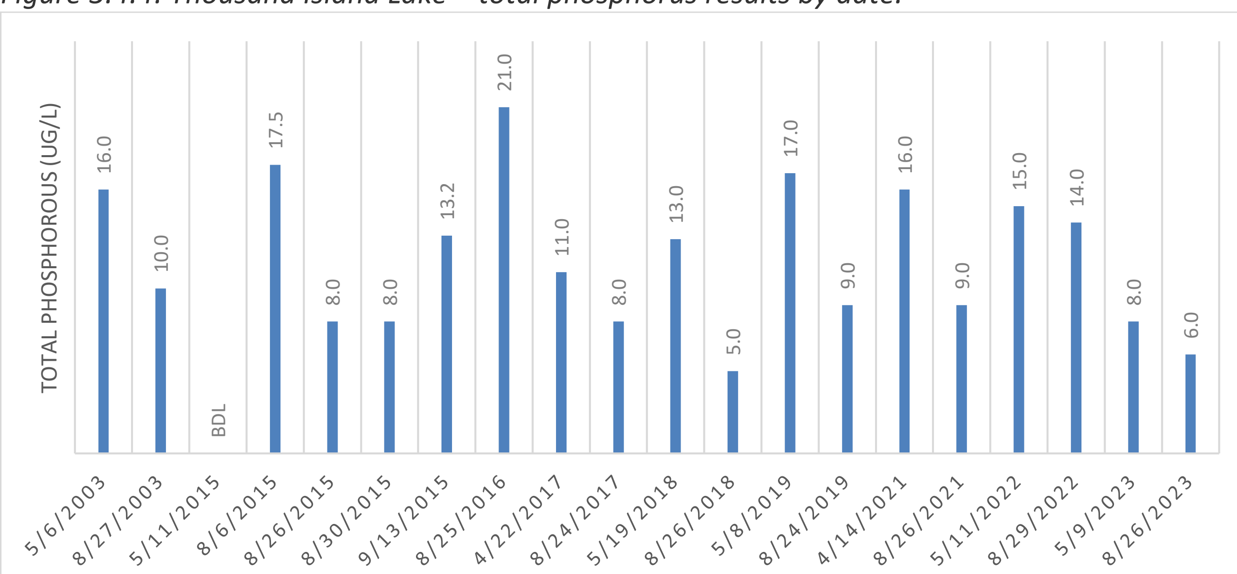


Figure 3.4.4: Thousand Island Lake – total phosphorus results by date.



Lindsley Lake

In the 2023 MiCorps individual report for Lindsley Lake, the report summary indicates a "slow movement toward lower nutrients and TSI values." Lower nutrients usually correlate to increases in water clarity. Monitoring suggests an increase in water clarity, and declining summer total phosphorous, though total phosphorous results are not significant.

Figure 3.4.5: Lindsley Lake - trophic status indices by year.

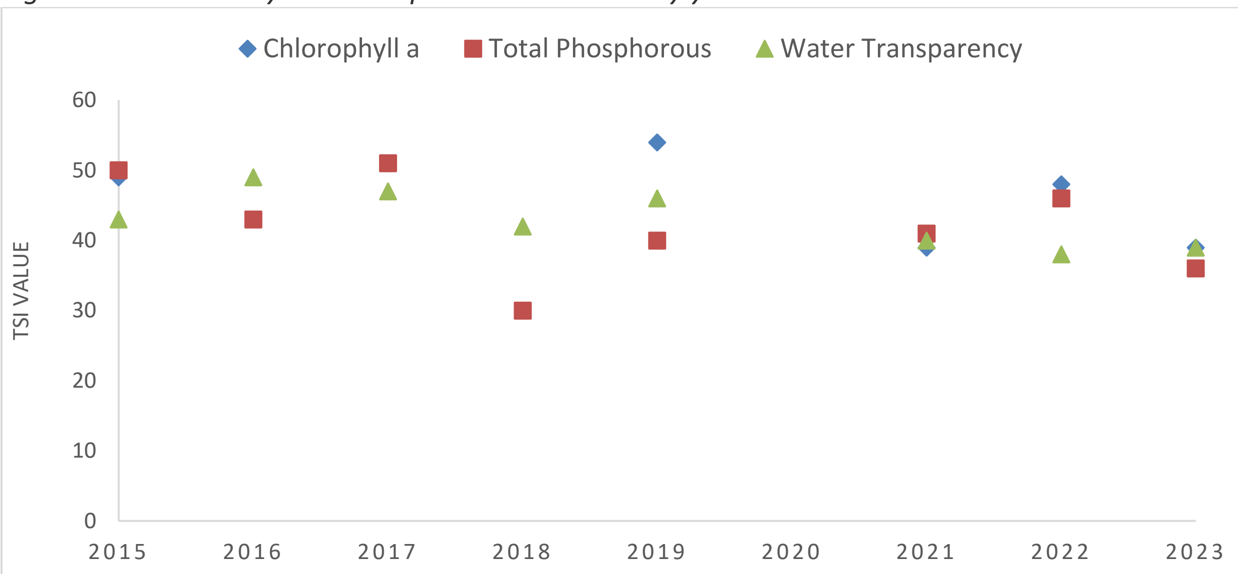


Figure 3.4.6: Lindsley Lake – secchi depths by year.

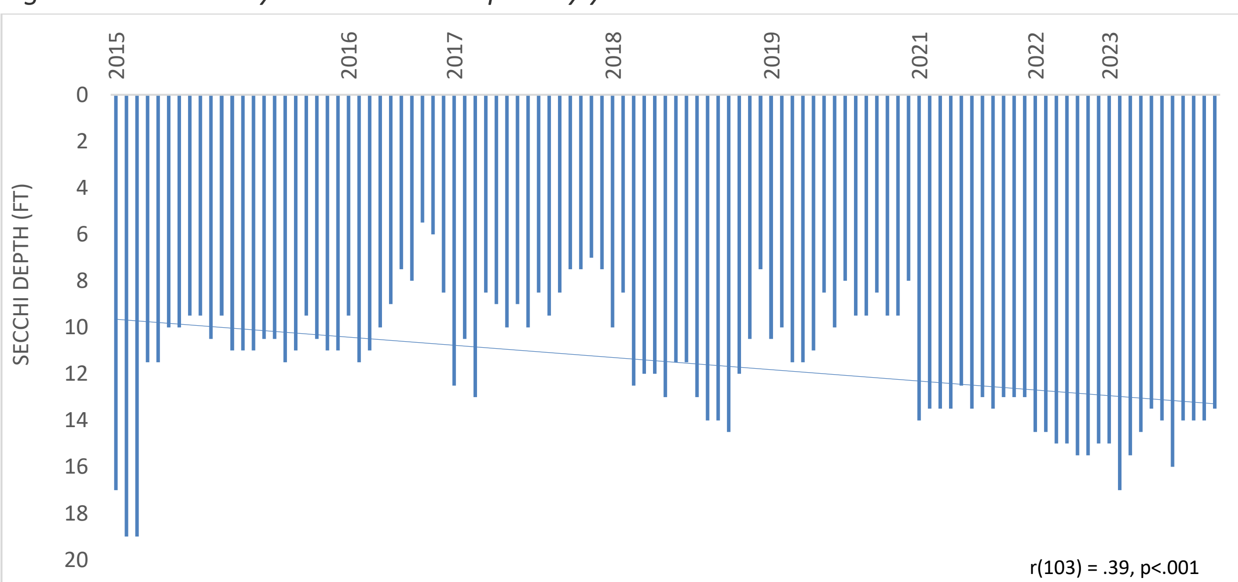


Figure 3.4.7: Lindsley Lake – total phosphorus results by date.

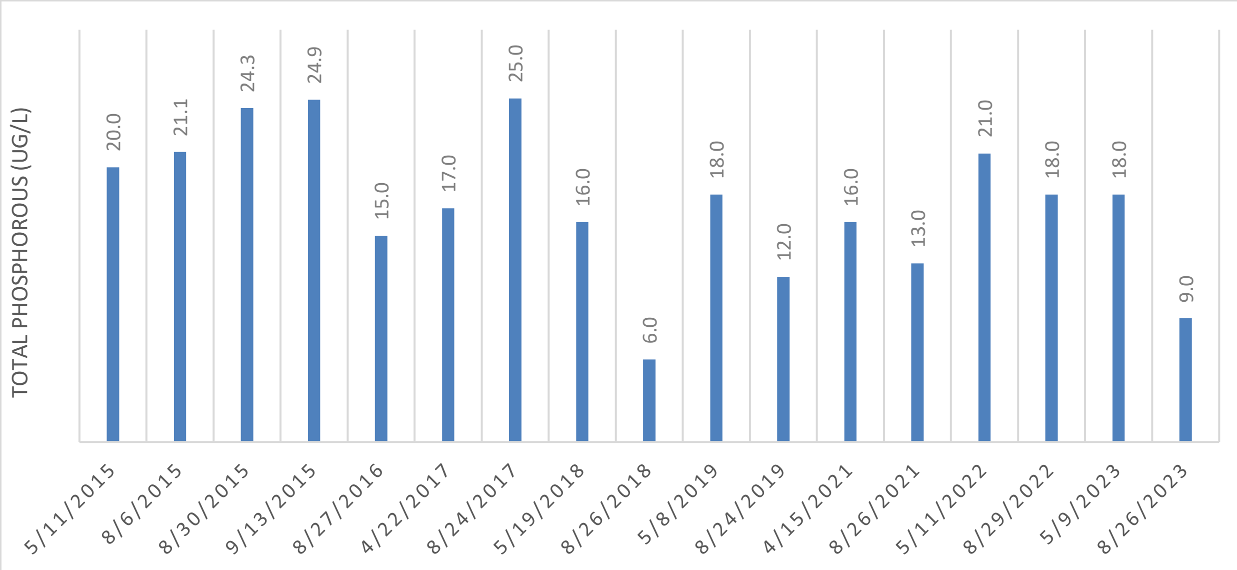
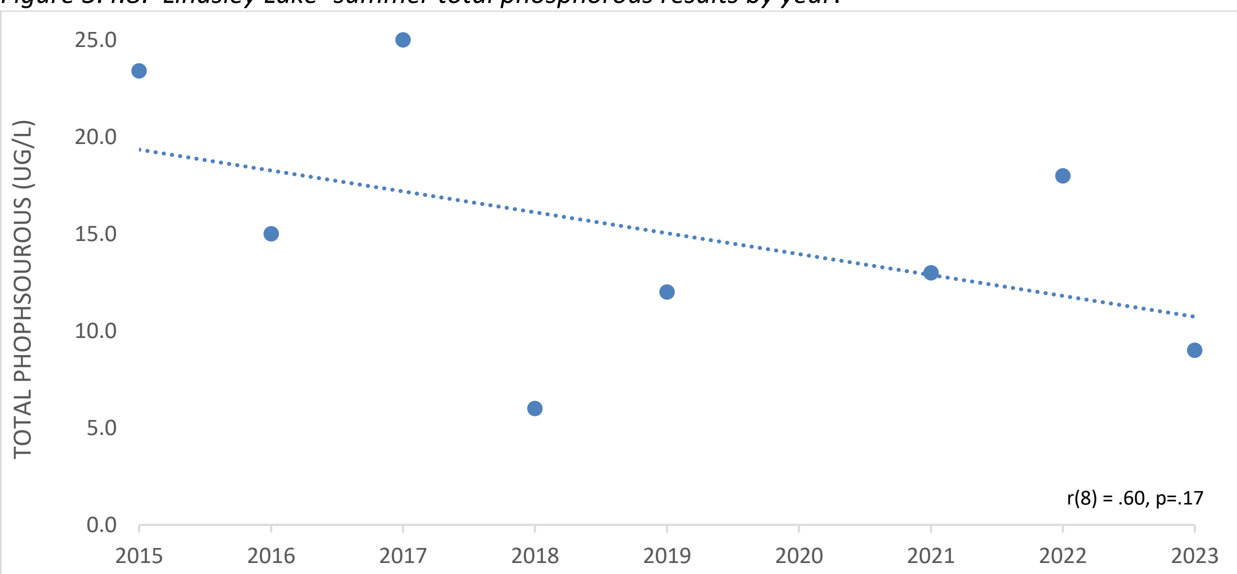


Figure 3.4.8: Lindsley Lake -summer total phosphorous results by year.



Clearwater Lake

Clearwater Lake is connected to Little Africa Lake through a non-navigable channel. According to MiCorps, water quality data for Clearwater is limited, with the longest record being for secchi, beginning in 2013. Though the data is limited, it does appear that spring phosphorus levels are decreasing.

Figure 3.4.9: Clearwater Lake - trophic status indices by year.

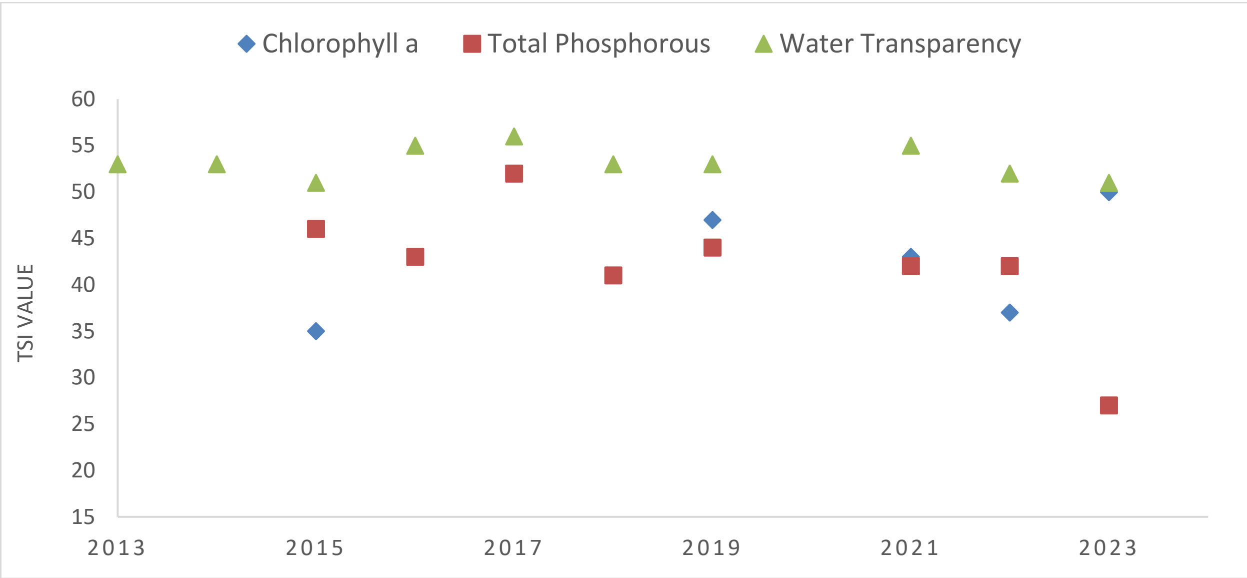


Figure 3.4.10: Clearwater Lake – secchi depths by year.

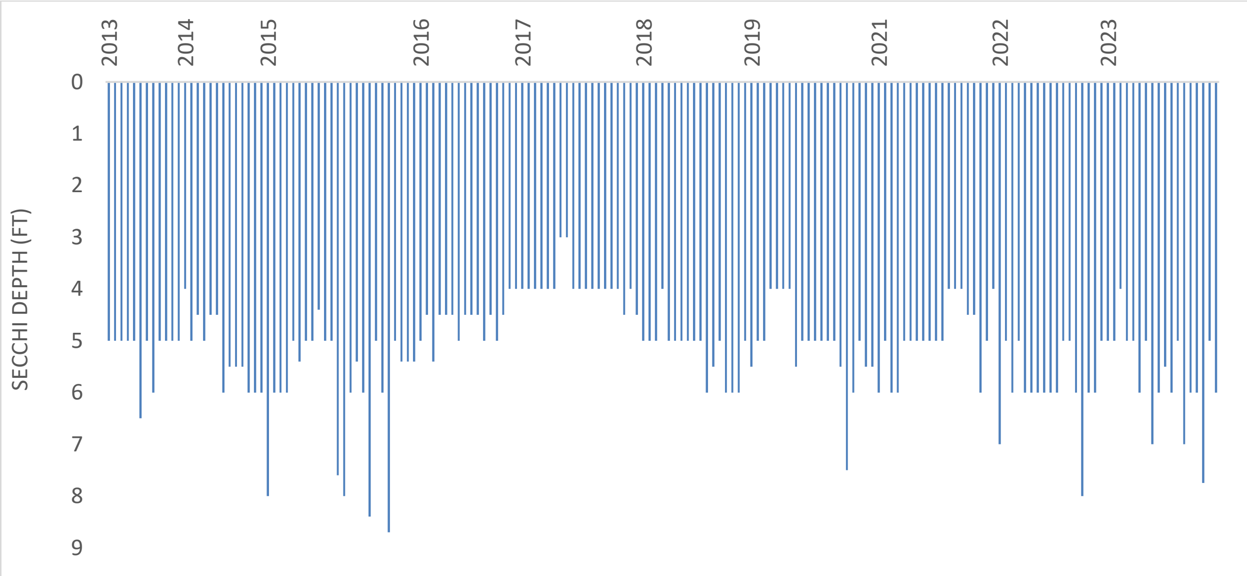


Figure 3.4.11: Clearwater Lake – total phosphorus results by date. (BDL is below detectable levels.)

