Pelican River
watershed district

2022 Annual Monitoring Report

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Pelican River Watershed District

DISTRICT MISSION

To enhance the quality of water in the lakes within our jurisdiction. It is understood to accomplish this, the District must ensure wise decisions are made concerning the management of streams, wetlands, lakes, groundwater, and related land resources which affect these lakes.

2022 Board of Manager's Tour (Headwaters of the Pelican River)

Managers left to right: Chris Jasken, Charles Jasken, Dennis Kral, Rick Michaelson, Phil Hansen, Tera Guetter (Administrator), Orrin Okeson. Not pictured: Laurie Olson.

Table of contents

List of Abbreviations

ALUM .... Aluminum Sulfate
AIS .... Aquatic Invasive Species
CHL-A .... Chlorophyll-a (pheophytin-a)
CLMP .... Citizen Lake Monitoring Program
CSAH .... County State Aid Highway
IBI .... Index of Biological Integrity
MN DNR .... Minnesota Department of Natural Resources
MPCA .... Minnesota Pollution Control Agency
MPN/100ml .... Most Probably Number per 100 milli-liters
MS4 .... Municipal Separate Stormwater System
MSL .... Mean Sea Level
OHW .... Ordinary High Waterline
OP .... Orthophosphate
PPB .... Parts per Billion
PRWD .... Pelican River Watershed District
SIZ .... Shore Impact Zone
SOP .... Standard Operating Procedures
TMDL .... Total Maximum Daily Load
TP .... Total Phosphorous
WMA .... Water Management Area
WWTP .... Wastewater Treatment Plant
TSS .... Total Suspended Solids
Secchi Depth .... Water Clarity
DO .... Dissolved Oxygen
NGVD .... National Geodetic Vertical Datum

1 Executive Summary

The Pelican River Watershed District (PRWD) performs an extensive monitoring operation to track trends and anomalies in the quality of District Waters. It is the intent of this program to maintain consistent and accurate water quality data to guide District practices and programs. This program was initiated in 1995 and has continued to the present date. Routine monitoring activities are performed according to the 10-Year Monitoring Plan adopted by the District in 2020.

In 2022, District Staff conducted water quality sampling on 14 lakes (St. Patrick was only able to be tested one time due to inaccessibility caused by aquatic vegetation) and 17 locations on 5 different stream systems. Of the 14 lakes sampled, 3 lakes were sampled for the first time in 2022. An aquatic vegetation survey was performed on Muskrat, Meadow, Fox, and Mill Pond Lakes. Shoreline surveys were conducted on Sallie, Melissa, and Lind Lakes.

Water Quality in 2022 was above average on lakes across the District except for Fish (shallow lake) (Table 1.1) (Figure 1.1). Drought conditions started to appear late August and continued into the end of the monitoring season.

Table 1.1 Lake water quality results from 2022 sampling efforts

Water Management Area	Lake	2022 Average			Historical Averages (2001-2021)			MNPCA Lake Standards		
		TP (µg/L)	Chl-a (µg/L)	Secchi (feet)	TP (µg/L)	Chl-a (µg/L)	Secchi (feet)	TP (µg/L)	Chl-a (µg/L)	Secchi (feet)
Detroit/Rice	St. Patrick**				--	--	--	<40	<14	>4.6
	Big Detroit	30/18***	3.11	15	20	7.86	10	<40	<14	>4.6
	Little Detroit	16	2.81	16	20	4.45	11	<40	<14	>4.6
Floyd/Campbell	Big Floyd	12	3.23	14	20	5.09	12	<40	<14	>4.6
	North Floyd	33	11.03	9	30	13.26	8	<40	<14	>4.6
	Little Floyd	26	8.64	12	20	8.58	9	<40	<14	>4.6
	Sands	19	2.86	11	20	2.86	10	<40	<14	>4.6
	Fish	116	92.71	1	--	--	--	<40	<14	>4.6
	Kennedy	42	17.93	6	--	--	--	<40	<14	>4.6
Long	Long	9	2.89	18	30	38.87	14	<40	<14	<4.6
Sallie/Melissa	Sallie	25	5.95	12	20	11.66	8	<40	<14	>4.6
	Melissa	15	4.06	13	10	6.52	11	<40	<14	>4.6
	St. Clair*	37	14.01	4	40	7.19	3	<60	<20	>3.3
Brandy	Brandy	40	7.19	5	40	7.19	5	<60	<20	>3.3
****Shallow Lake***	*****Only 1 testing day available***			****** see Big Detroit Water Quality section***						

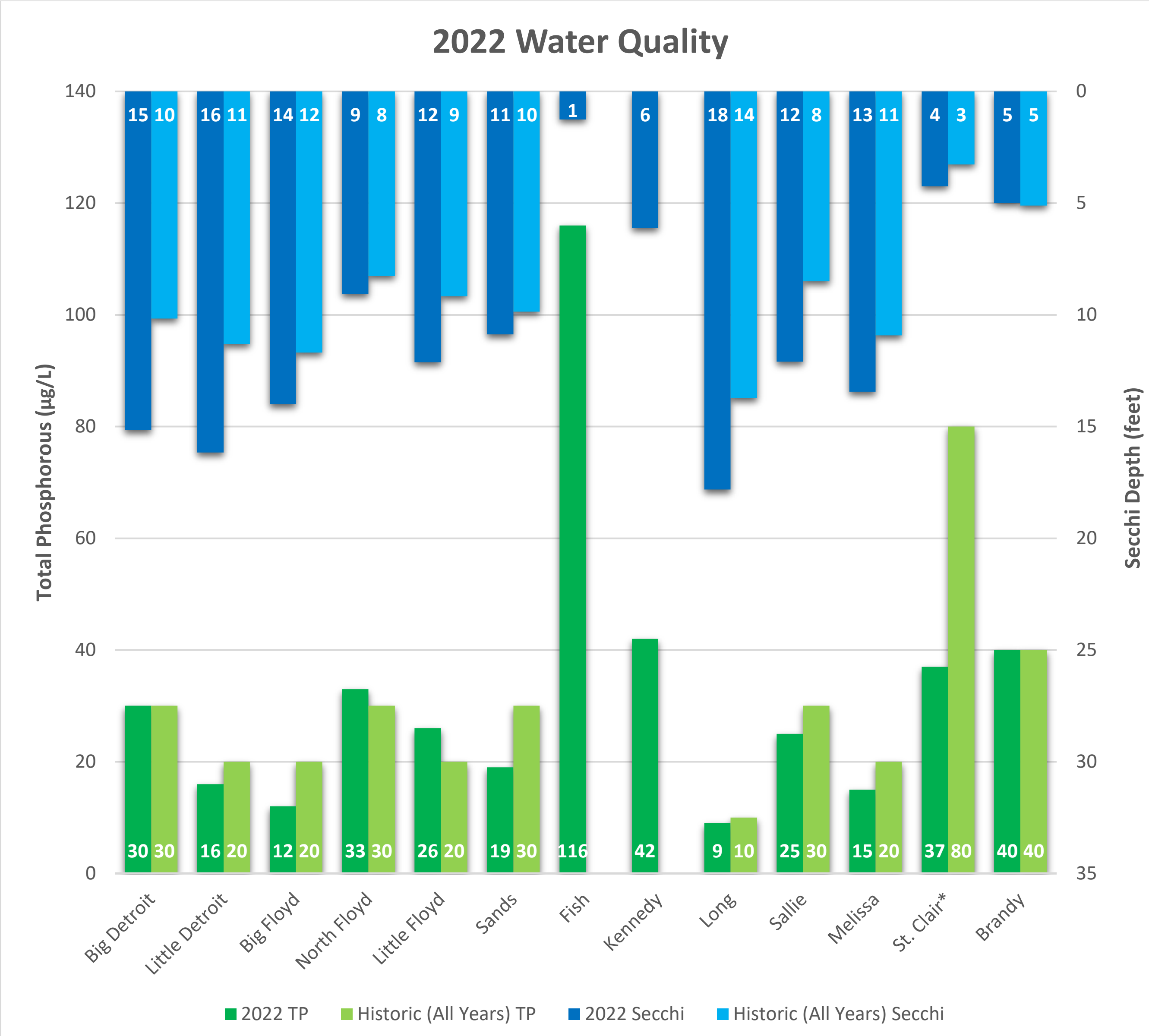


Figure 1. 1 Lake water quality results from 2022 compared to historic averages.