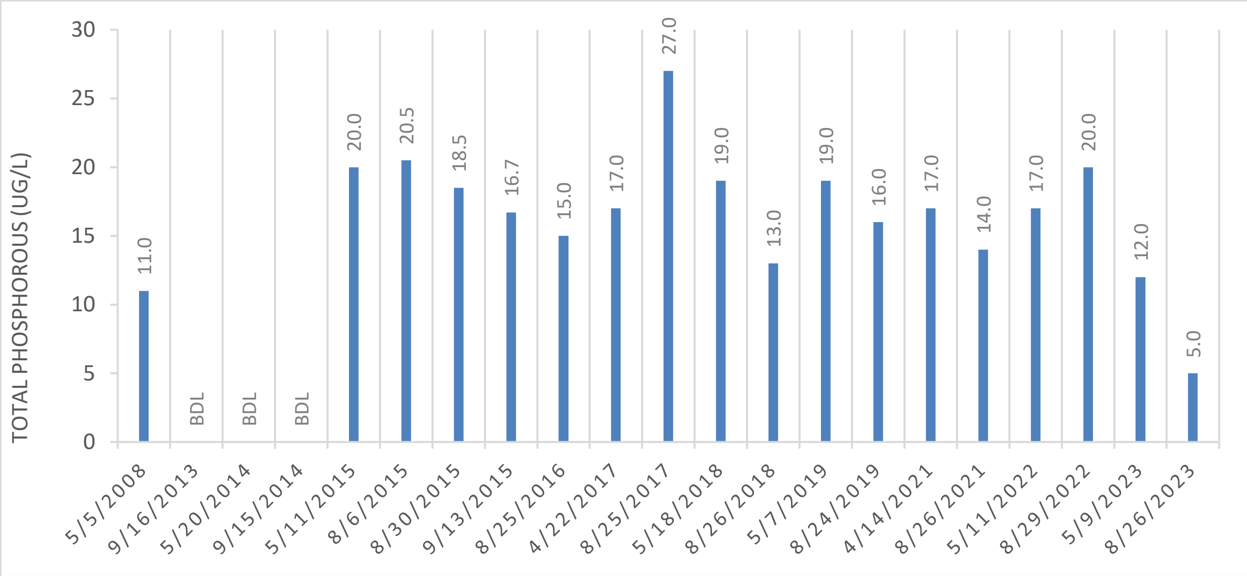
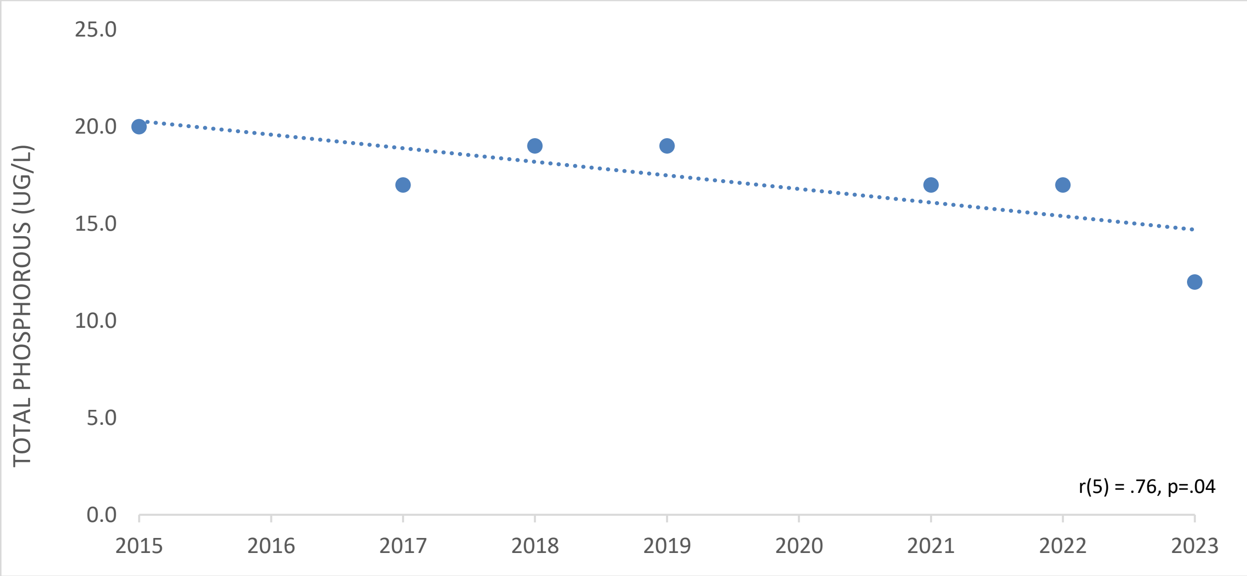


Figure 3.4.12: Clearwater Lake – spring turnover total phosphorus results by year.



Big Africa Lake

Big Africa Lake is accessed through a channel connected to Thousand Island Lake, at the far northeast end of the Chain. The shoreline is primarily forested, with most land being publicly owned by the USFS Ottawa National Forest. Water quality data for Big Africa is limited, with the longest record being for secchi (water clarity), beginning in 2017. Though limited, it does appear that water clarity has been increasing. More monitoring data for water clarity may lend support to the evidence of any changes taking place. Big Africa is enrolled in the MiCorps program, which requires eight secchi reading per year to be considered acceptable data. The last year of eight readings occurred in 2018, and only three readings were recorded in 2023.

Figure 3.4.13: Big Africa Lake - trophic status indices by year.

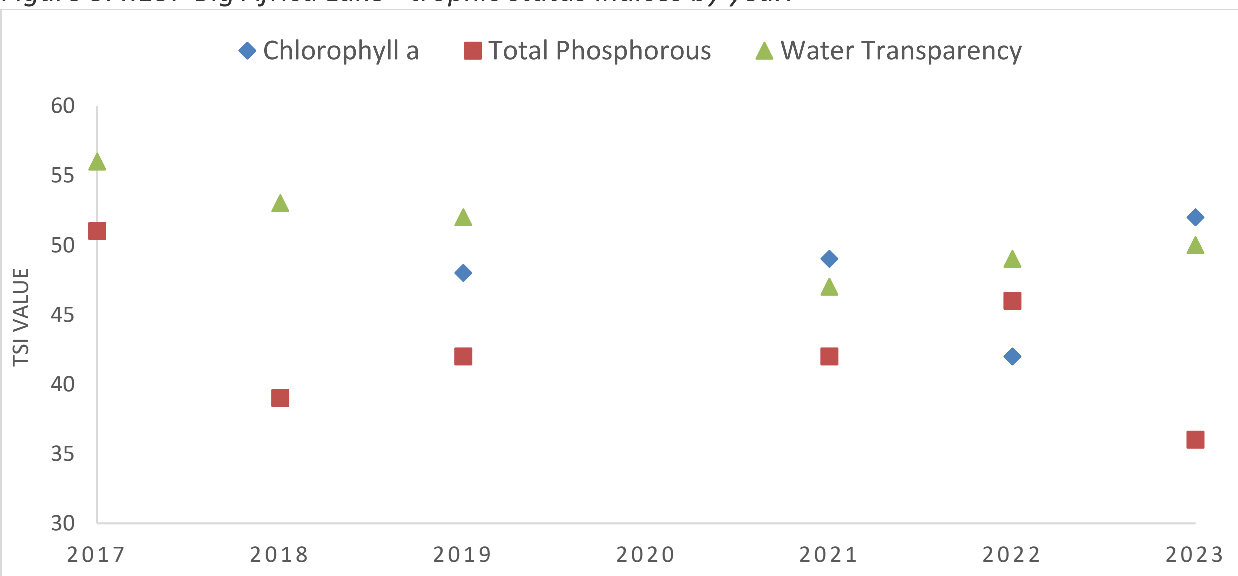


Figure 3.4.14: Big Africa Lake – secchi depths by year.

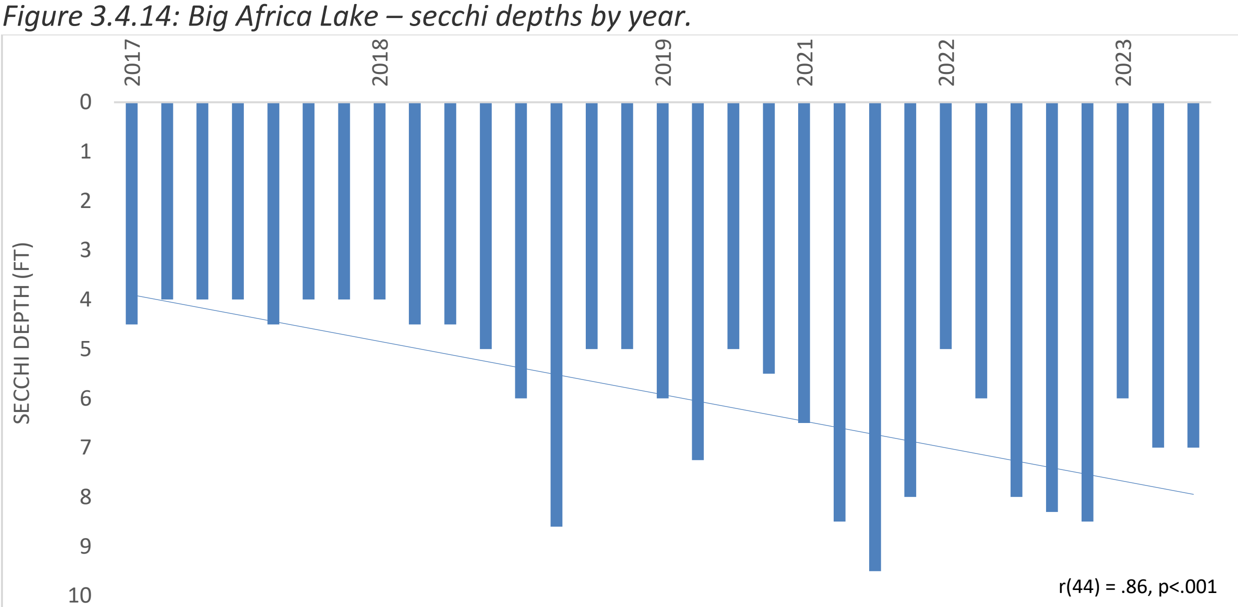
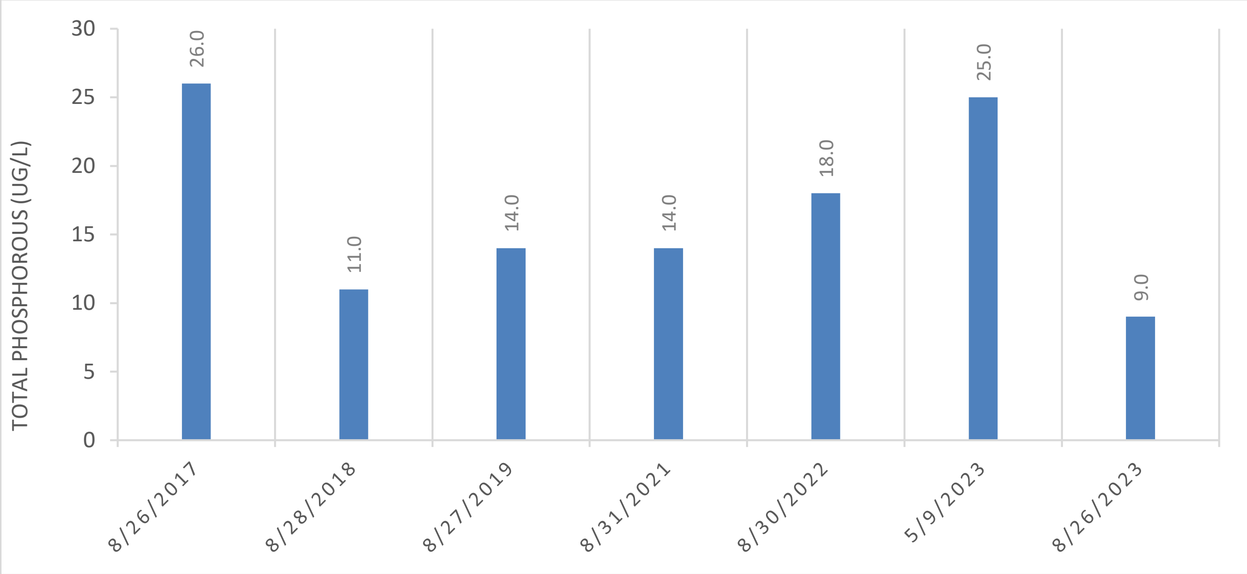


Figure 3.4.15: Big Africa Lake – total phosphorus results by date.



<u>*Record Lake*</u>

Record Lake is accessed through a channel from Big Africa Lake, at the far northeast end of the Chain. The shoreline is primarily forested, with most land being publicly owned by the USFS Ottawa National Forest. Water quality data for Record is limited, with the longest record being for secchi, beginning in 2017. Though limited, it does appear that water clarity has been increasing.

Figure 3.4.16: Record Lake - trophic status indices by year.

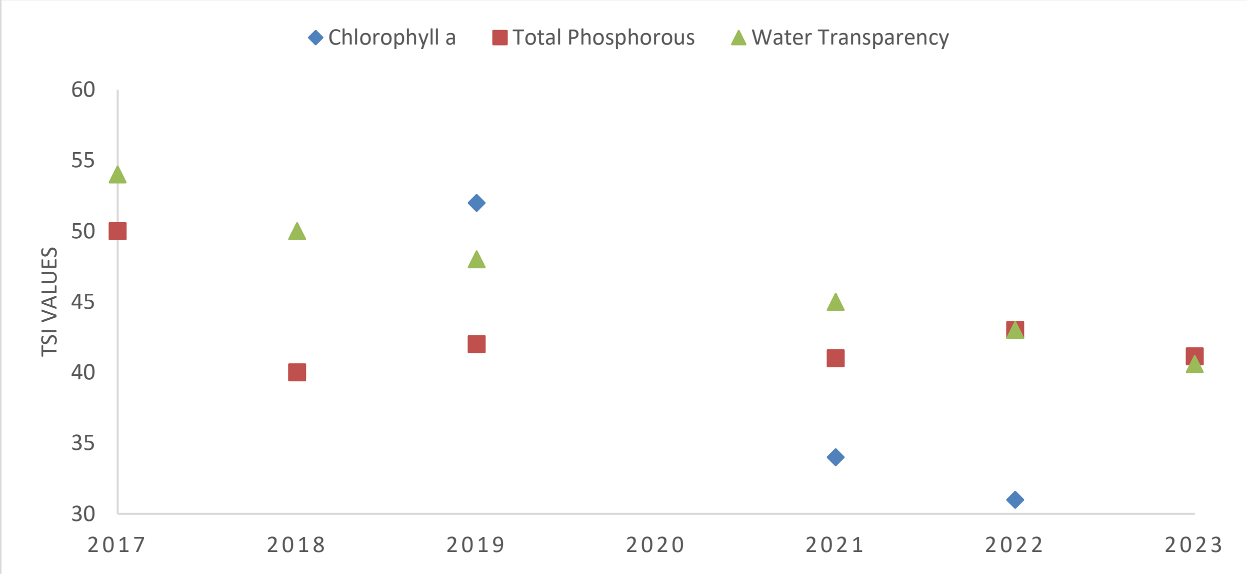


Figure 3.4.17: Record Lake – secchi depths by year.