In 2023, 13 lakes and 17 stream sites (Table 1.3) will be sampled for water quality. Vegetation surveys will be conducted on Pearl, Munson and Long. Shoreline surveys will be conducted on Big Detroit, Little Detroit and Curfman.

Table 1. 2 2022 Lake Monitoring Schedule

				Water Quality	Ecological Integrity	
EQuIS ID	**Lake Name**	**LWQMA**	**Monitoring**	**Water Chemistry/Clarity**	**Vegetation Survey**	**Shoreline Survey**
03-0387-02-206	Big Floyd	Floyd/Campbell	Major	X		
03-0387-01-207	North Floyd	Floyd/Campbell	Major	X		
03-0386-00-201	Little Floyd	Floyd/Campbell	Major	X		
03-0381-00-204	Big Detroit	Detroit/Rice	Major	X		X
03-0381-00-207	Little Detroit	Detroit/Rice	Major	X		X
03-0383-00-201	Long	Long	Major	X	X	
03-0382-00-202	Saint Clair	Sallie/Melissa	Major	X		
03-0359-00-201	Lake Sallie	Sallie/Melissa	Major	X		
03-0475-00-202	Lake Melissa	Sallie/Melissa	Major	X		
03-0376-00-201	Lind Lake	Small Lakes	Minor	X		
03-0398-00-201	Wine	Brandy/Wine	Minor	X		
03-0377-00-201	Mill Pond	Sallie/Melissa	Minor	X		
	Tamarack	Floyd/Campbell	Minor	X		
03-0363-00-202	Curfman	Detroit/Rice	Minor			X
03-0486-00-201	Pearl	Pearl/Loon	Minor		X	
03-0358-00-201	Munson	Fox/Munson	Minor		X	

Table 1.3 2022 Stream Monitoring Schedule

			Weekly Visit			Bi-Weekly	Event/Storm		
Site	**EquIS Location ID**	**Description**	**Staff Guage**	**Chemical**	***E. Coli***	**Flow**	**Chemical**	***E. Coli***	**NOTES**
CC2**	S002-164	Campbell Creek at 230th St	X	X		X	X		
CC1**	S002-163	Campbell Creek at CR-149	X	X		X	X		
PR1	S002-167	Little Floyd Outlet on Little Floyd Rd	X	X					
PR2a**	S016-453	Pelican River at Rice Lake Outlet (Rice Lake Structur	X	X		X	X		
PR3	S002-169	Pelican River at State Highway 34	X	X	X	X	X	X	
PR4b	S002-170	Pelican River at Corbett Rd						X	
PR4a**	S002-176	Pelican River at Railroad Trestle	X	X	X	X	X	X	
PR6**	S002-172	Pelican River at Detroit Lake Outlet	X	X		X	X		
PR6a	S009-364	Pelican River at US Highway 59	X	X					
PR8	S002-174	Pelican River at Lake Sallie Outlet	X	X					
PR9	S002-175	Pelican River at Lake Melissa Outlet	X	X					
SC3**	S002-158	Ditch 14 at Lake St. Clair Outlet	X	X		X	X		
SC3b	S005-247	Ditch 14 Between Lake St. Clair and Pelican River	X	X					
SC4	S002-160	Ditch 14 at Outlet to Pelican River	X	X		X	X		
SU1**	S002-162	Sucker Creek at Outlet to Detroit Lake	X	X		X	X		
IP	S015-007	Industrial Park By dog park bridge	X		X		X	X	
PUB	PD00033	Public Water Access Storm Water Outflow (Roosevelt Ave)						X	ONLY IF FLOW
ESW	PS00177	Stormwater pond East of Cheryl Ave.					X	X	ONLY IF FLOW
PR3a	S016-006	8th Street North East of IP North Side of road					X	X	
PR5	S002-171	Pelican River at North Shore Drive (South side)						X	
PAV-E	S002-186	Pavilion East-picnic area- Storm water outflow					X	X	ONLY IF FLOW
PAV-W		Pavilion West-Washington Ave. outflow					X	X	ONLY IF FLOW

**** HOBO**

TP, OP	2 Bottles	**IF THERE IS NO FLOW DO NOT SAMPLE AT THAT SITE**
TP, OP, TSS	3 Bottles	E. coli testing even along PR (6 Sites) PR3, PR3a, IP, PR4a Railroad trestle, PR4b (Corbett Rd S002-170) and PR5 (Detroit Inlet)
Ecoli	1 Bottle	

2 Background

The Pelican River Watershed District (PRWD) is one of 46 watershed districts established in Minnesota (Figure 2.1) whose purpose is to conserve the natural resources of the state by land use planning, flood control, and other conservation projects utilizing sound scientific principles for the protection of the public health and welfare and the prudent use of the natural resources.

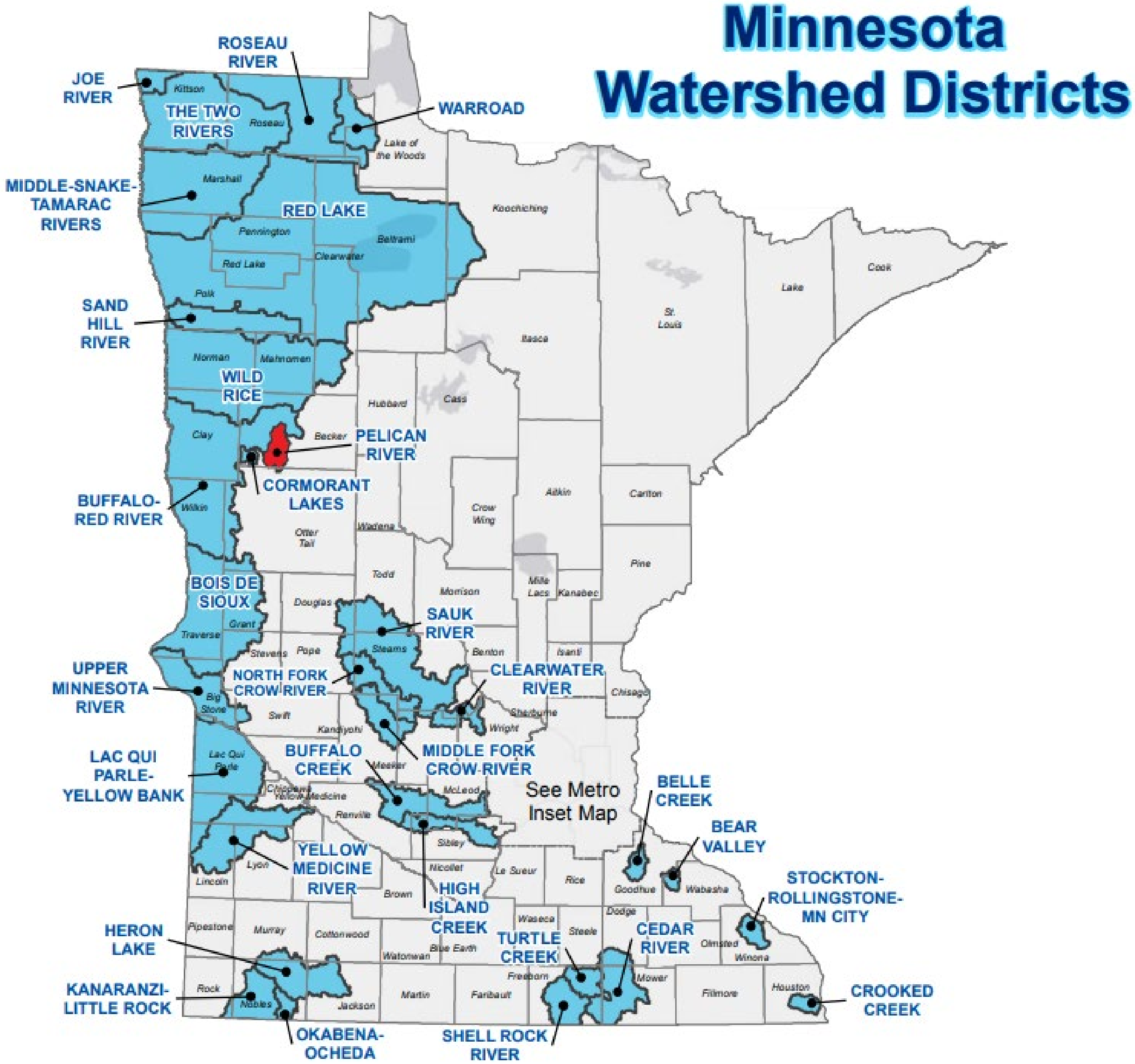


Figure 2. 1 Minnesota watershed districts map

Due to the deteriorating water quality in area lakes and streams in the 1950s and 1960s, residents petitioned the state of MN to establish a watershed district in the upper Pelican River watershed area to address the water quality issues. Established on May 27, 1966, PRWD was the first watershed district formed to address water quality issues rather than flooding issues.

The District is 120 square miles in size and is located primarily in Becker County (95%), with a small portion (5%) in Ottertail County. The Pelican River watershed is part of the Ottertail River basin which eventually discharges to the Red River of the North. Eight major lakes include the Floyd Lake Chain, Big/Little Detroit Lakes, Long Lake, Lake Sallie, and Lake Melissa. These lakes also serve as the economic engine for the NW region of Minnesota, providing recreational opportunities for residents and visitors, including fishing, boating, and swimming.

The Pelican River Watershed District is located within the North-Central Hardwood Forest Ecoregion (Figure 2.2). This region is an area of transition between the forested areas to the north and east, and the agricultural areas to the south and west. The terrain varies from rolling hills to smaller plains and is abundant with glacial lakes, wetlands, and remnant hardwood forests. The plains areas of the region are a mix of row crops, livestock grazing, and native prairie land. Much of the land surrounding the lakes has been developed for housing and recreation, resulting in an increase of the nutrient runoff associated with the lawns and impervious surfaces. The lakes in this region are typically found to be mesotrophic but are occasionally found to be slightly eutrophic, especially during mid-late summer, in shallower systems, and in more highly developed areas.

Figure 2. 2 PRWD within the MN Ecoregions

The Pelican River Watershed is a “headwaters watershed” of the Ottertail River Basin, meaning the location is upstream from most other watersheds in the basin. The status of a “headwaters watershed” comes with benefit and responsibility; the benefit being that waters of the Pelican River are not negatively affected by upstream development, land use, or industry. However, downstream resources and communities are affected by the land use implications, policies, and decisions made within this drainage system. By caring for our own resources, we also act as good neighbors.

The Pelican River Watershed District is dedicated to protecting and improving not only the resources within its jurisdiction but helping protect the downstream neighbors as well. This is done through collaborative conservation efforts, working with local, state, and federal agencies, to help reduce and manage stormwater runoff, educate the public with benefits of responsible development, and promote healthy lakes and rivers. The District pursues projects which meet the mission, "to enhance the quality of water in the lakes", by actively seeking state and federal Grant Funding to stretch and best utilize local tax dollars.

The Pelican River Watershed District has maintained a comprehensive water quality monitoring program since 1995, consistently monitoring lakes and stream throughout the District. The primary goal of the program is to be able to identify areas of decreased and impaired water quality so nutrient reduction efforts could be focused on the locations with the most benefit. A secondary goal of the program was to develop a database of water samples that could be used to identify trends in water quality. If a decreasing trend is observed, there is an opportunity to determine the cause and implement a remedy before the waterbody becomes impaired.

The District keeps all water quality records in a database in-house, including many water clarity samples collected through the Minnesota Pollution Control Agency's (MPCA) Citizen Lake Monitoring Program (CLMP). In addition to the PRWD database, District staff annually review and submit all water quality data to the MPCA's surface water database.

This program maintains an emphasis on tracking phosphorous as it travels through the watershed. Additional water quality metrics including water clarity (secchi depth), chlorophyll-a (CHL-A), total suspended solids (TSS), Dissolved oxygen (DO), etc. are captured at sample points to maintain a robust data set. This program also tracks changes to upland and riparian development through shoreline surveys and land use tracking. In the interest in maintaining healthy ecosystems within District waters, the District monitors the composition of aquatic vegetative communities and treats Curly-leaf pondweed and Flowering rush to control the spread of these aquatic invasive species (AIS). The District follows Standard Operating Procedures (SOP's) in all data collection (Adopted from Minnesota Pollution Control Agency and Red Lake Watershed District). For information on the District's sampling procedures and long-term planning, please see the 2020 10-Year Water Quality Monitoring Plan.

The data reported in this plan will be organized by Water Management Area (WMA) as outlined in the 2020 Pelican River Watershed District Revised Management Plan. It is important to emphasize the connectivity of the surface waters across WMA's and the District, as well as the impacts of weather patterns on water quality. With a total of 144 lakes and 49 miles of stream, it is important to prioritize monitoring activities. Select lakes are sampled on a rotating basis to ensure adequate data is collected to assess the health of the water body. In the same way, select stream sampling locations are established to assess the "load" of nutrients, sediment, and bacteria being transmitted through the system. This schedule can be found in the 2020 PRWD 10-Year Water Quality Monitoring Plan and the yearly Annual Monitoring Work Plans published by District Staff.

3 Climate Data

The District keeps a record of weather to track changes to District waters. Daily temperature and precipitation can help explain certain increases in nutrients and algal growth as well as increases in suspended sediment in streams.

The two key climate words for Minnesota in 2022 are windy and drought. Both were prevalent during the year and impacted many citizens.

In terms of both average wind speeds, as well as frequency of wind gusts over 30 mph, 2022 brought the highest numbers across Minnesota in over four decades. There were many days that brought damaging winds (over 50 mph). There is no simple explanation for this, and I am sure this anomaly in our weather will be studied in years to come.

After one of the wettest combinations of April and May in state history, there were no signs of drought present in Minnesota during June of 2022, but by the second week of November over 50 percent of the state was in Moderate Drought and over 20 percent in Severe or Extreme Drought. Some of the worst drought was in areas of the Twin Cities and in south-central and southwestern counties, where rainfall deficiencies for the year ranged from minus 10 to minus 15 inches (Table 3.1). Despite the mid to late summer drought onset, most Minnesota crops produced better than expected yields (Figures 3.2 and 3.3).

First Quarter 2022 – Winter Months: January – March

Average temperatures for the first quarter of 2022 were slightly below the historical averages for the highs and well below the averages for the lows. The lowest recorded temperatures were on January 1st, 2nd, and February 3rd with a low of -31°F, and the highest temperature during this period was on March 21st with 50°F. Fluctuations are not uncommon in the first quarter of the year.

First quarter started with below average precipitation, with total rainfall being 1.92", 0.06" less than historic average and snowfall being 33.43", 7.52" above average.

Second Quarter 2022 – Spring Months: April – June

Second quarter temperatures were slightly below the historical average for the first half of the quarter, toward the last half of the quarter the highs were more in sync with the historical average while the lows still remained slightly lower than average. Average highs and lows for April were 39°F and 27°F, with the second quarter lowest temp being 10°F on April 19th. May average highs and lows were 64°F and 46°F. June's average high was 78°F and average low was 57°F. June had the highest recorded temperature of the quarter with 99°F on the 19th.

Second quarter rainfall had a total of 3.93 inches falling in April, 3.82 inches in May and 2.66 inches in June. This was a grand total of 10.41inches of rainfall in the second quarter. This was 1.11 inches higher than the 10-year average total second quarter rainfall.

Third Quarter 2022 – Summer Months: July – September

Third quarter temperatures seemed to have trended closer to historical average temperatures. The average highs and lows for July were 80°F and 62°F. The hottest day in July was on the 19th with a reading of 91°F and the coolest day in July was on the 25th with a reading of 50°F. The average highs and lows for the month of August were 78°F and 60°F. The highest temperature recorded for August this year was also 90°F, which was on the 5th. The lowest temperature for August was on the 8th and the 26th, with both days having the same temperature of 52°F. In September the high was recorded at 84°F on the 1st and the lowest was recorded at 36°F on the 28th.

Precipitation greatly varied between July through September. In July, rainfall was well below the historical average totaling only 2.66 inches (1.59 inches below the 10-year average monthly rainfall of 4.25 inches). August trended closer to normal rainfall, with 2.98 inches, just above the 10-year monthly rainfall average by 0.07 inches. September trended drier with a total of 1.72 inches, 0.97 inches below the ten-year monthly average of 2.69 inches.