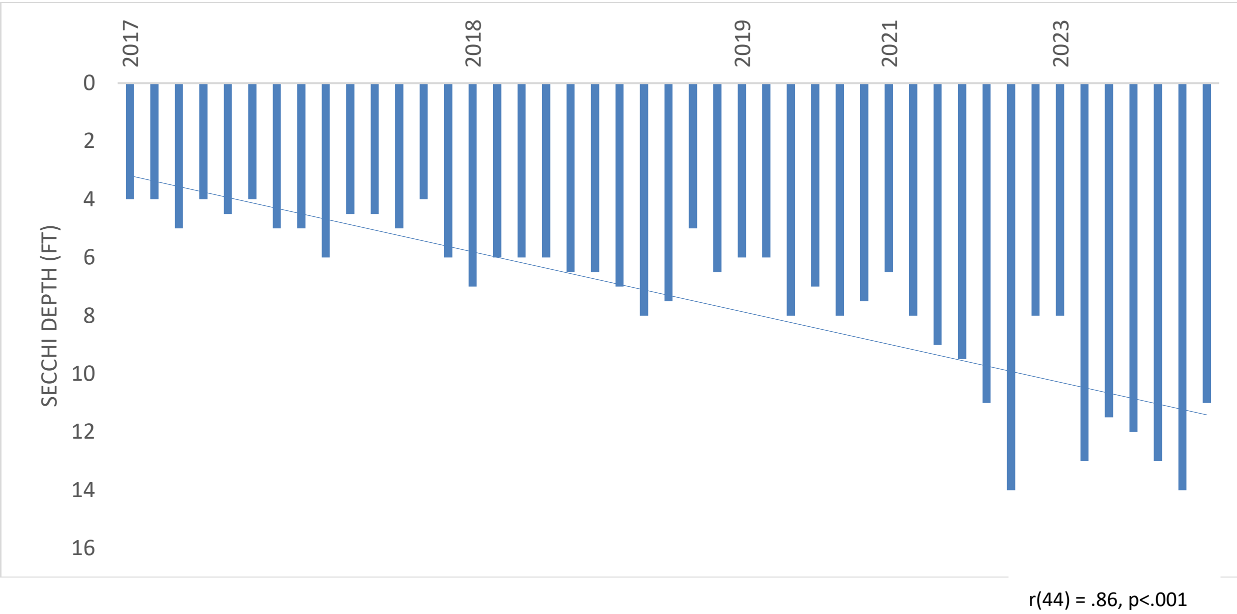
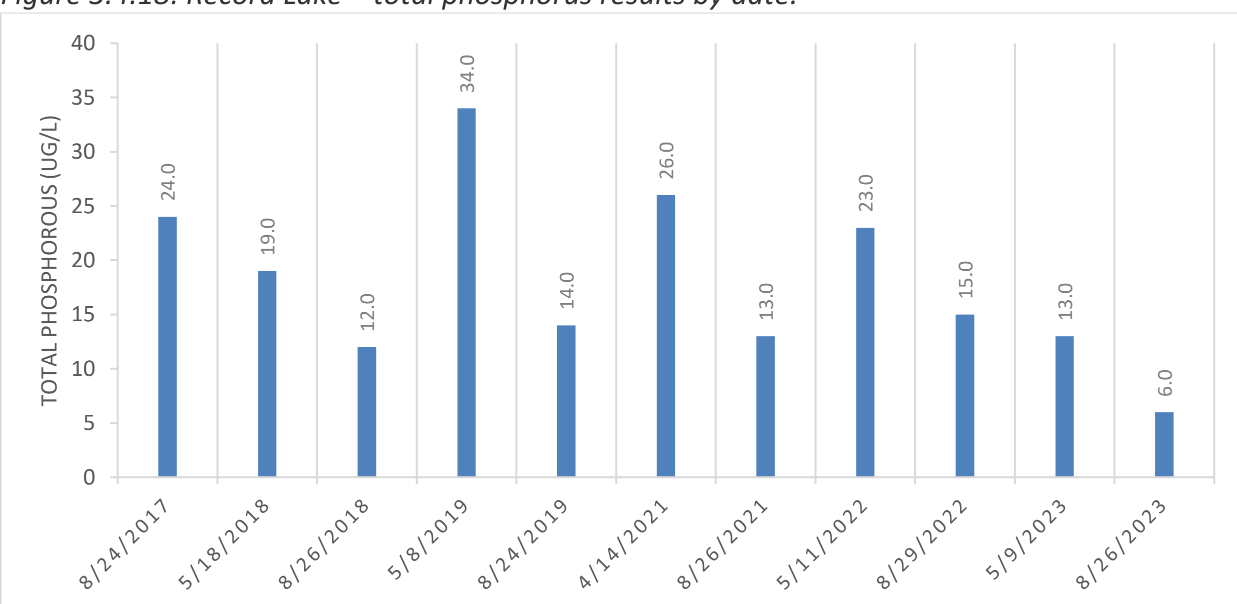


Figure 3.4.18: Record Lake – total phosphorus results by date.



<u>*Little Africa Lake*</u>

Little Africa Lake may have the shortest monitoring period (2017-2023) with only two of the seven years for secchi monitoring meeting the MiCorps minimum of eight samples. Though limited, it is of interest to note that water clarity over the sampling period does appear to be increasing. Teasing out just the late summer transparency data, which is the time of the season when most lakes will see seasonal declines in water clarity, Little Africa's water clarity again appears to be increasing. Given the short data set, this trend should be taken with caution, more data would be beneficial to understand if this is an actual trend or an irregularity in the data analysis.

Figure 3.4.19: Little Africa Lake - trophic status indices by year.

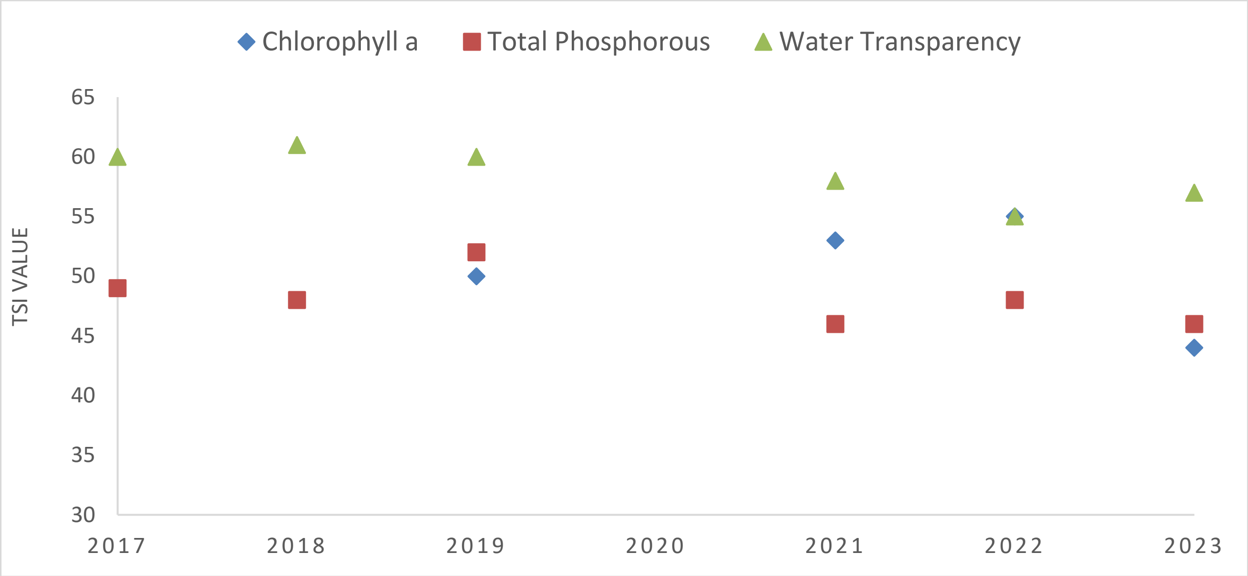


Figure 3.4.20: Little Africa Lake – secchi depths by year.

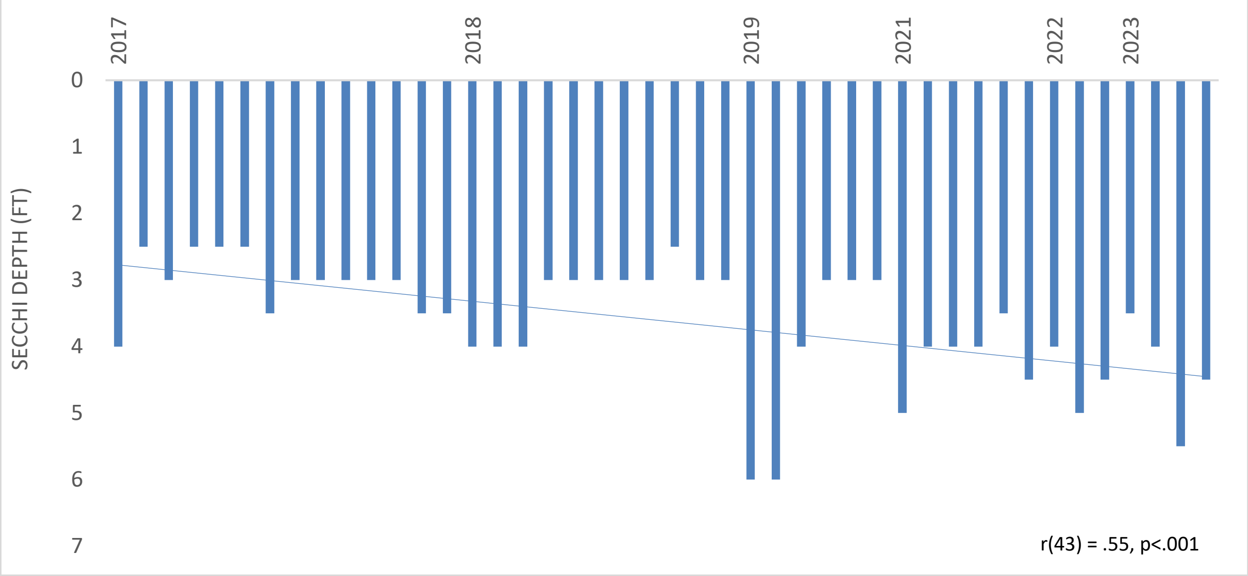


Figure 3.4.21: Little Africa Lake – July 15th – Sept. 15th secchi depths by year.

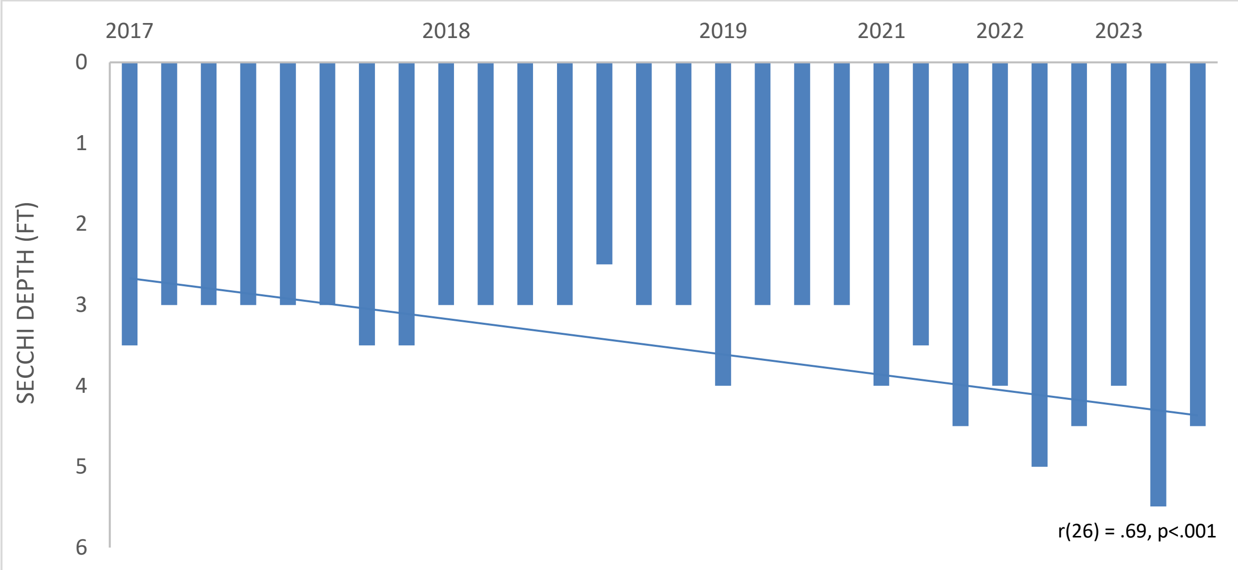
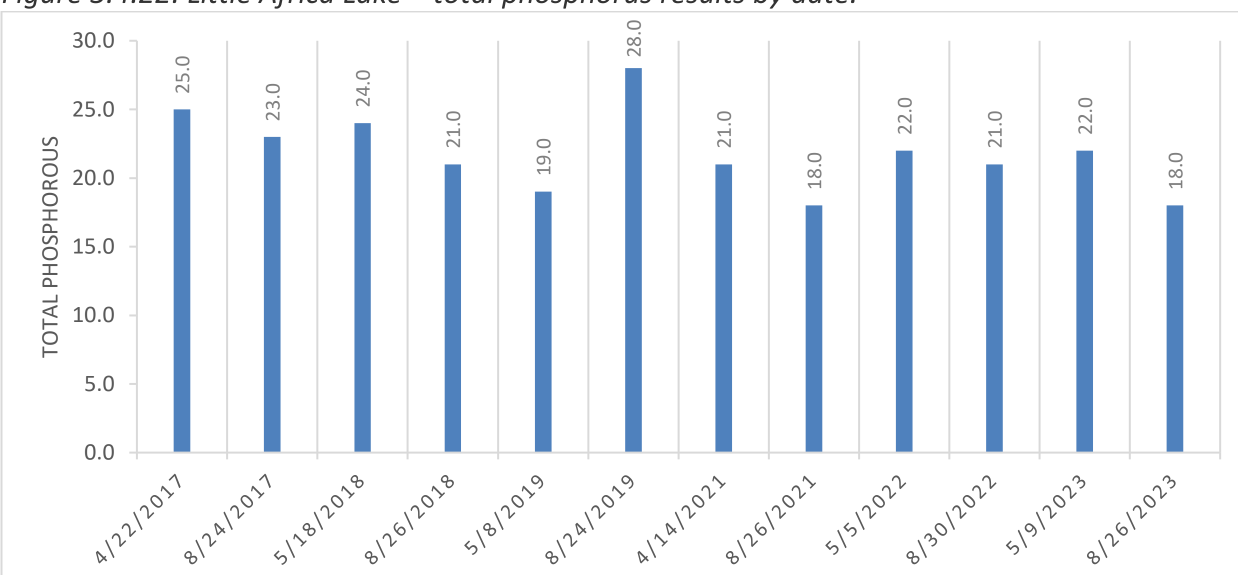


Figure 3.4.22: Little Africa Lake – total phosphorus results by date.



Cisco Lake

All surface water flowing through the Cisco Chain of Lakes will ultimately make its way to Cisco Lake and over the Cisco Lake Dam. MiCorps' data set for Cisco Lake from 2016-2023 does not suggest any changes to TSI since monitoring began. Of interest when teasing out the individual parameters of total phosphorus and water transparency, there appears to be some indication that the spring turn-over phosphorous is decreasing and water transparency is increasing. Summer phosphorous trends are consistent in the MiCorps data, with relatively little change.

Figure 3.4.23: Cisco Lake - trophic status indices by year.

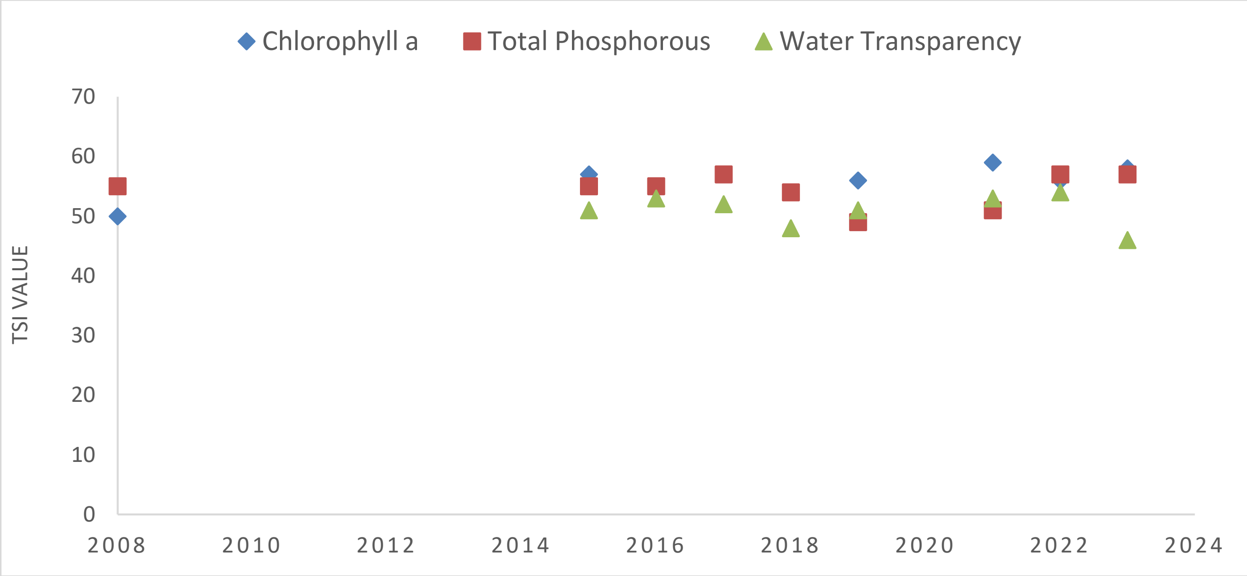


Figure 3.4.24: Cisco Lake – secchi depths by year.

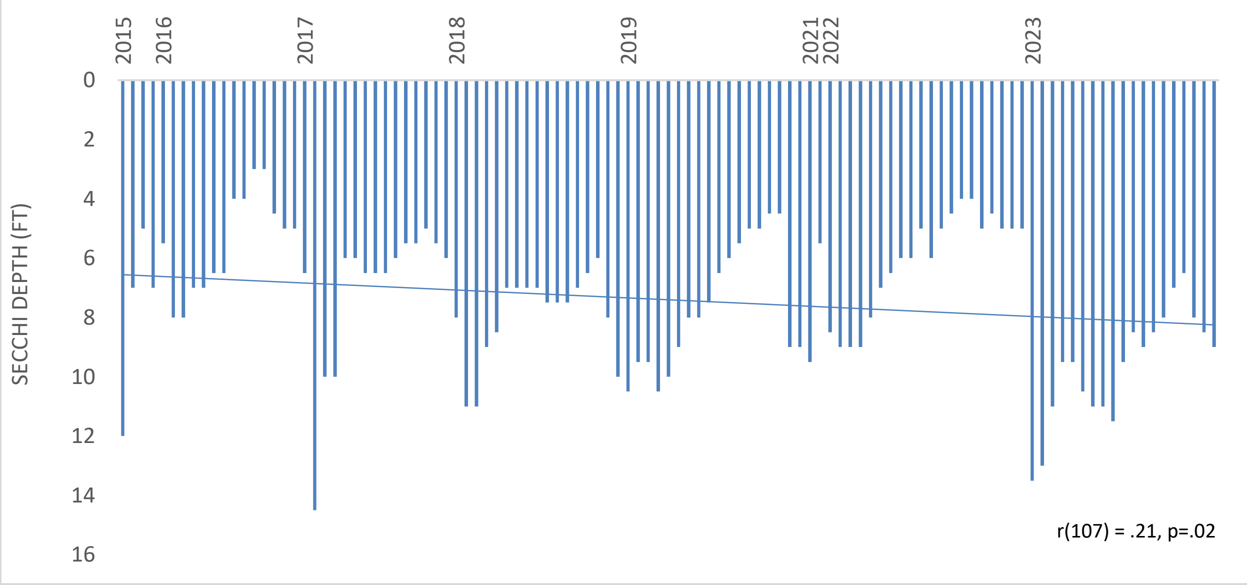


Figure 3.4.25: Cisco Lake – July 15th – Sept. 15th secchi depths by year.