Fourth Quarter 2022 – Fall Months: October – December

Fourth quarter high temperatures followed the historical average temperatures in the beginning of the quarter but then it started to trend below the 10-year historical average towards the second half. For the month of October, the average high temperature for the year was 57°F which was 13 degrees cooler than the 10-year historical average of 70°F. The warmest day was on October 11th with a temperature of 77°F. The average low for the month of October was 37°F, which was same as the 10-year historical average of 37°F; with the lowest temp for October 2022 being on the 18th, with a temperature of 14°F. In November, the average highs of 34°F were lower than the historical average high temps of 40°F by 6 degrees. The average lows for November were 21°F, which was 2 degrees cooler than the historical average of 23°F. The highest temperature for November was 70°F on the 1st and 2nd, and the lowest was 3°F on the 18th and 30th. During the month of December, the average highs were 17°F and the lows were 5°F. The historic average high and low were 23°F and 7°F, so it was slightly cooler. The highest temperature for December was 32°F on the 6 of the 31 days (4th, 10th 11th, 13th, 14th, and 15th) and the lowest was -24°F on the 20th.

October was the second driest month of the year, with a total of 0.57 inches of rainfall which was well below the 10-year historical average of 2.41 inches. We did, however, get 1.70 inches of snow which was .86 inches more than the 10-year average of 0.84 inches. In November there was 1.44 inches of precipitation recorded, with 11.70 inches of snowfall which is well above the 10-year historical average of 7.75 inches of snowfall. During the month of December, we received 1.31 inches of precipitation and 21.90 inches of snow. This was well above the historical average for both precipitation (0.91 inches) and snow (13.29 inches).

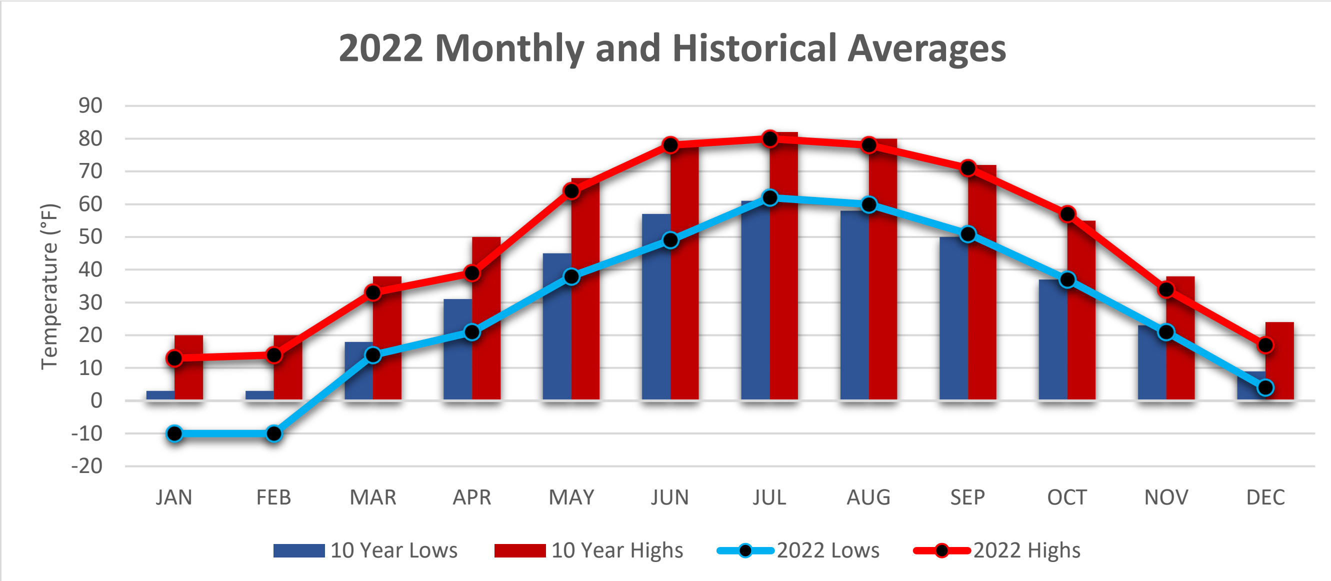


Figure 3. 1 Monthly high and low temperatures from 2022

Table 3. 1 Rainfall events in Detroit Lakes >0.5" April-October 2022.

Date	Inches	Date	Inches	Date	Inches
4/11/2022	1.14	5/12/2022	0.74	8/6/2022	0.52
4/30/2022	1.67	6/21/2022	0.62	8/19/2022	1.40
5/1/2022	0.55	6/24/2022	1.54	9/15/2022	0.70
5/9/2022	1.02	7/17/2022	0.62		
5/10/2022	0.72	7/27/2022	0.75		

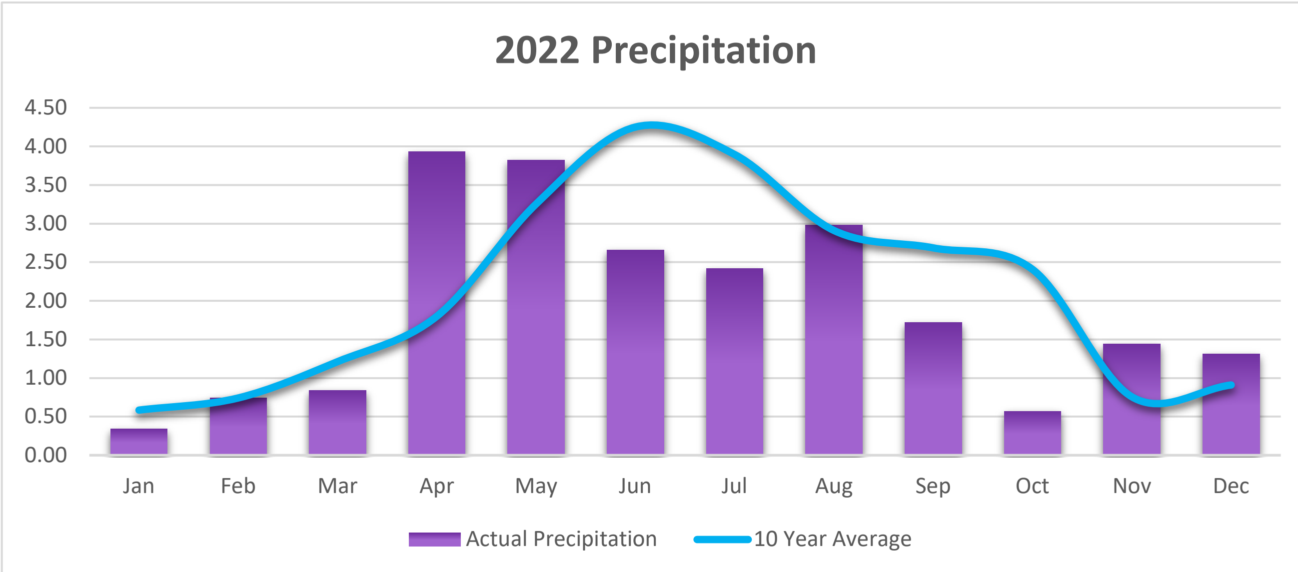


Figure 3. 2 Monthly precipitation from 2022

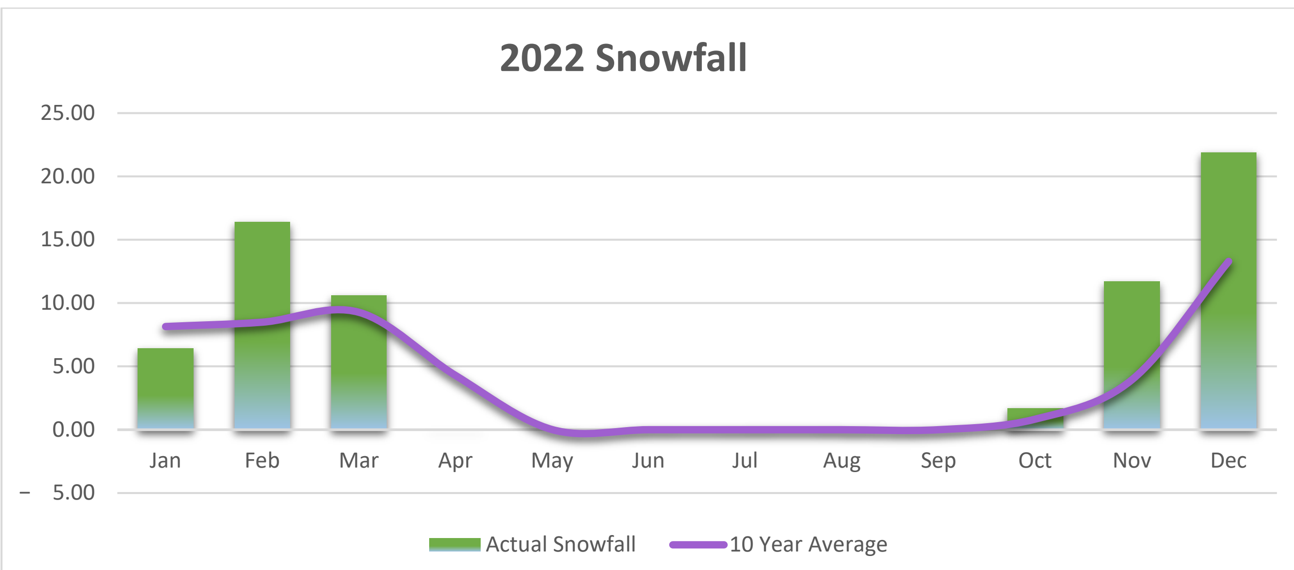


Figure 3. 3 Monthly Snowfall from 2022

4 Water Management Areas (WMA)

The District has designated 8 planning regions, called Water Management Areas (WMA), within its borders to focus monitoring and planning efforts (Figure 4.1). While all boundaries are based upon a subwatershed area, some subwatersheds were combined based on physical area, lake and land characteristics, water quality attributes or problems, development characteristics, and adjacency. The charts located in the appendices (Appendix A, B, & C) are from the MPCA 2020 Otter Tail Watershed Restoration and Protection Strategies (WRAPS). This chart shows status of District waters and strategies to restore and protect waters in the District.

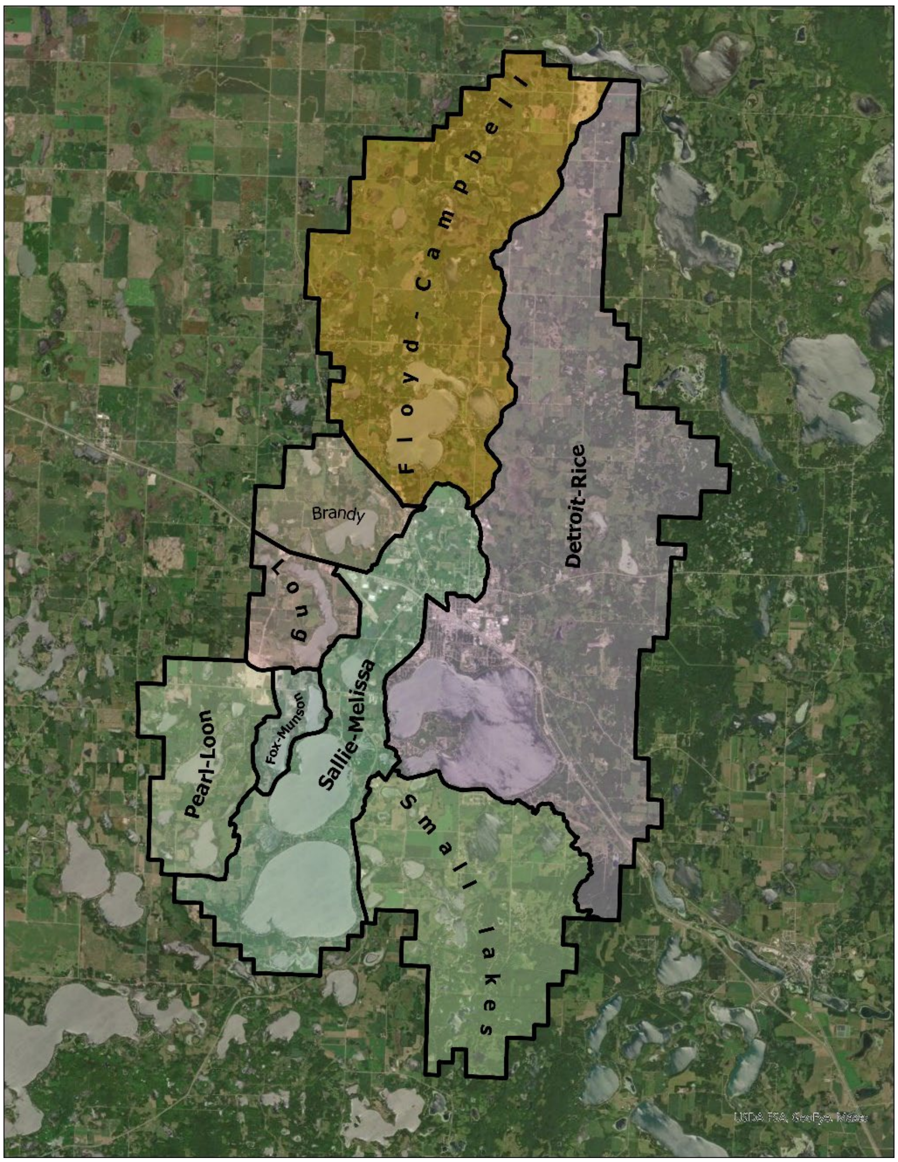


Figure 4.1 Water Management Areas.

5 Floyd/Campbell Water Management Area

The Floyd/Campbell WMA is at the top of the watershed and is about 16,000 acres in size (Figure 5.1). Campbell Creek flows south from Campbell Lake to North Floyd Lake. Becker County Ditch 11 flows into Campbell Lake from the North. Several small "potholes" exist throughout the WMA, most of which are isolated basins with no surface connection to the rest of the watershed. Major issues of the WMA include stream channelization and bank erosion, intensive agriculture, shoreline modifications, and altered hydrology. Becker County Ditch 12/Campbell Creek from Campbell Lake to North Floyd has an impairment caused by excess sediment loading due to channel erosion, causing North Floyd Lake to be at risk of impairment from eutrophication.

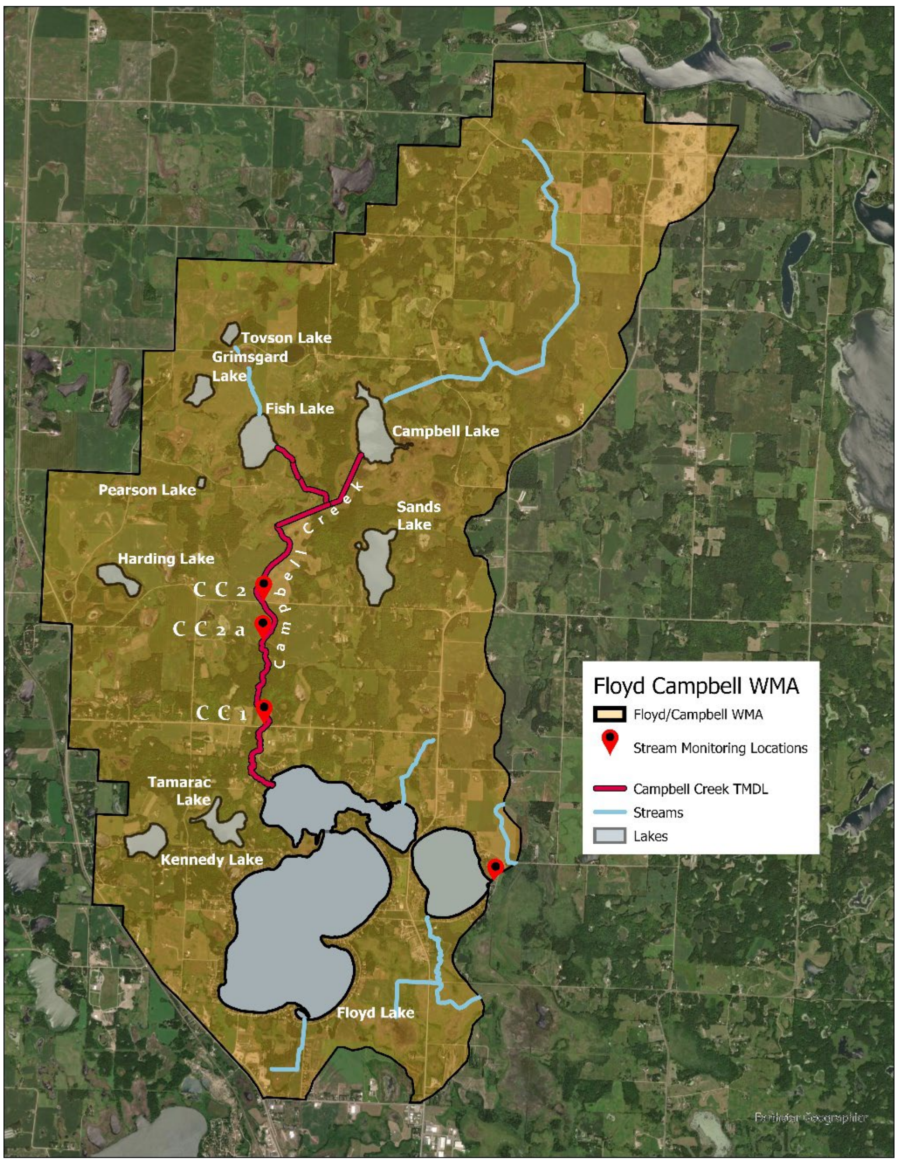


Figure 5.1 The Floyd/Campbell WMA.