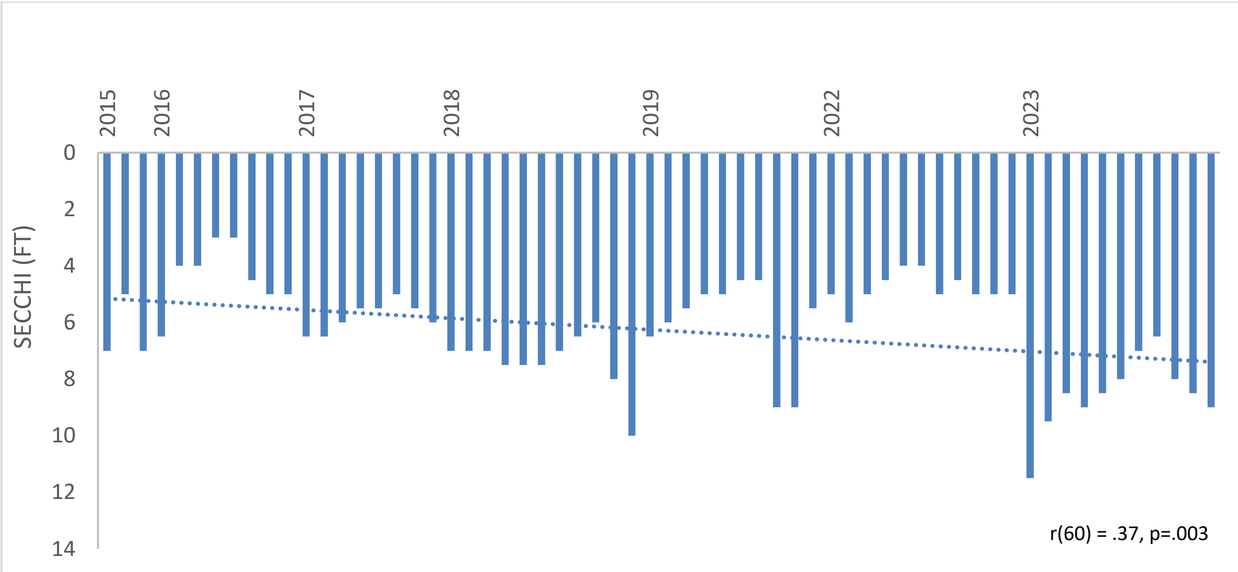


Figure 3.4.26: Cisco Lake – total phosphorus results by date.

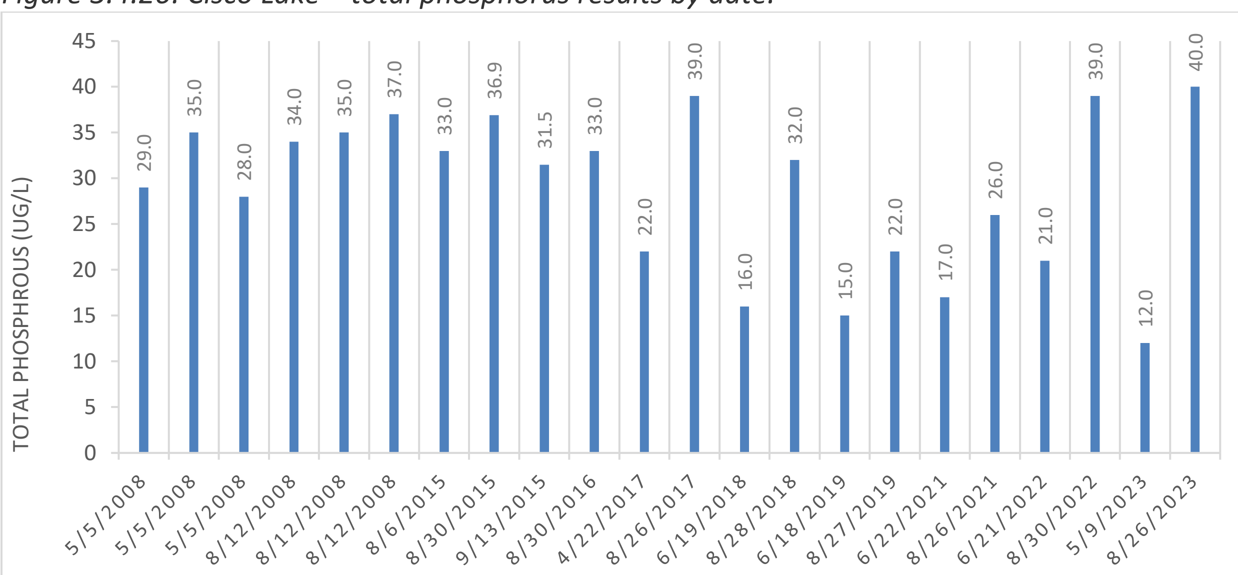
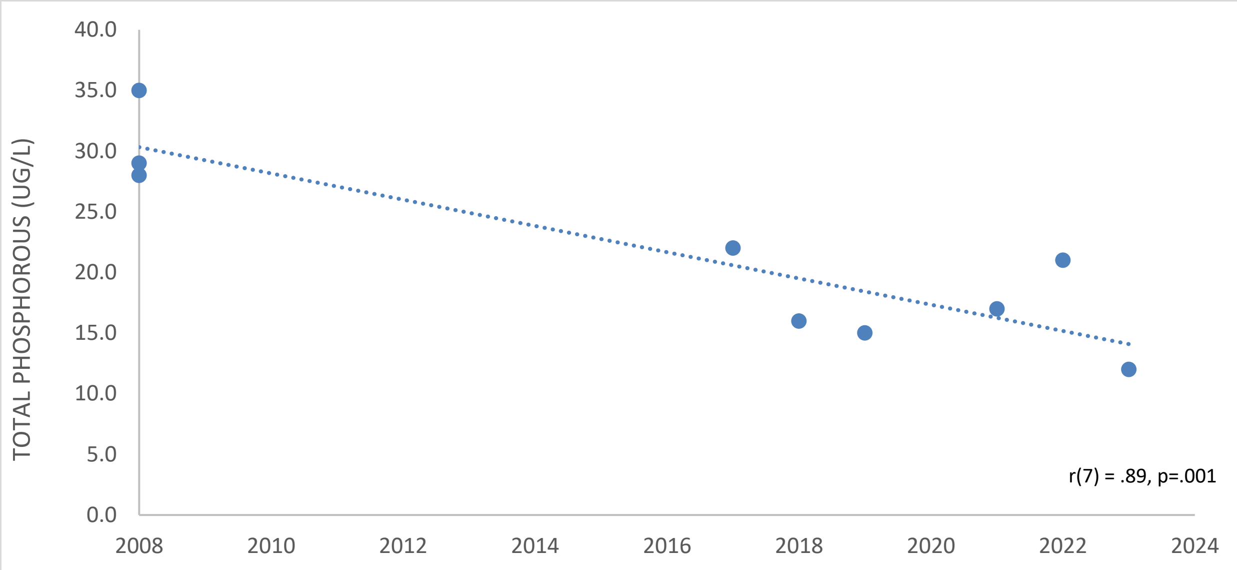


Figure 3.4.27: Cisco Lake – Spring turnover total phosphorous results by year.



<u>*Mamie Lake*</u>

Mamie is a boundary water lake with Wisconsin. The water quality record for Mamie Lake goes back to the mid 1980's, with over 230 secchi samples collected since 1995. Mamie Lake is identified as a eutrophic lake. Eutrophic Lakes are very productive lakes; being shallow, turbid and supporting abundant plant growth.

Wisconsin DNR provides total phosphorous and chlorophyll *a* guidance that is used to determine if a waterbody is meeting the water quality criteria for its designated uses. Mamie Lake is described as a shallow lowland lake, which have a total phosphorus threshold for fish and aquatic life impairments of ≥100 ug/l. The recreational impairment threshold for total phosphorous in shallow lowland lakes is ≥40 ug/l. Summer phosphorus levels in Mamie Lake exceeded the recreational impairment threshold of 40 ug/l during more than half of the summer periods, but fish and aquatic life impairment levels were not reached. As of the 2024 WDNR water conditions list, the occasional exceedance does not qualify the site for specific monitoring (Tier II), which may lead to an impairment listing. Water transparency appears to be declining based on the total secchi record. Continued total phosphorous and secchi monitoring is important to verify if phosphorous levels in Mamie are increasing and water clarity is decreasing. At this point, there is not enough chlorophyll *a* data for analysis.

Figure 3.4.28: Mamie Lake - trophic status indices by year.

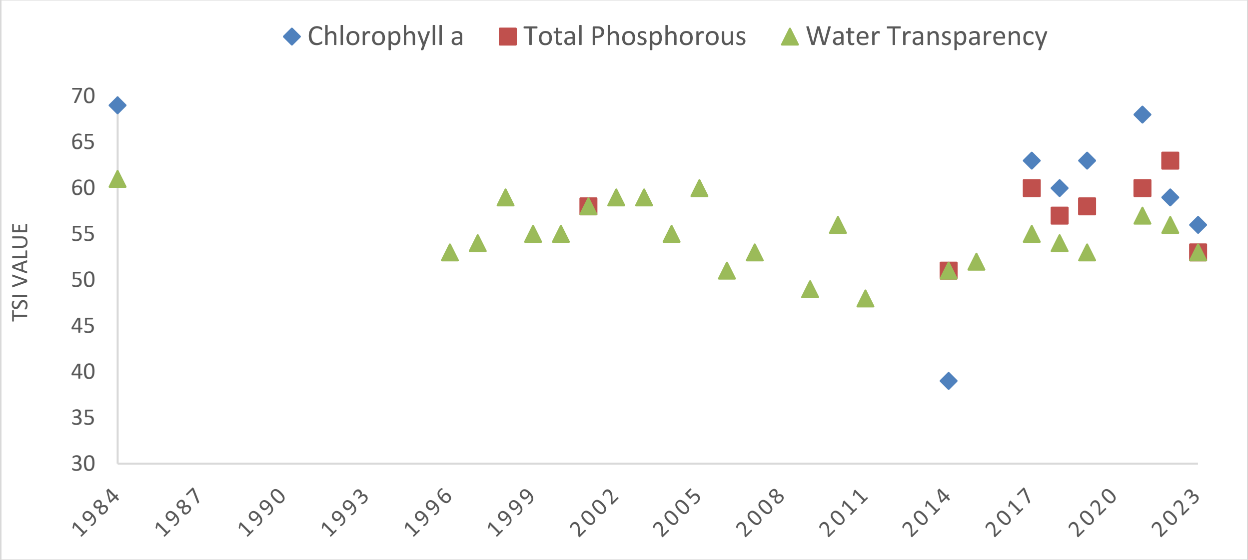


Figure 3.4.29: Mamie Lake – secchi depths by year.

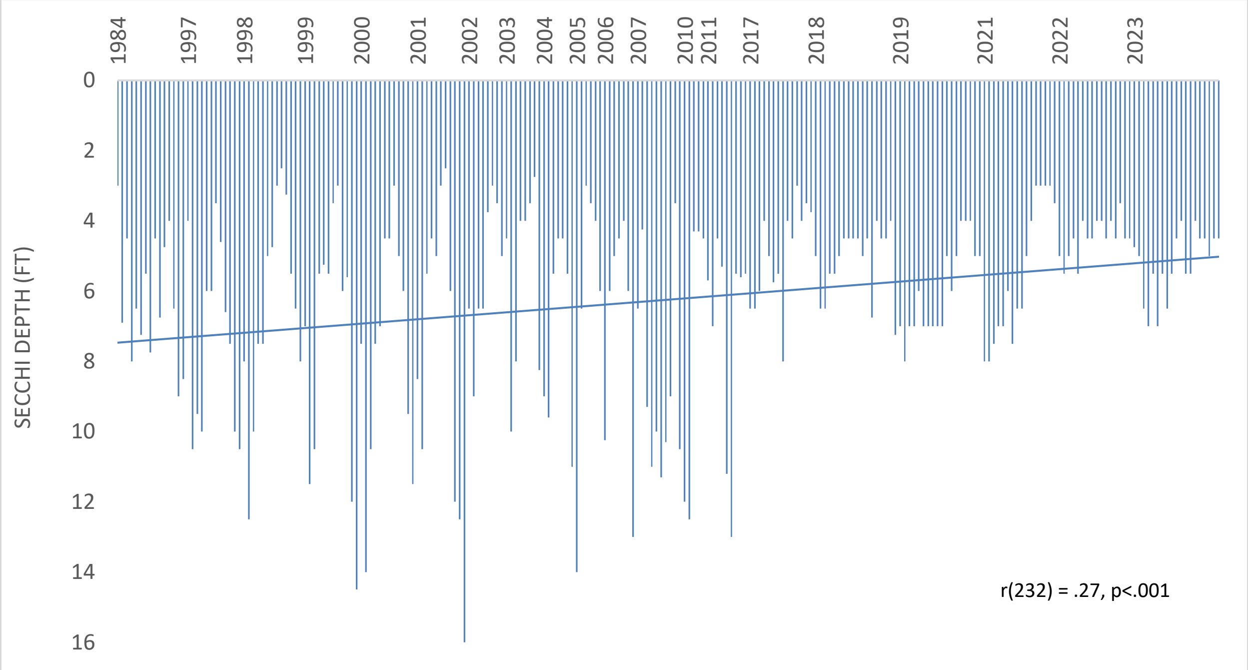
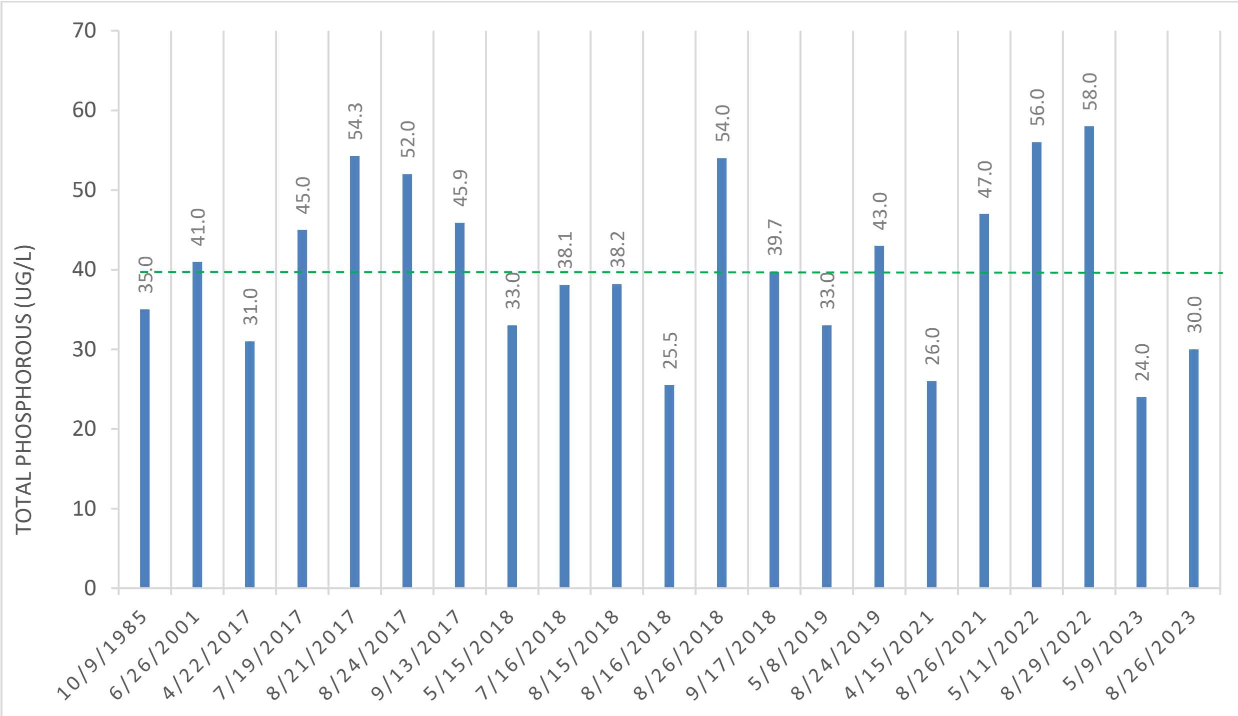


Figure 3.4.30: Mamie Lake – total phosphorus results by date. Green dashed line indicates WDNR recreational use impairment threshold for shallow lowland drainage lakes.



<u>Poor Lake</u>

Poor Lake is accessible via a narrow marshy channel from East Bay Lake. The shoreline surrounding the lake is privately owned, with a mix of development. Some properties are natural with shoreline vegetation intact, whereas others have landscaped shorelines. This lake is relatively clear, with summer secchi readings averaging about 10 feet. Monitoring data going back to 2015 shows some seasonal differences, however, very little change overall.

Figure 3.4.31: Poor Lake - trophic status indices by year.

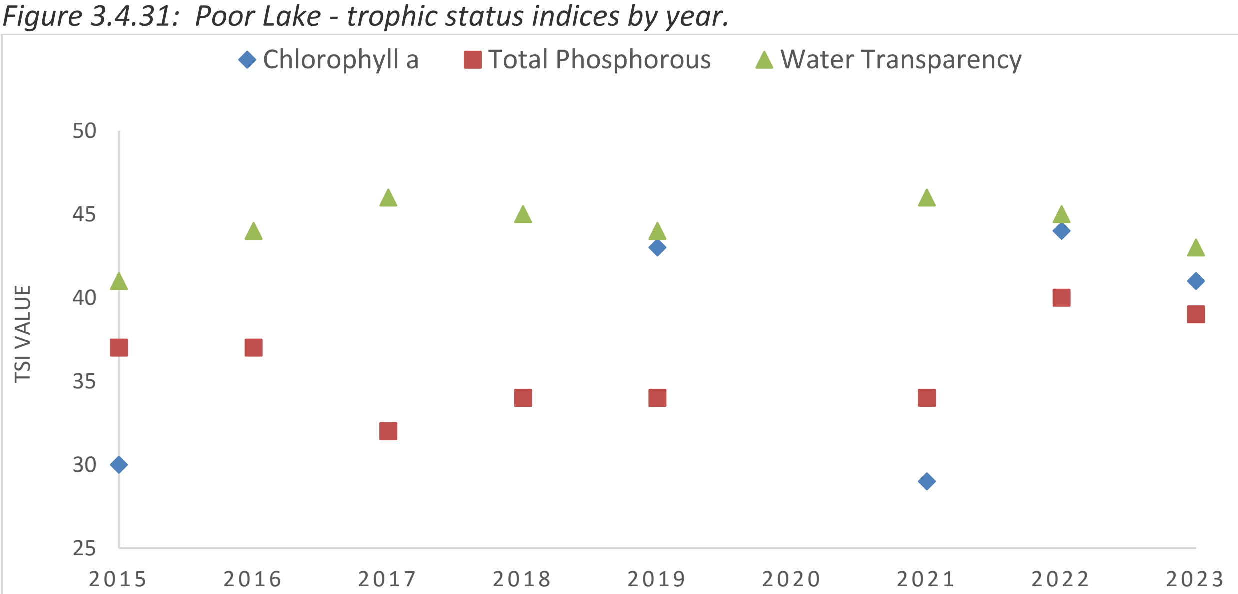


Figure 3.4.32: Poor Lake – secchi depths by year.

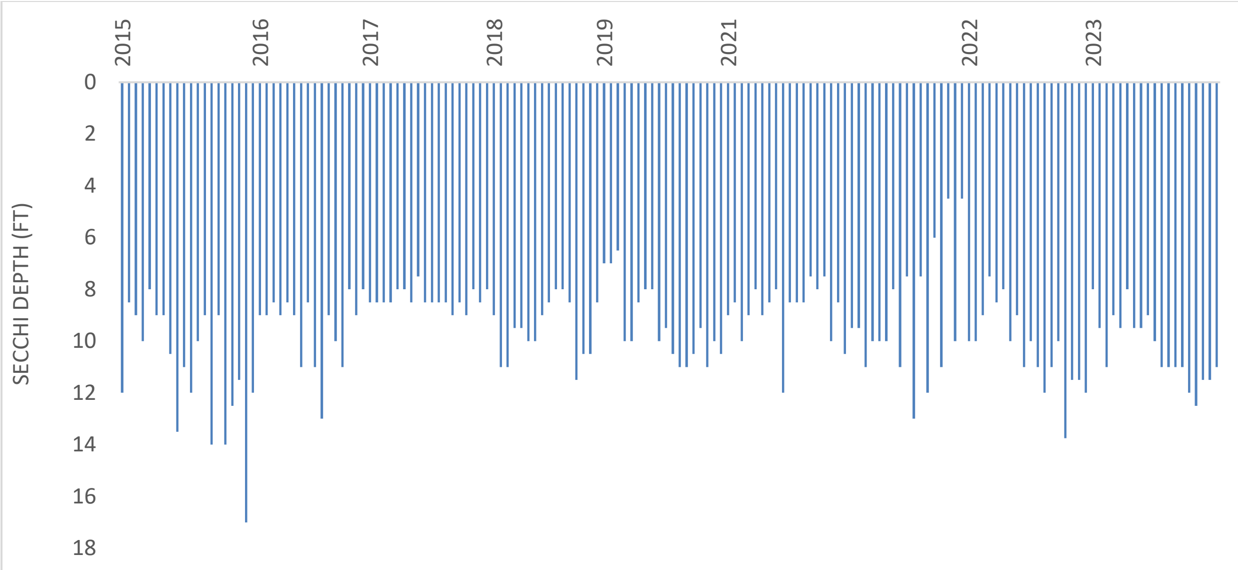
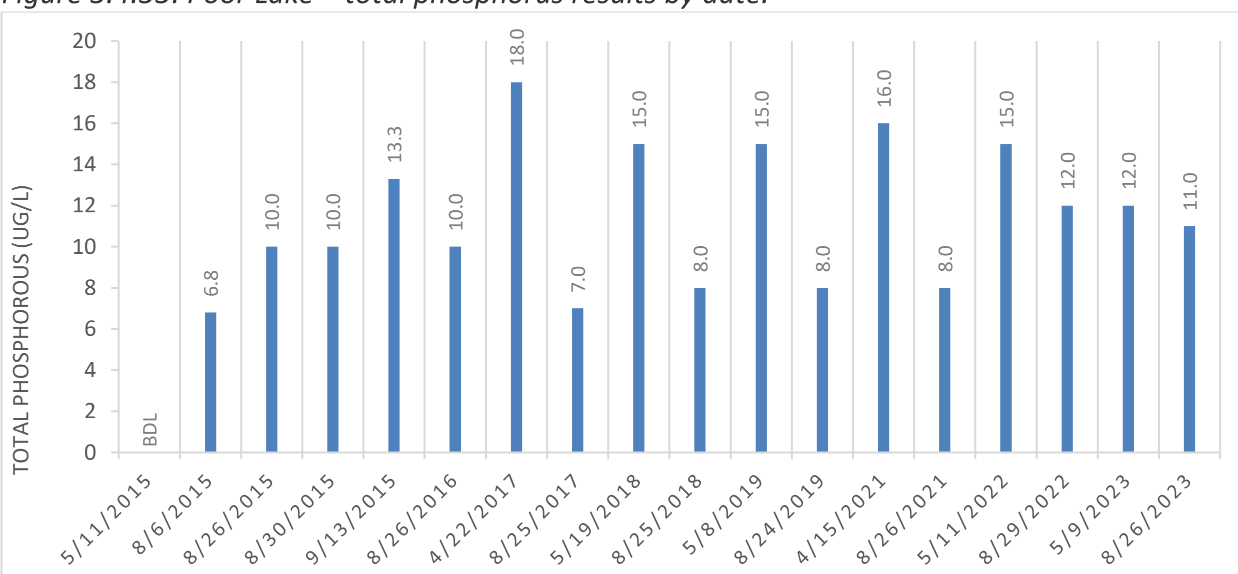


Figure 3.4.33: Poor Lake – total phosphorus results by date.



<u>West Bay Lake</u>

West Bay Lake is a boundary water lake with Wisconsin. This lake is accessed through a channel from Big Lake or from East Bay Lake. The water quality record for West Bay goes back to the mid 1980's, with over 240 secchi samples collected since 1995. TSI for water transparency has ranged from 37 in 2015 to 54 in 2022, with an average of 47, which would designate it as a eutrophic lake. Wisconsin DNR provides total phosphorous and chlorophyll *a* guidance that is used to determine if a waterbody is meeting the criteria for designated uses. This data is tracked over time, and if a waterbody exceeds the threshold levels of phosphorous or chlorophyll *a* enough times in so many years, the waterbody may be evaluated and determined if it would qualify to be put on the State's impaired water body list. Standards vary depending on the lake's natural community type, the pollutant and the designated use. For example West Bay Lake is a deep lowland lake, where the total phosphorus threshold for fish and aquatic life impairments is ≥60 ug/l, and the recreational impairment threshold for total phosphorous is ≥30 ug/l. Summer phosphorus levels have exceeded the recreational threshold a few times in the record, and once in the record for fish and aquatic life. As of the 2024 WDNR water conditions list, these occasional exceedances, do not meet the criteria for site specific monitoring (Tier II), which may lead to an impairment listing. Of interest is the spring turnover phosphorus and the mid-summer chlorophyll *a* levels documented in 2022, which is the year that a large blue-green algae bloom was observed on West Bay Lake.

Figure 3.4.34: West Bay Lake - trophic status indices by year.

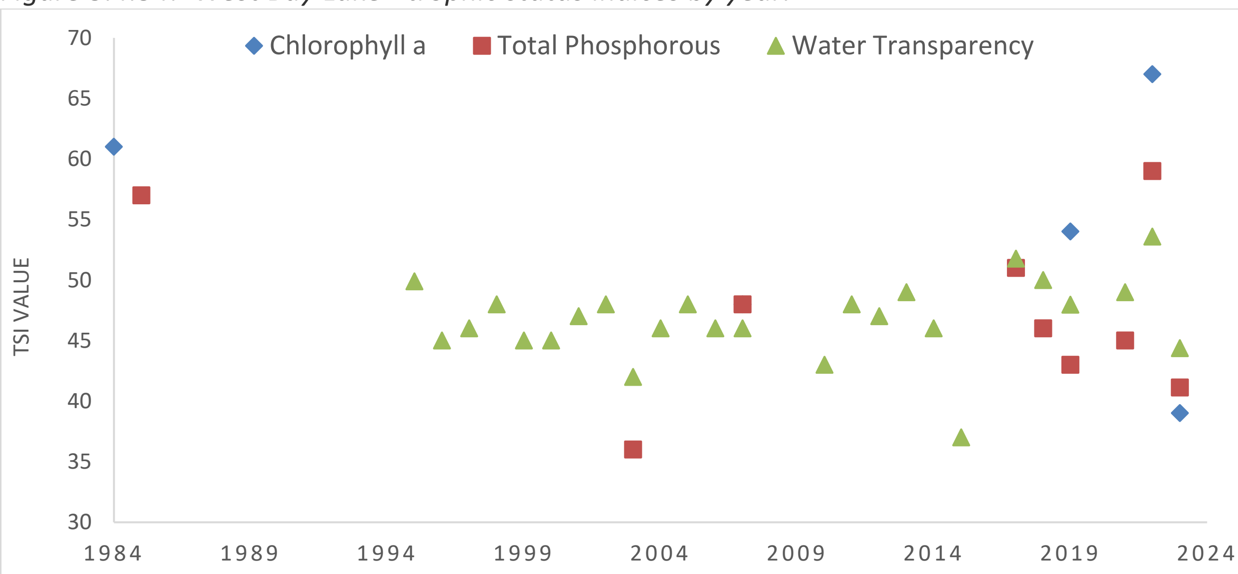


Figure 3.4.35: West Bay Lake – secchi depths by year.

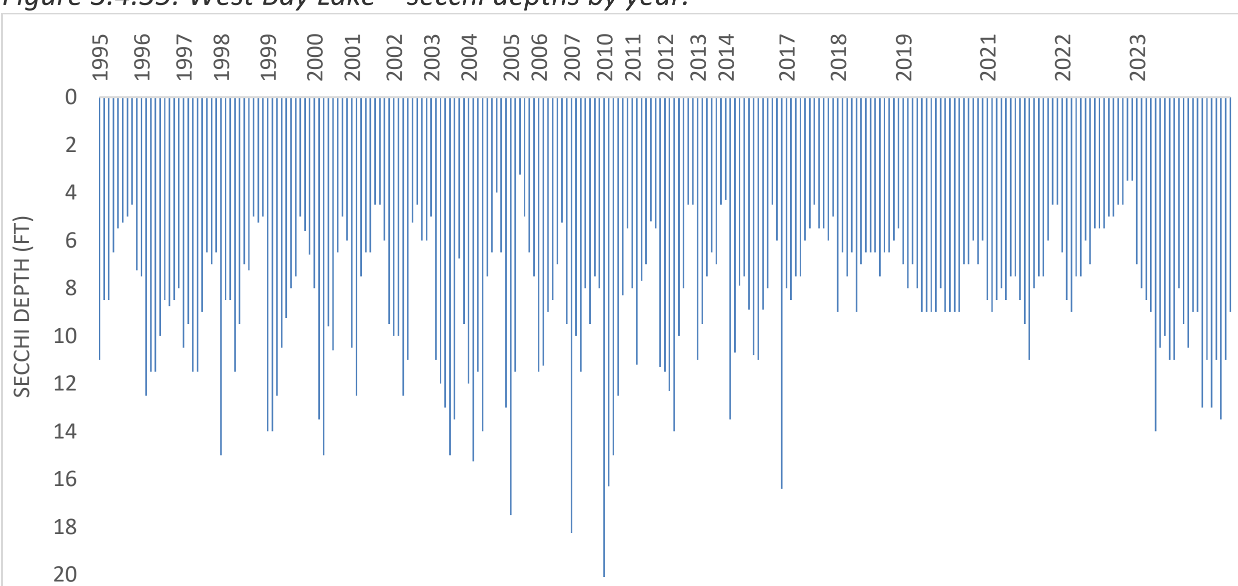


Figure 3.4.36: West Bay Lake – total phosphorus results by date. Green dashed line (30 ug/l) indicates WDNR recreational use impairment threshold for deep lowland drainage lakes. Red dashed line (60ug/l) indicates WDNR fish and aquatic life use impairment for deep lowland lakes.

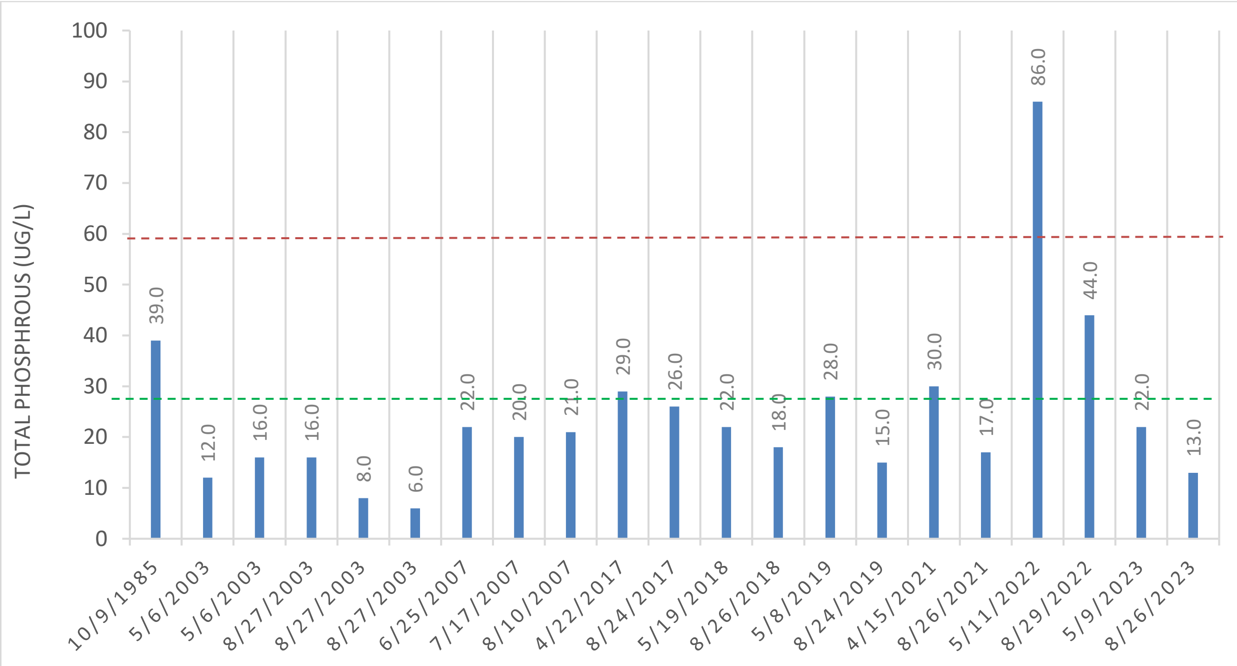


Figure 3.4.37: West Bay Lake – spring turnover total phosphorus results by year.