5.1 Lakes

Lakes monitored by the District in the Floyd Lake WMA include the Floyd Chain of Lakes (Big Floyd, North Floyd, and Little Floyd), Sands Lake, Kennedy Lake, Tamarack Lake, Campbell Lake and Fish Lake.

5.1.1 Floyd Chain of Lakes

Floyd Lake, a 1,178-acre, general development lake with heavily developed shoreline, is located north of the City of Detroit Lakes. The lake is divided into two distinct basins, known locally as Big Floyd and North Floyd. The lakes are heavily used for game fishing, boating, and other summer, or winter recreational activities. The larger of the two basins, Big Floyd, is 862 acres in size, reaches a maximum depth of 25 feet, and has approximately 5.5 miles of shoreline. The littoral area (<15 ft) of the lake accounts for nearly 70% of the lake area and emergent aquatic plants are common. North Floyd is smaller, with 316 acres of surface area, 2.2 miles of shoreline, and a maximum depth of 34 feet. North Floyd littoral area (<15 ft) coverage is approximately 60%. There is one MN DNR owned public access located on the southeast side of Big Floyd. North Floyd Lake does not have a public access but is accessible via a channel between the two basins.

Little Floyd Lake is a 214-acre lake with a maximum depth of 34 ft. It has a moderately developed shoreline. Little Floyd sub-watershed area is approximately 342 acres including surface water area. Little Floyd receives most of its water from North Floyd, which outlets to Little Floyd through the Becker CSAH 21 road, though there are some small natural drainage ways that lead to the lake. The littoral area (< 15ft depth) of the lake accounts for 95 acres (45%) with an extensive emergent (cattail and hard stem bulrush) vegetation area located on the northeast side. There is an abundant native plant community. There is one MN DNR public access on Little Floyd located on the south end.

The major water source into North Floyd is Becker County Drainage Ditch 12/Campbell Creek located on the west side of North Floyd along with one minor inlet on the southwest side of Big Floyd. It appears that most of the time Big Floyd also contributes some flow to North Floyd, although it is thought the source of this water is mainly from groundwater. Other minor water sources include overland flows and groundwater seeps and springs. The outflow is located on the east side of North Floyd and connects to Little Floyd through the Becker CSAH 21 road culvert. Little Floyd Lake has two outlets located on the south side. Historically, the lake had one outlet, located near the present-day public access, however, a new outlet was constructed in 1919, when the Becker County Drainage System 13 was built to channelize the Pelican River between Little Floyd Lake and Big Detroit Lake. In 1936, the Civilian Conservation Corps built a concrete weir dam on Becker Drainage System 13. This structure controls Little Floyd, as well as North and Big Floyd's water levels.

Both Big and North Floyd Lakes are dimictic lakes (Spring/Fall turnover). Most of the time Big Floyd's water is clear, with moderate phosphorus and algae concentrations, good game fish populations, and moderate aquatic plant growth. Big Floyd, a mesotrophic lake, exhibits above average water quality when compared with other District Lakes with annual averages of 12.5' secchi depth (clarity) and 18 ppb in-lake phosphorus concentrations. In comparison, North Floyd suffers from poorer water clarity, high phosphorus, and severe algal blooms as a result of almost of 100 years of elevated phosphorus and sediment loading from Campbell Creek. In North Floyd, there is a phenomenon occurring known as "internal phosphorus loading" which recycles and releases phosphorus back into the water column causing algae blooms. This is due to decades of legacy phosphorus that has accumulated in the lake sediment. In late summer, after water "turnover", North Floyd experiences occasional algae blooms caused by the release of phosphorus from the enriched lake sediments. North Floyd is considered borderline eutrophic as the annual average of in-lake phosphorus concentrations have remained in the 32-34 ppb range. Little Floyd Lake is classified as a mesotrophic lake based on the Tropic State Index average for phosphorous, chlorophyll-a, and water clarity. In-lake phosphorus concentrations can vary between 20ppb to 34ppb and are highly responsive to storm-events and heavy rainfall patterns. The 10-year (2008-2017) average is 25 ppb in-lake phosphorus concentration.

A citizen scientist submits ice-on and ice-off data for the Floyd Lakes as part of the District's CLMP. The District has data from 1971 to 2022 to track trends in relation to climate change. For 2022, there were 198 days without ice cover on Floyd Lake, and 162 days of ice cover in the winter of 2021-2022. The number of ice cover days is an increase from the 10-year average of 143 and from the historic average of 150 days. The number days without ice cover from the winter of 2021-2022 was a decrease from the historic average of 215 days and the 10-year average of 222 days.

5.1.1.1 Water Quality/Quantity

Water Quantity – Floyd Lake Chain

Big Floyd, Little Floyd, and North Floyd maintain similar water levels. The OHW for all 3 basins is set at the same elevation (1354.8' NVGD 29) by the MN DNR. There is a fixed crest weir (1354.8 NVGD 29) on the outlet of Little Floyd Lake. Due to a late spring and deep snow conditions water levels were well above the OHWL (the highest since 2006, 16 years), however by late August to early September, water levels had dropped to no-flow conditions at the Little Floyd Lake dam outlet due to drought (Figures 5.2 & 5.3).