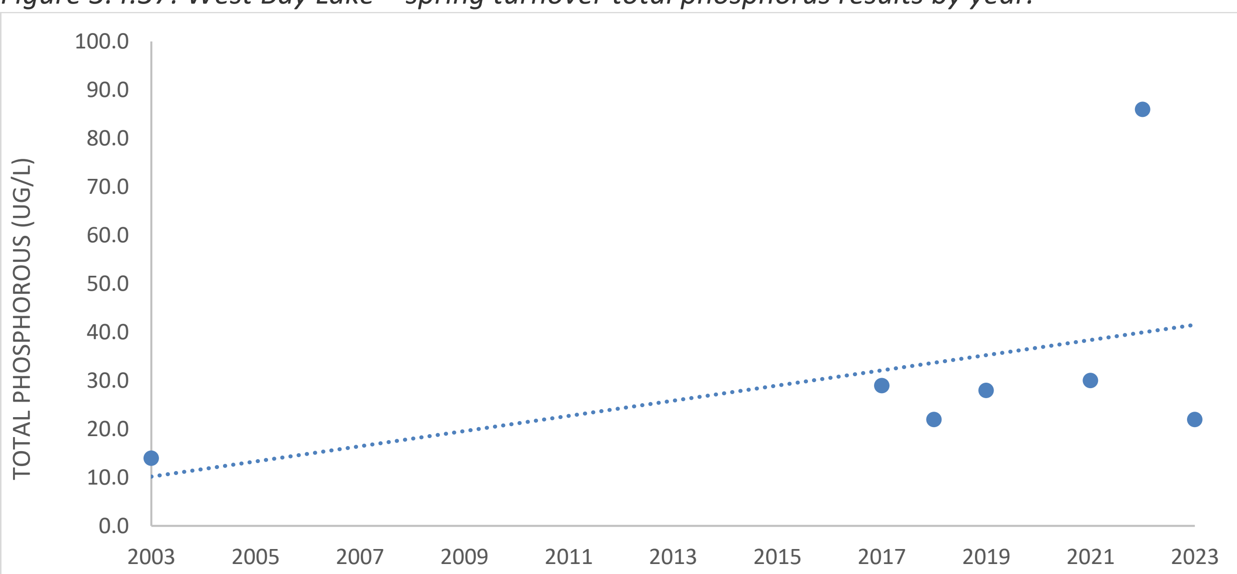
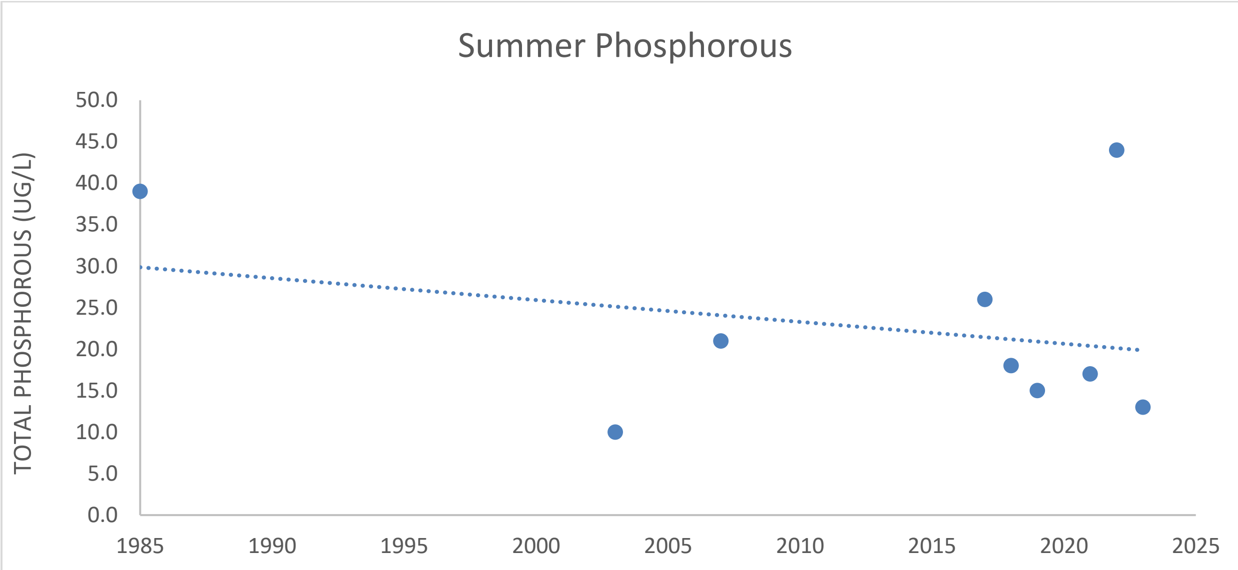
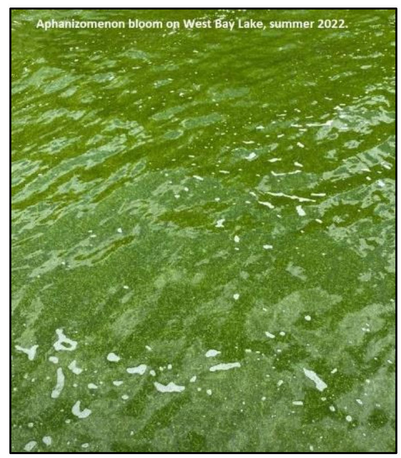


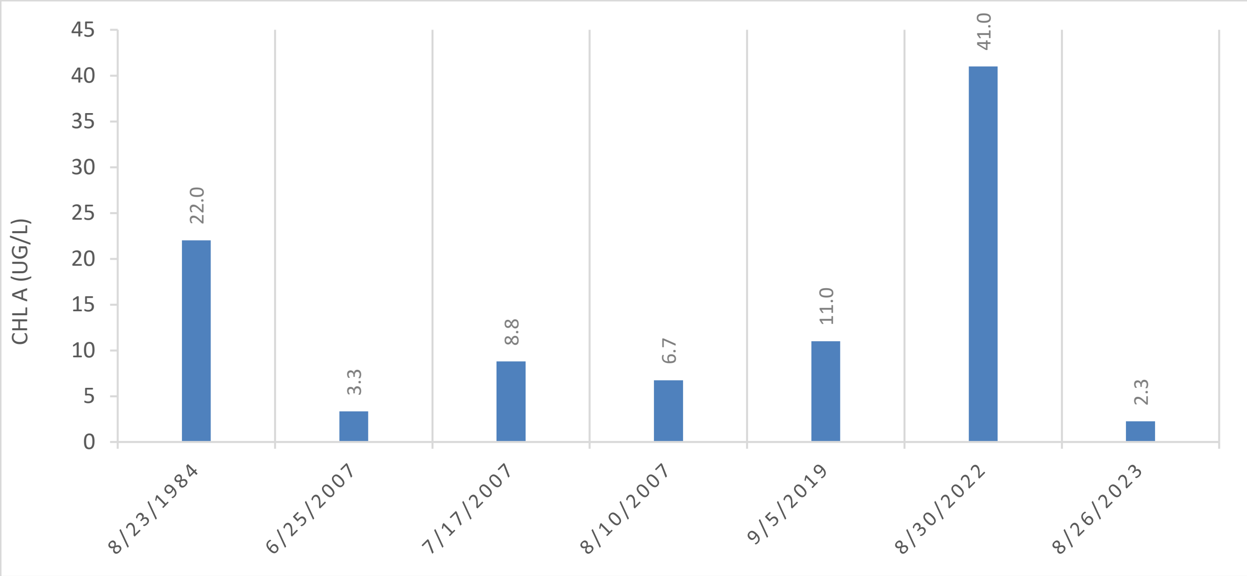
Figure 3.4.38: West Bay Lake – summer total phosphorus results by year.





In 2022, a very large blue-green algal bloom was confirmed to be Aphanizomenon. This blue-green algae looks like grass clippings in the water and can potentially produce toxins. Spring and summer total phosphorous levels reached the highest levels recorded and TSI values were the highest recorded values over the monitoring period beginning in 1984. Chlorophyll *a* data, though limited, spiked during the summer of 2022. Aphanizomenon blooms on the Chain are not uncommon, especially on the lower half of the Chain. They have been observed in East Bay, Big Lake, Fishhawk, and Lindsley Lakes. The bloom in 2022, did appear to be one of the larger blooms observed in recent times.

Figure 3.4.39: West Bay Lake – Chlorophyll results by year.



Fishhawk lake

Fishhawk sits at the upper end of the meso-eutrophic spectrum, with TSI values averaging 47 across. MiCorps suggests that the water quality on Fishhawk Lake has changed very little since monitoring began. Secchi monitoring began in 2000, with consistent annual records beginning in 2017.

Figure 3.4.40: Fishhawk Lake - trophic status indices by year.

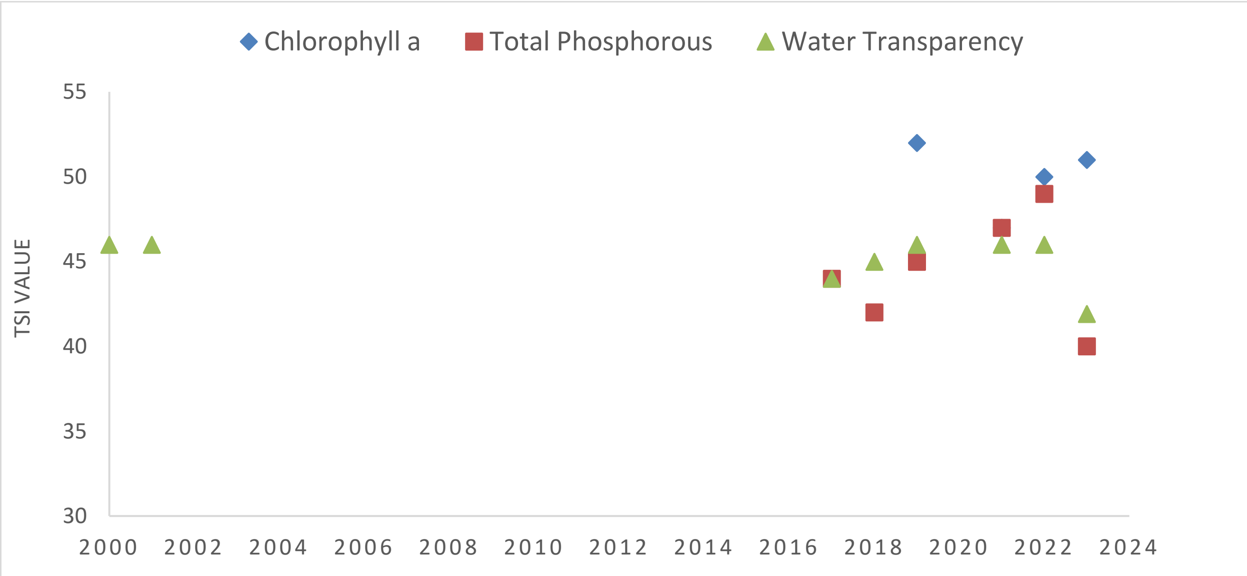


Figure 3.4.41: Fishhawk Lake – secchi depths by year.

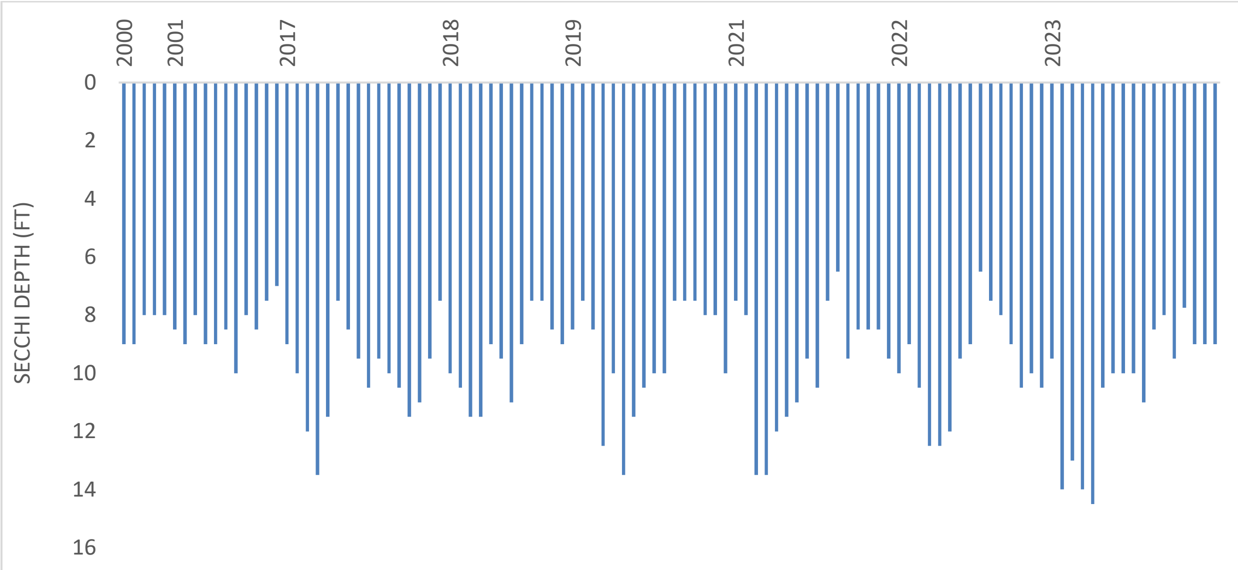
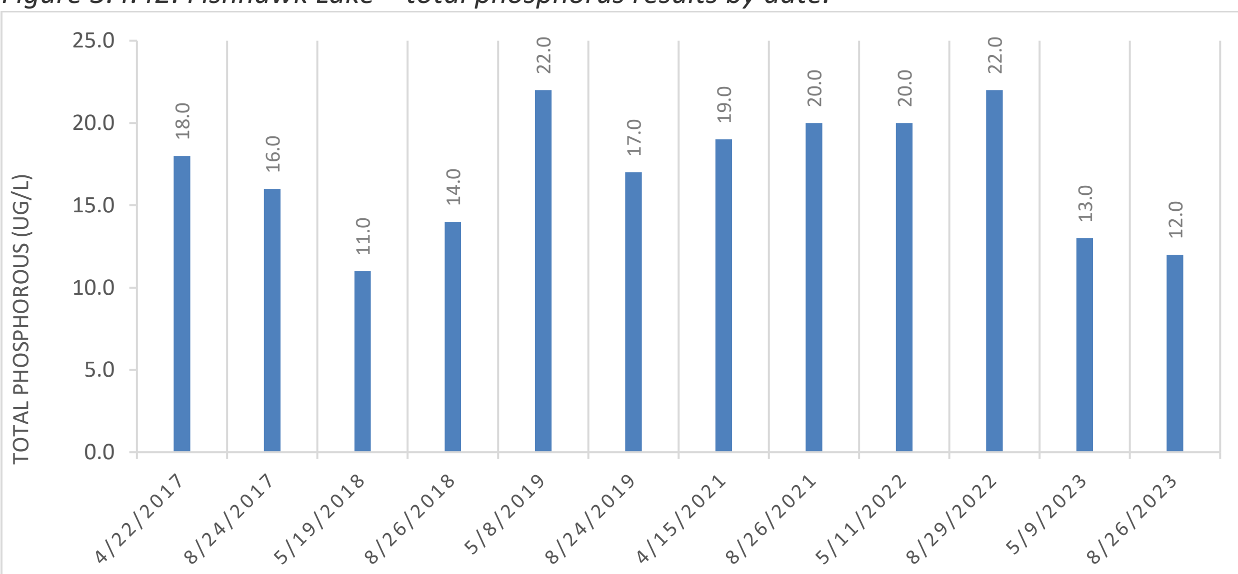


Figure 3.4.42: Fishhawk Lake – total phosphorus results by date.



Indian Lake

Indian Lake is drains to and is accessed through a channel to East Bay Lake. Most of the shoreline is wooded and publicly owned by the USFS Ottawa National Forest. Indian Lake, though clear, is generally very stained. Loons that nest on this lake have developed rust-colored bellies as a result. There are no water quality trends detected. This is probably a result of very little available data.

Figure 3.4.43: Indian Lake - trophic status indices by year.

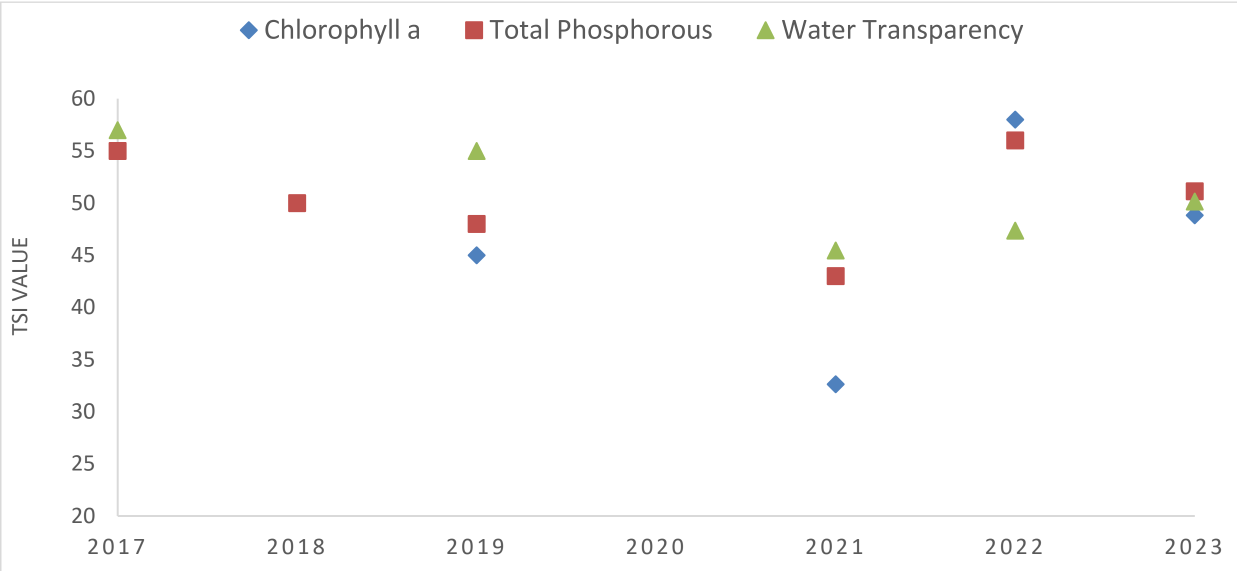


Figure 3.4.44: Indian Lake – secchi depths by date.