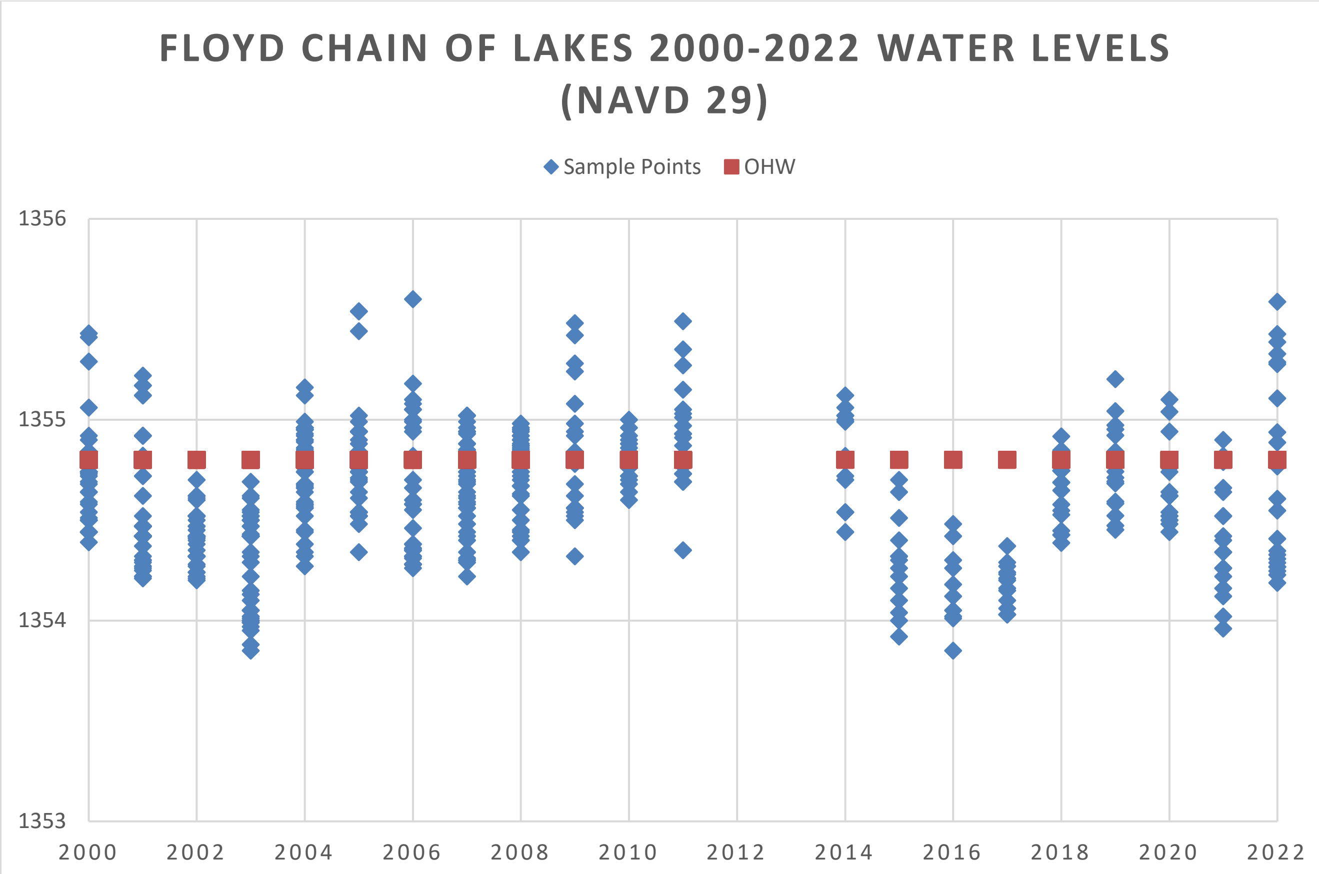


Figure 5.2 Floyd chain of lakes water levels from 2000-2022.

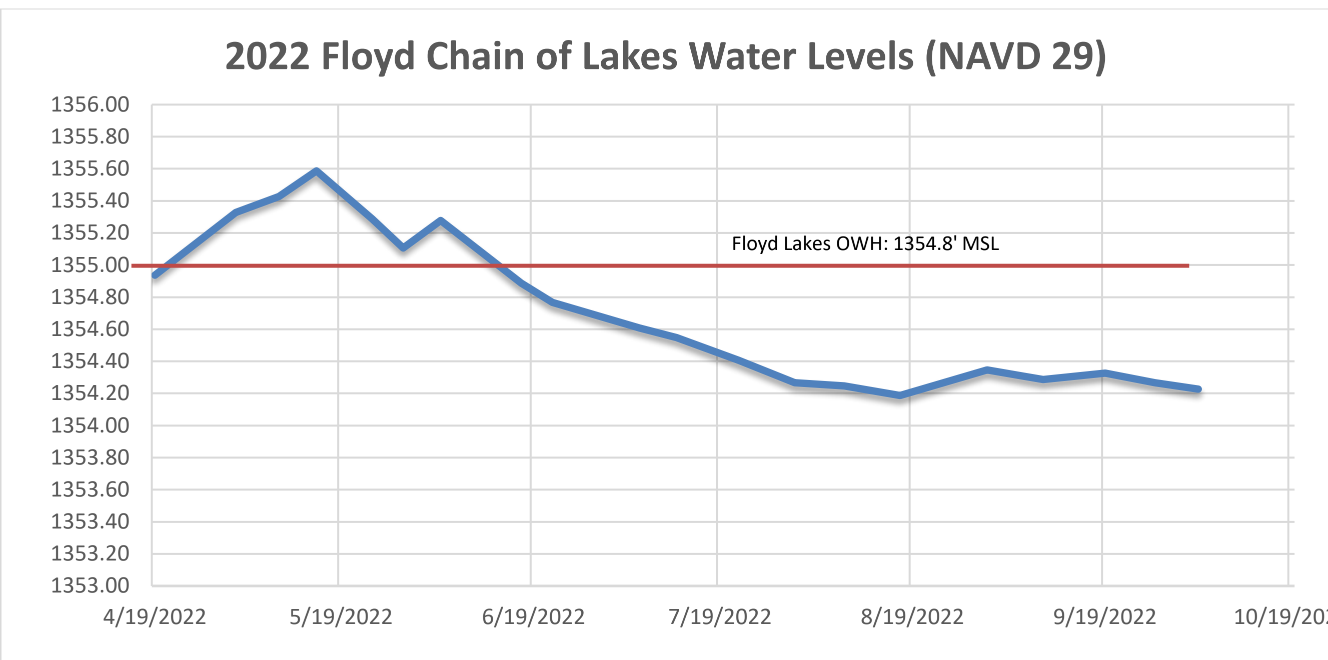


Figure 5.3 Floyd chain of lakes water levels 2022.

Water Quality - Big Floyd Lake

In 2022, Big Floyd's average Total Phosphorus (TP) was 12 µg/L, slightly better than the 20-year average of 15 µg/L (Figure 5.4). However, CHL-A (algae) was significantly lower at 3.23 (20-year 9.47 µg/L) (Figure 5.5) and water clarity (secchi depths) averaged 14.3 feet, almost 3 feet better than the 20-year average of 11.7 feet (Figure 5.6). Unfortunately, with the springtime high-water level conditions and lake wave action, there was a significant amount of lake shore damage, with many older retaining wall failures. Even after this event, water quality remained very good, with no algae blooms observed in late August and September.

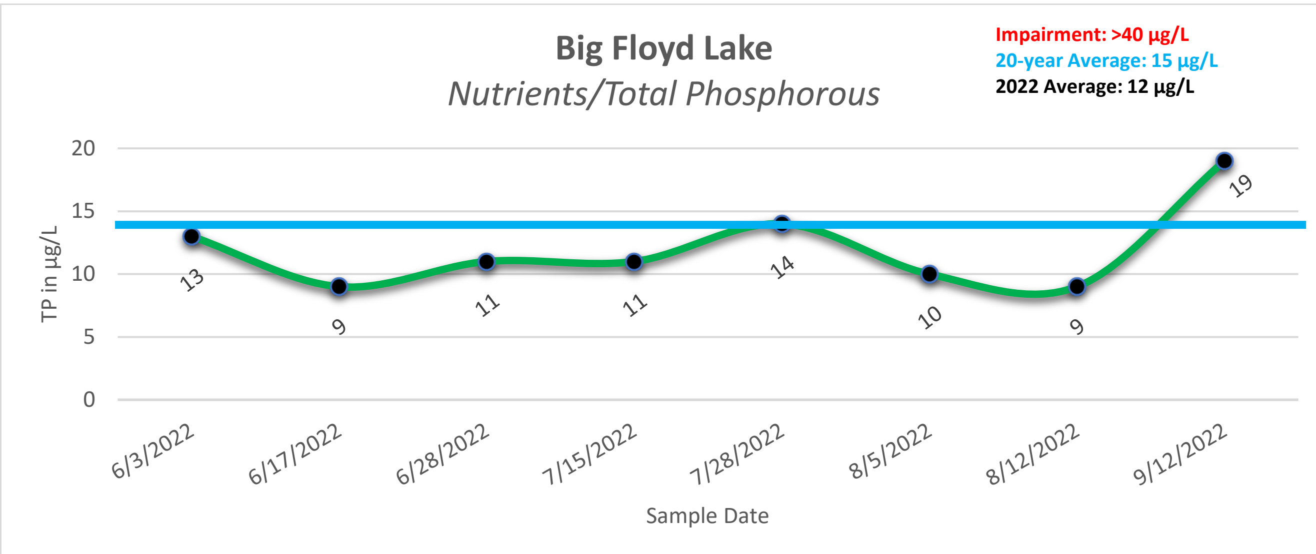


Figure 5.4 Big Floyd Lake 2022 total phosphorous.