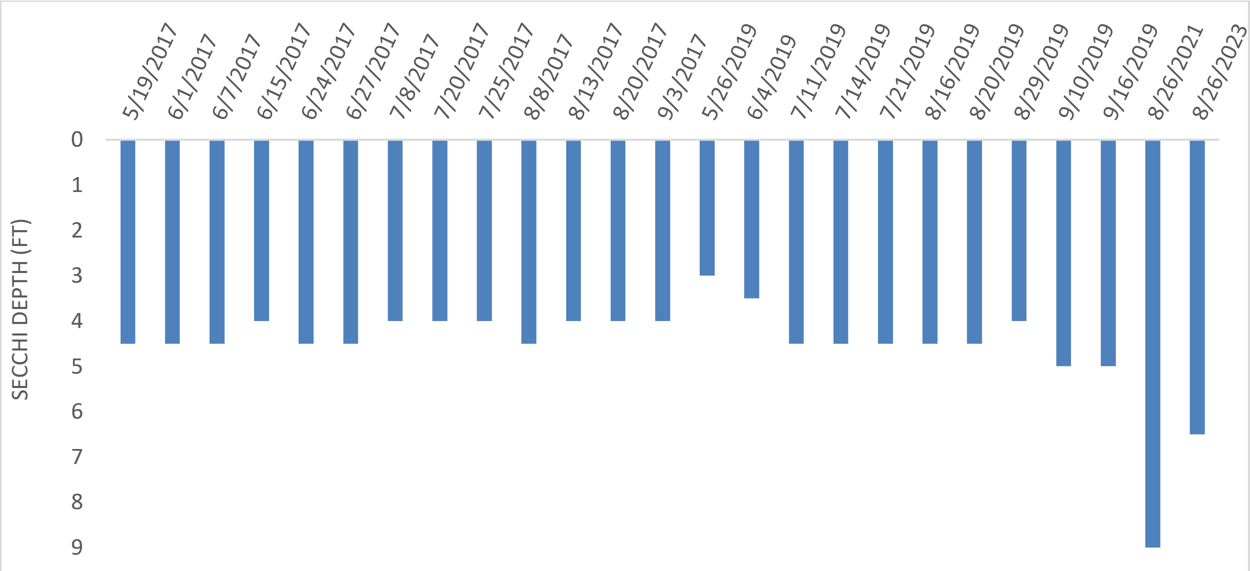
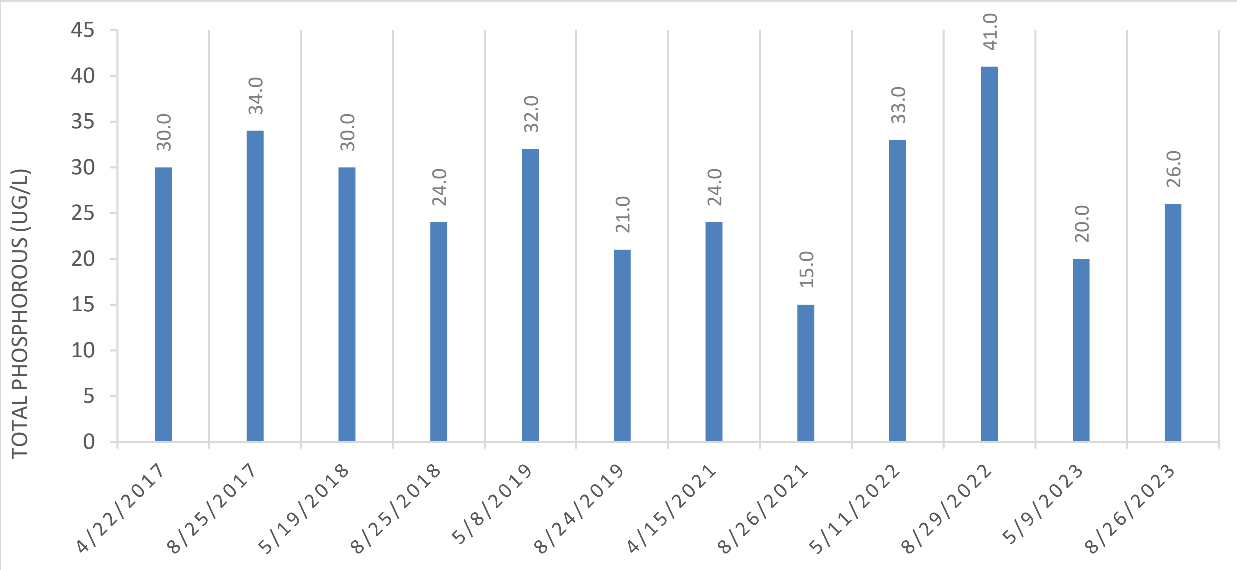


Figure 3.4.45: Indian Lake – total phosphorus results by date.



Morley Lake

Nutrient levels and trophic status have remained largely unchanged over the monitoring record.

Figure 3.4.46: Morley Lake - trophic status indices by year.

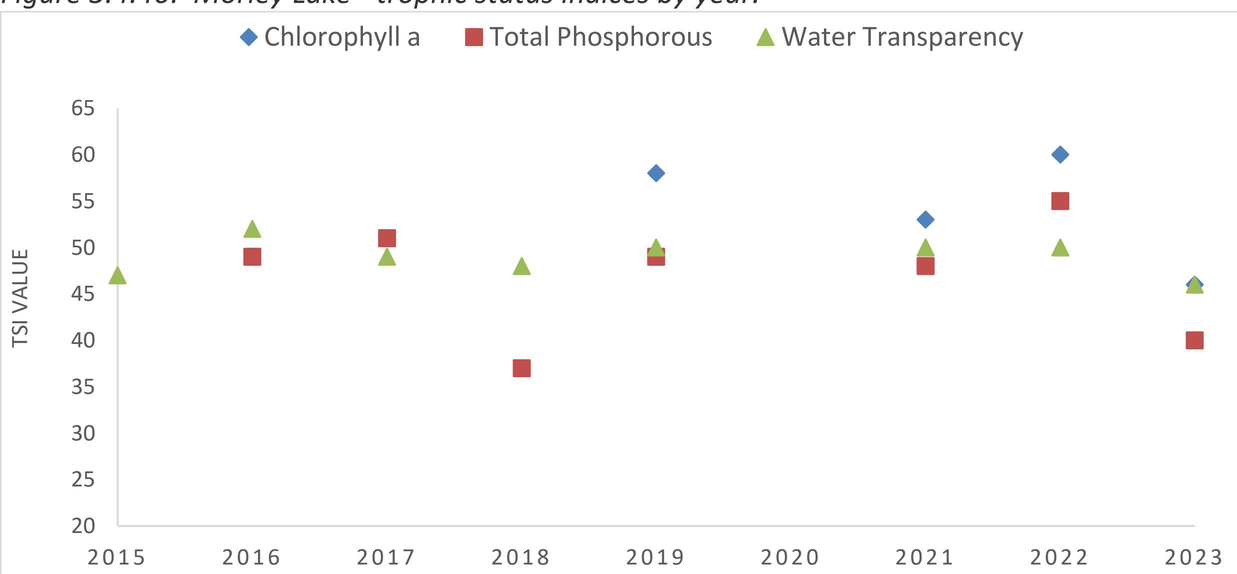


Figure 3.4.47: Morley Lake – secchi depths by year.

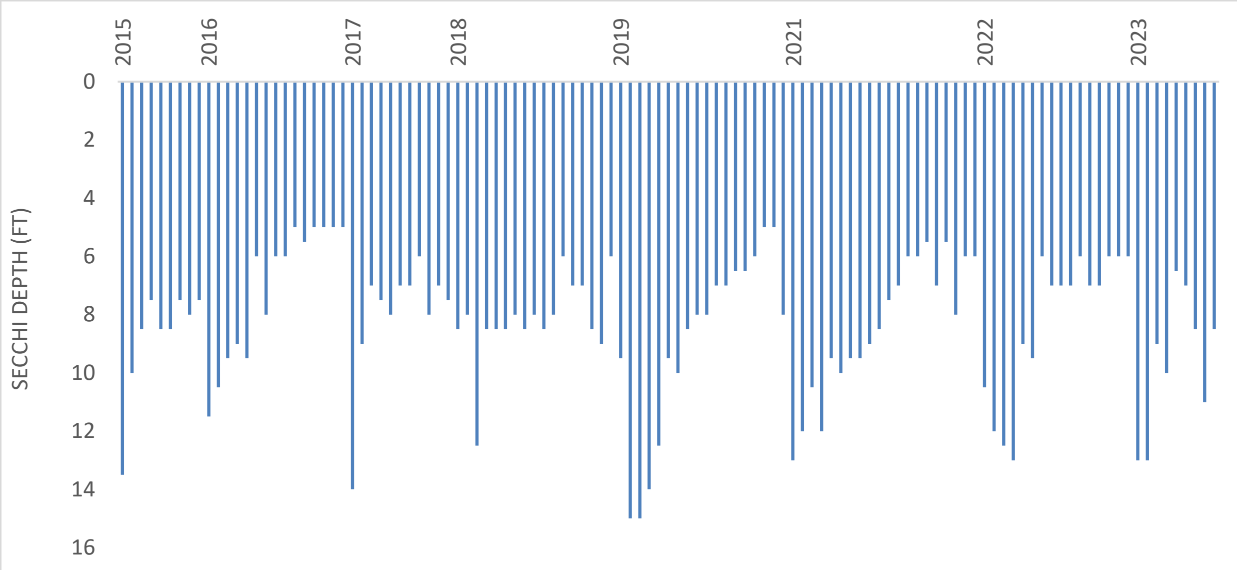
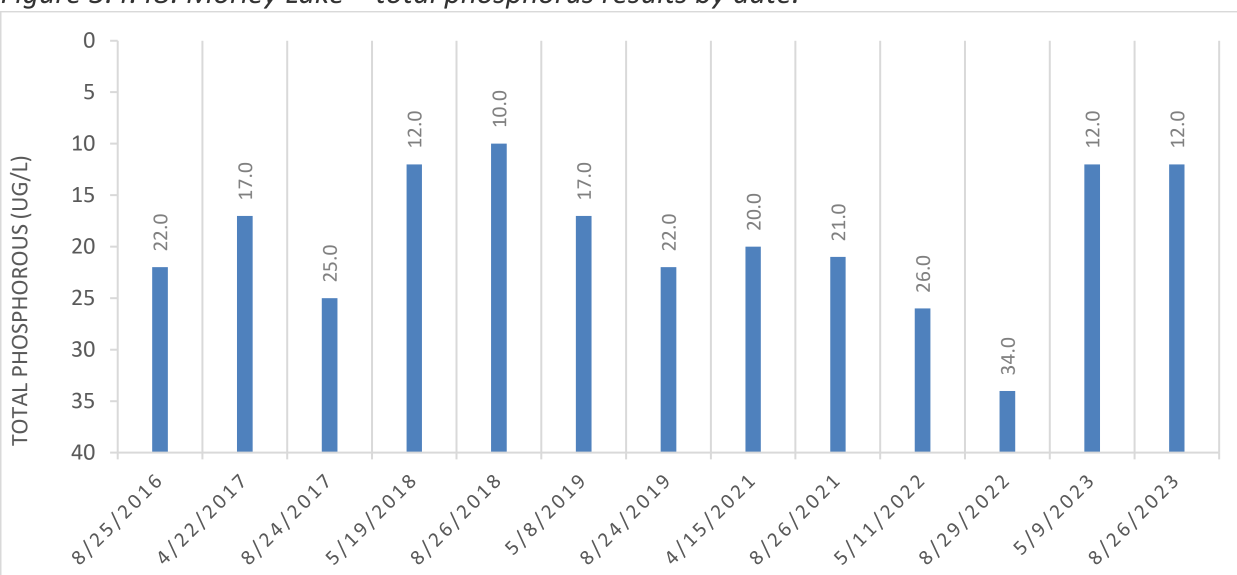


Figure 3.4.48: Morley Lake – total phosphorus results by date.



Big Lake

Big Lake is a boundary water lake with Wisconsin. The water quality record for Big Lake goes back to the mid 1980's, with over 300 secchi samples collected since 1995. TSI averages over the record for chlorophyll *a* (54), total phosphorous (50), and water transparency (49) suggest this lake is meso-eutrophic. WDNR considers this lake meso-eutrophic whereas MiCorps considers this lake more oligo-mesotrophic. The longer data set from WDNR would suggest Big Lake's trophic status is more meso-eutrophic than oligo-mesotrophic. Like West Bay, Wisconsin DNR provides total phosphorous and chlorophyll *a* guidance used to determine if a waterbody is meeting criteria for its designated uses. Big Lake is a shallow lowland lake, where the total phosphorus threshold for fish and aquatic life impairments is ≥100 ug/l, and the recreational impairment threshold for total phosphorus is ≥40 ug/l. Summer phosphorus levels have exceeded the recreational threshold a few times in the record but have not for fish and aquatic life. Other than the chlorophyll *a* levels reaching a level of 26 ug/l in 2021, there is really no pattern or observations similar to West Bay Lake during the blue-green algae bloom of 2022.

Figure 3.4.49: Big Lake - trophic status indices by year.

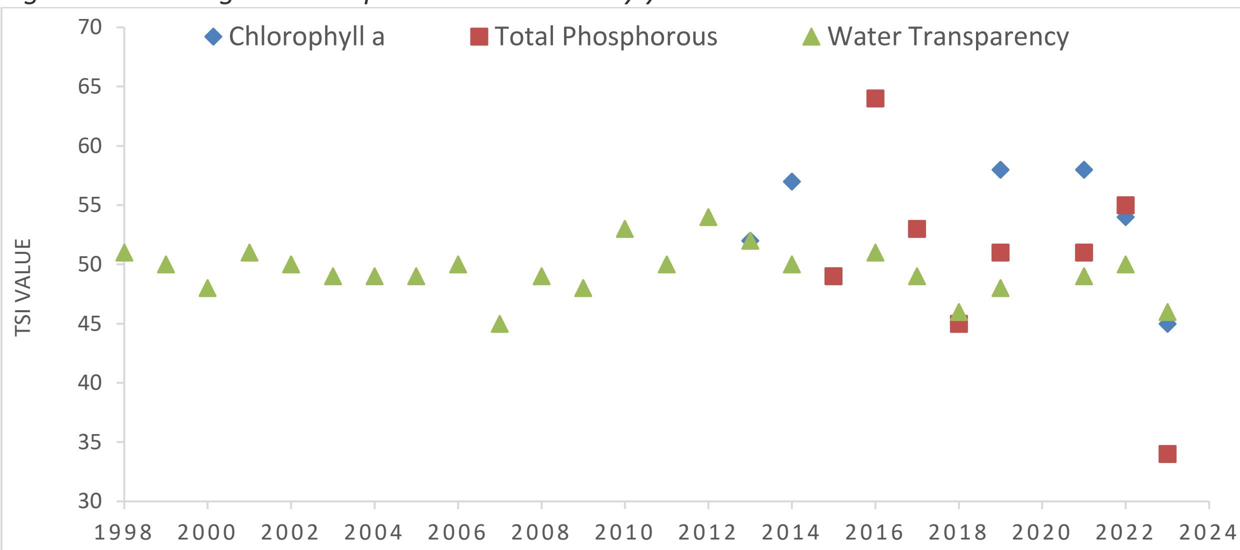


Figure 3.4.50: Big Lake – secchi depths by year.

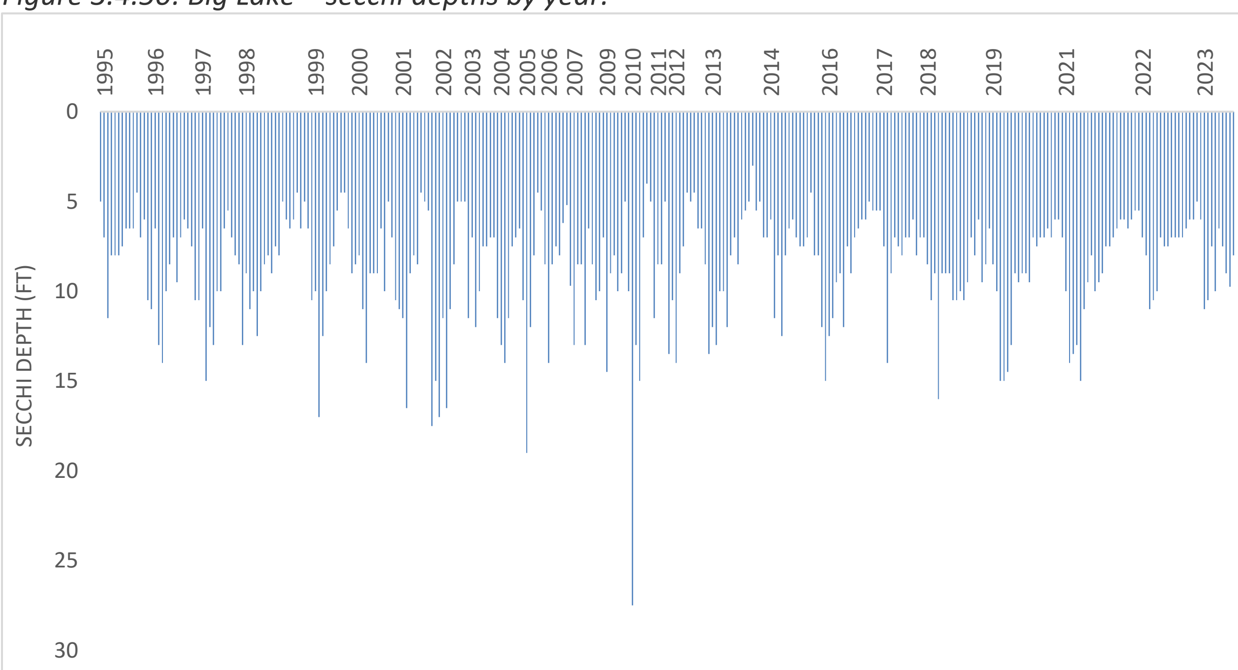


Figure 3.4.51: Big Lake – total phosphorus results by date. Green dashed line (40 ug/l) indicates WDNR recreational use impairment threshold for shallow lowland drainage lakes.

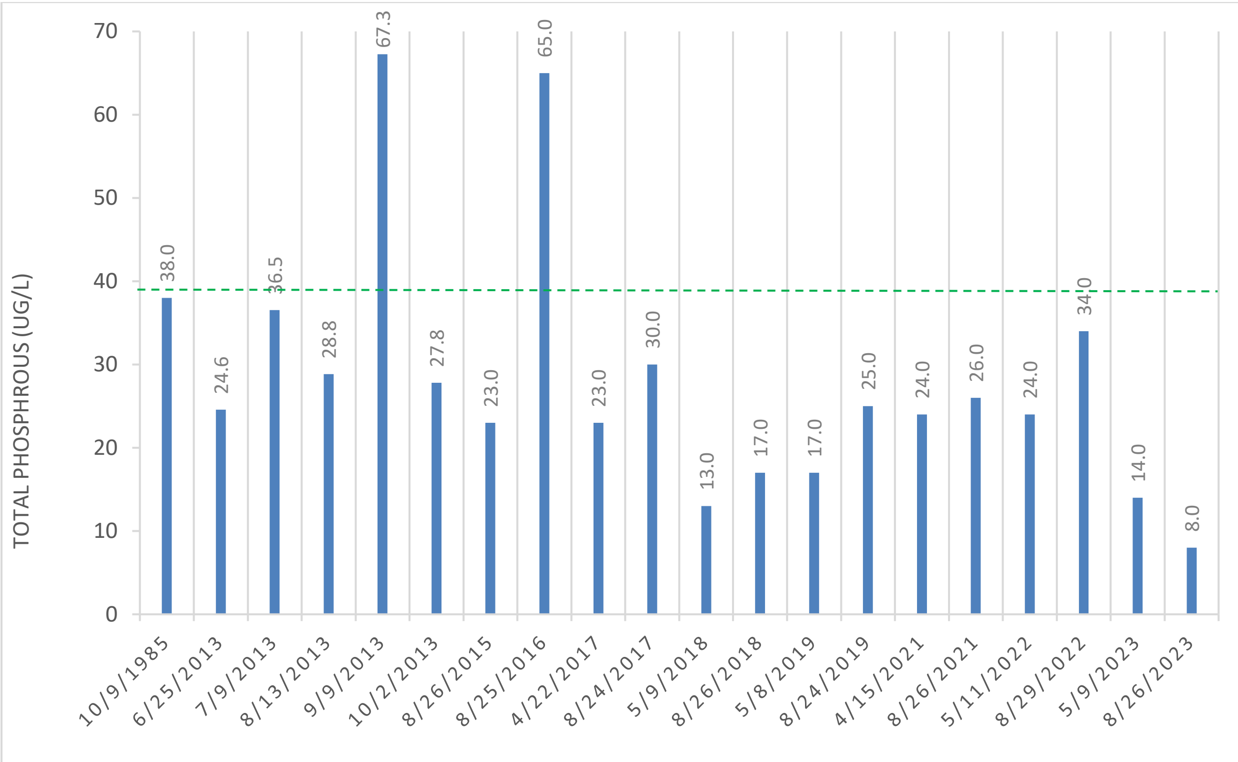
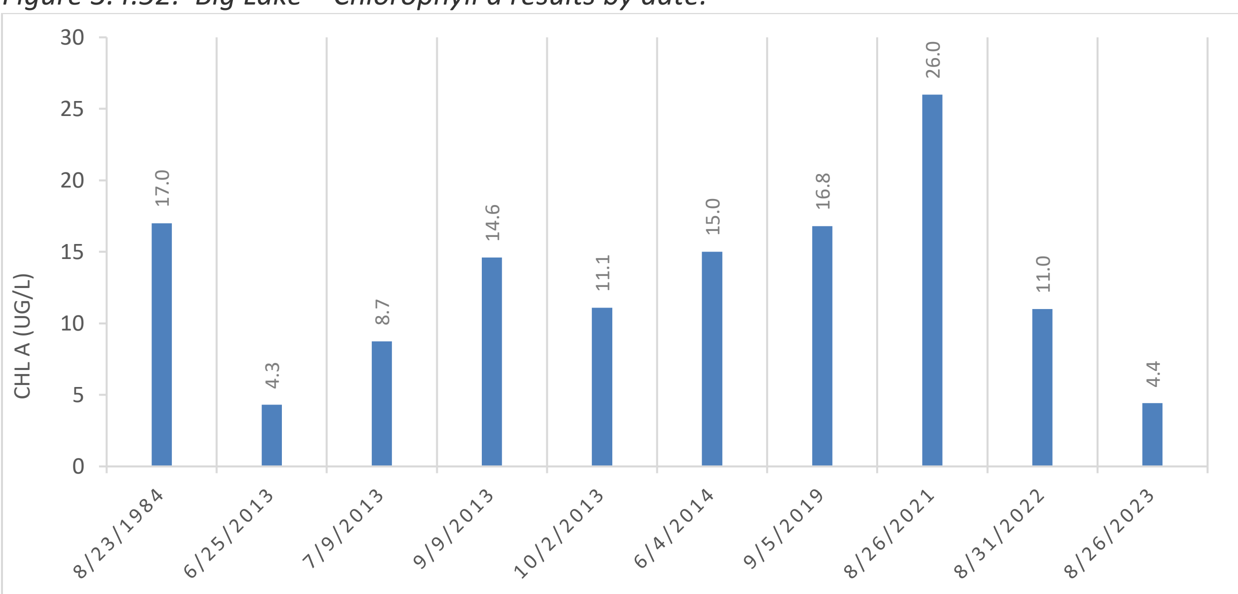


Figure 3.4.52: Big Lake – Chlorophyll a results by date.



East Bay Lake

East Bay Lake is one of the shallower lakes on the Chain. It connects West Bay to Mamie and includes drainage channels from both Poor Lake and Indian Lake. East Bay hovers at the higher end of the eutrophic scale and some years it tips into hyper-eutrophic conditions. There is a fair amount of secchi data for East Bay Lake, with about 100 readings since 2017, of which 60 readings occur during the July 15th – September 15th period. Secchi data suggests water clarity is increasing but given the nature of this lake and tendency to rank at the upper end of eutrophic, more data would be necessary to confirm any sort of trend. Though not in Wisconsin, the summer total phosphorus data would exceed the designated recreational use criteria set in Wisconsin. All the summer data is above the 40 ug/l level.

Figure 3.4.53: East Bay Lake - trophic status indices by year.

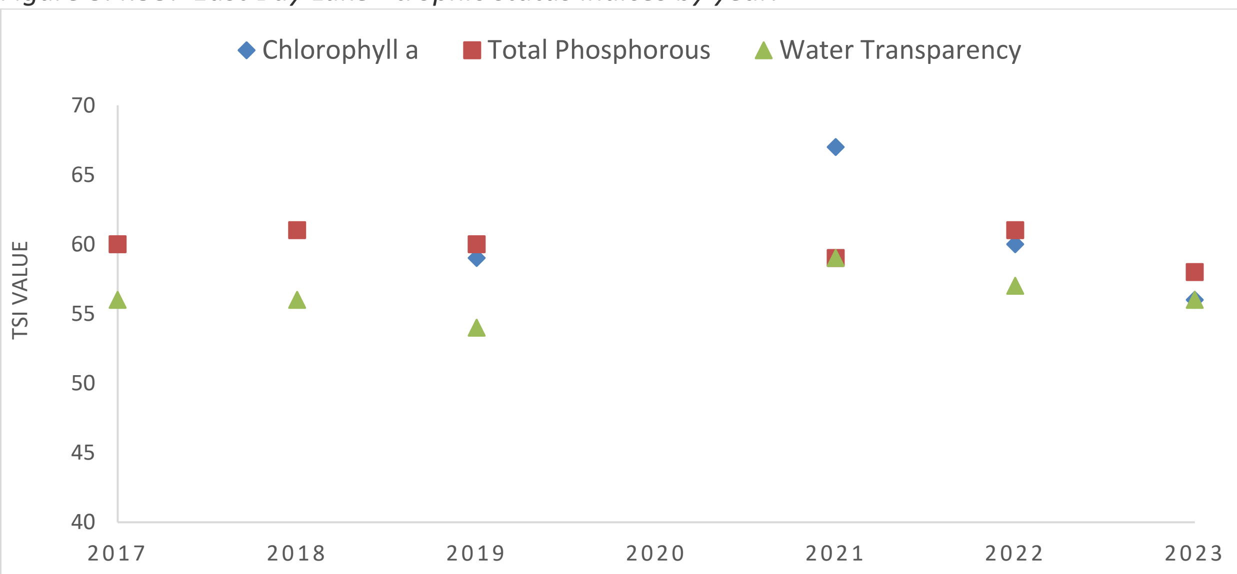


Table 3.4.2: East Bay Lake – TSI value for measured parameters. Green indicates hyper-eutrophic condition.

	2017	2018	2019	2021	2022	2023	AVE
Chlorophyll *a*			59	67	60	56	61
Total Phosphorous	60	61	60	59	61	58	60
Water Transparency	56	56	54	59	57	56	56

Figure 3.4.54: East Bay Lake – secchi depths by year.

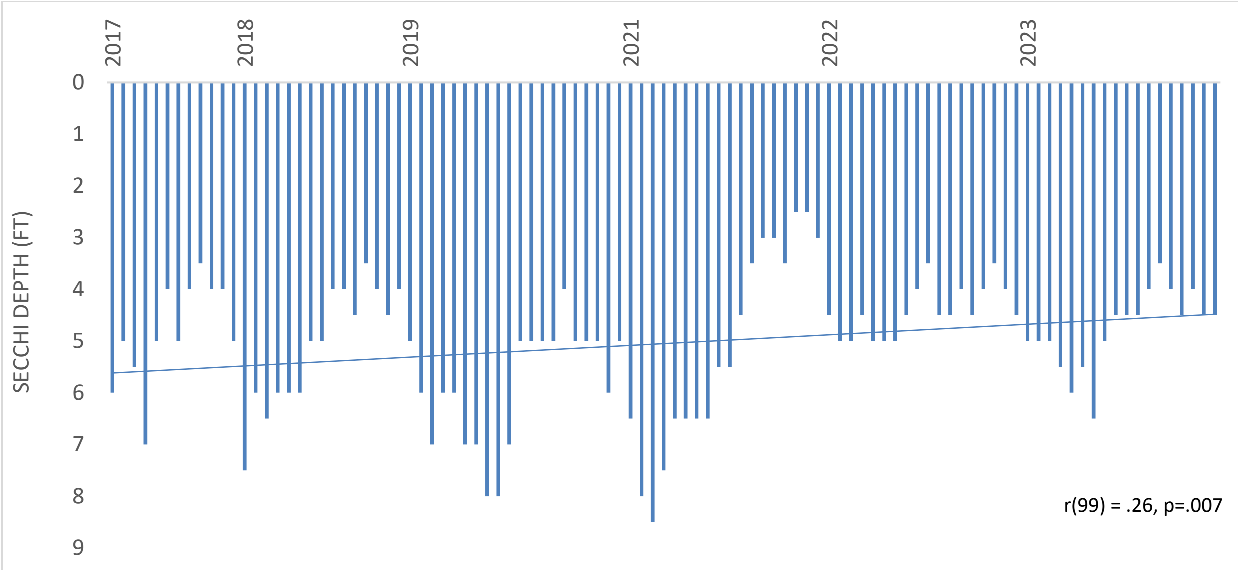
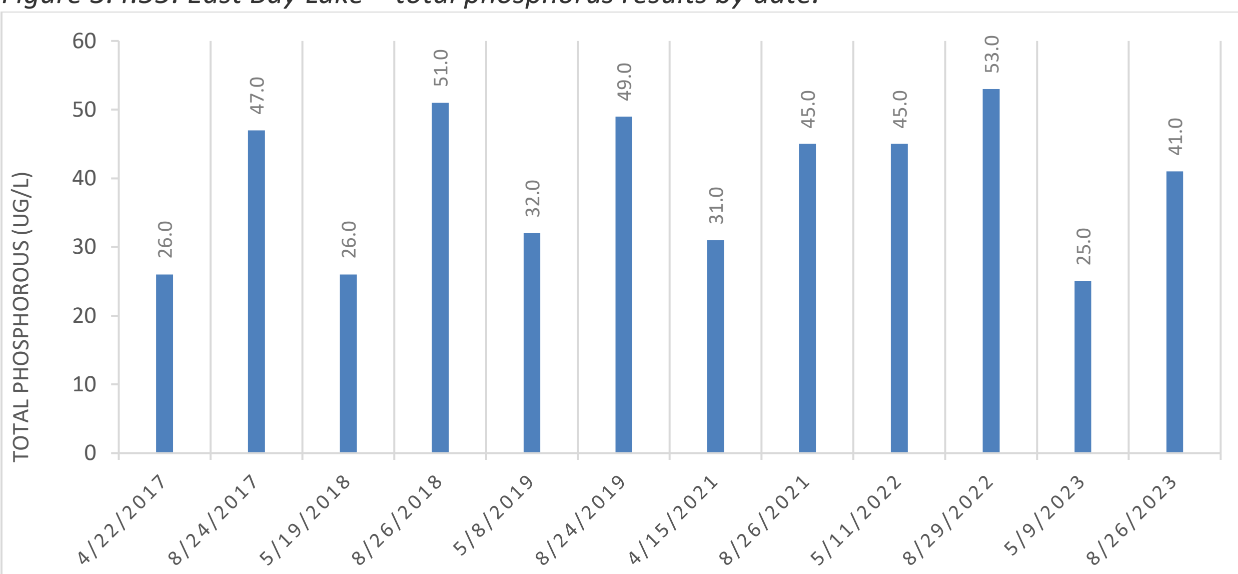


Figure 3.4.55: East Bay Lake – total phosphorus results by date.



SUMMARY AND RECOMMENDATIONS

The social perception of water quality is often complex. Those living on the lakeshore may describe water quality by watercolor, aquatic plant growth, smell, or quality of fishing. At a regional scale, as described above, interpreting water quality data can be complex and vary by State. Land cover and land use play an important role in the amount of sediment and nutrients entering a lake, affecting water quality. Natural vegetation and duff absorb rain and runoff coming from the surrounding landscape better than shallow rooted lawns. Diverting runoff from impervious surfaces such as rooftops and driveways to areas where water can infiltrate into the soil will minimize runoff to the lake. At the watershed level, land cover consists mainly of forests and wetlands, which allows water to infiltrate rather than run over the landscape, picking up pollutants that may enter the lakes.

Consistent and long-term water quality records benefit resource managers and lake stewards understand their lakes and recognize changes that may be occurring over time. This report consolidates water quality data for the Cisco Chain of Lakes, summarizes conditions by lake, and identifies gaps in monitoring. Hopefully, this document is useful to lake residents for decision making and becoming better lake stewards.

Even with the varying amounts of water quality data for each lake on the Chain, there appear to be some trends that can be seen across the Chain, mainly seen in water clarity and nutrients, which can occur with natural variations in climate, such as drought periods and periods of high precipitation. During drought periods, there is less runoff from the landscape, resulting in less flushing of nutrients into a lake. This may create periods of increased water clarity. Whereas, during periods of high precipitation, water running off the surrounding landscape picks up nutrients, which enter a lake, fueling plant and algae growth, and resulting in lower water clarity.

Takeaway messages to highlight

- The watershed surrounding the Cisco Chain is relatively undeveloped, with vast sections of protected land, filtering water and lowering nutrients and pollutants entering the Cisco Chain.
- Thousand Island Lake is one of only a handful of lakes in the State of Michigan that can support cold water fish, such as cisco.
- Overall, the water quality on the Cisco Chain is healthy, providing quality habitat to support fish and aquatic life.

Challenges to maintaining good water quality

- While the addition of one cottage or development on a lake may seem inconsequential, the cumulative total of lost habitat areas can have a negative effect on habitat quality, particularly on water clarity and on aquatic plants in near-shore areas that provide habitat for young fish.

- Identifying and reducing non-point pollution. Every lakeshore property, even those that are undeveloped, contribute nutrients to a lake. Though individually, this may not seem like an issue but cumulatively lakeshore practices affect fish and aquatic life. Some examples of non-point pollution include runoff from paved surfaces and lawn fertilizer.

Practices to protect water quality and aquatic habitats

- Educational and hands on learning opportunities
- Protection of existing natural shoreland habitats
- Improvement of marginal shoreland habitats for aquatic life and protecting water quality

Elements recommended to continue monitoring water quality and lake health

- Continued participation in volunteer water quality monitoring programs.
- Expand volunteer monitoring on lakes with limited data.
- Additional monitoring parameters to consider:
    - Expand nutrient testing on lakes with observed algal blooms or higher levels of nutrients.
    - Water temperature monitoring and additional dissolved oxygen monitoring on Thousand Island Lake.
    - Complete a baseline shoreland assessment. Prioritize lakes mainly under private ownership. MiCorps has a volunteer program to do this called score the shore. WDNR has standardized protocols, but currently not offered in a volunteer program.
- Aquatic plants play an important role in water quality and ecosystem health. Lakes with high plant diversity generally have good water quality. For example, Poor Lake's floristic quality ranks very high compared to neighboring lakes for aquatic plant diversity.
    - Continue monitoring aquatic plants.
    - Summarize aquatic plant data collected for the Cisco Chain to assist in understanding ecosystem health and monitor for trends or changes.