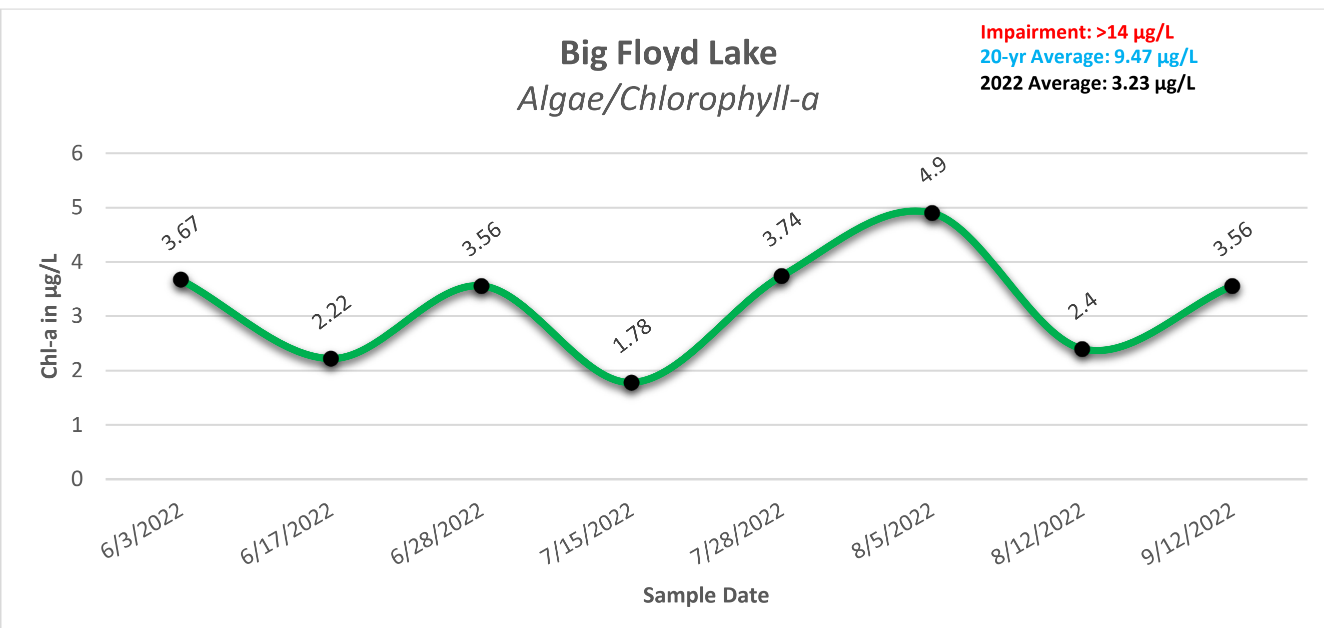


Figure 5.5 Big Floyd Lake 2022 chlorophyll-a.

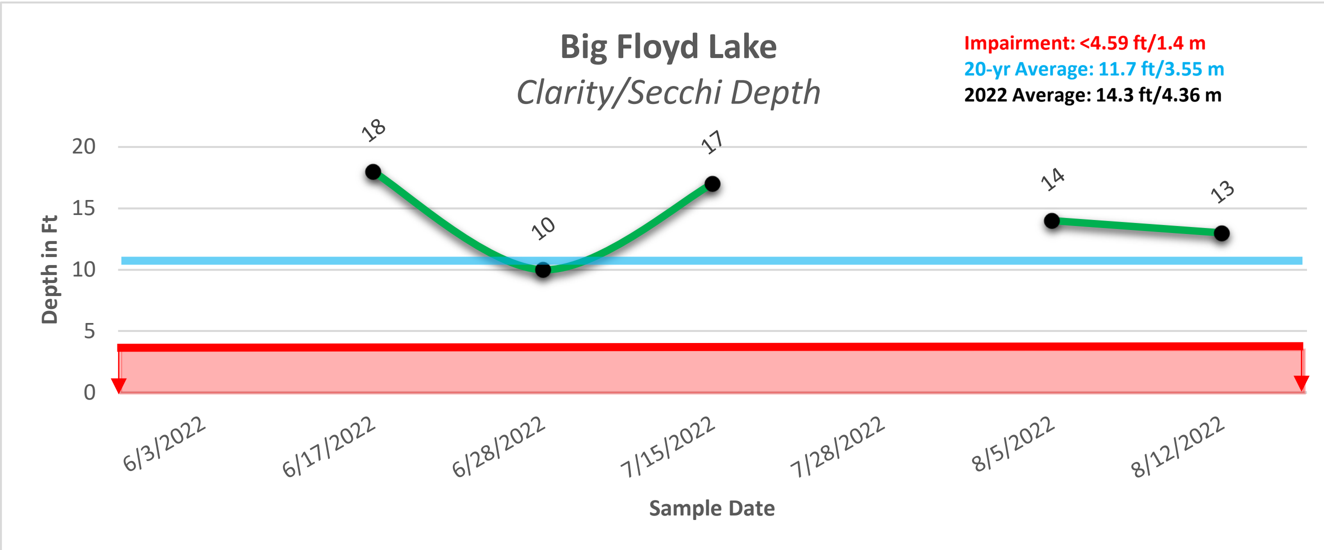


Figure 5.6 Big Floyd Lake 2022 secchi depth.

Water Quality - North Floyd Lake

North Floyd Lake water quality suffered more from the high-water levels compared to Big Floyd Lake. The average TP was 33 µg/L, slightly above the 20-year average of 31 µg/L (Figure 5.7). Most TP results were right around that 20-year average throughout the summer, with two TP readings much higher at 41 µg/L on June 3rd and 39 µg/L on August 12th. CHL-A (algae) levels were also higher at 11.03 µg/L, compared to the 20-year average of 13.26 µg/L (Figure 5.8). The highest CHL-a measurement was at 18.4 µg/L on August 5th. Water clarity readings started off promising, but by the 3rd sample (June 28th) the readings fell from 20 feet to 6.5 feet which is below the 20-year historical average (Figure 5.9). The clarity stayed there the remainder of the monitoring season. These readings show the direct correlation of the negative impact Campbell Creek has on North Floyd's water quality. With the lack of rainfall in 2021 (summer drought conditions) preventing the normal nutrient loading discharges from Campbell Creek, the water quality was much better in comparison with the 2022 high spring-melt conditions, which caused unusually high flushing of nutrients.

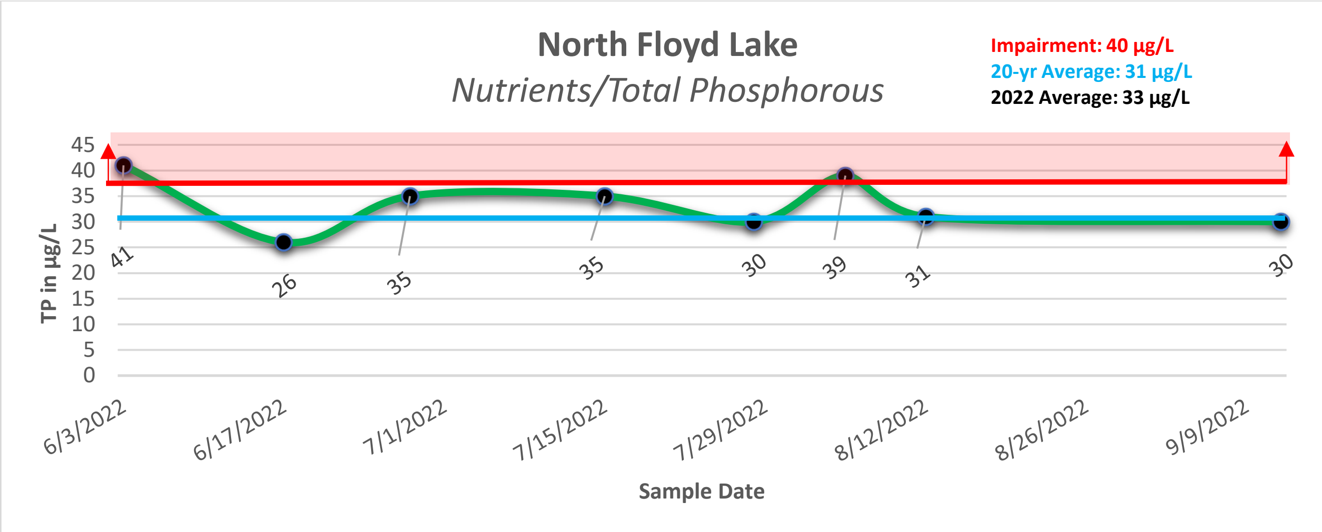


Figure 5.7 North Floyd Lake 2022 total phosphorous.

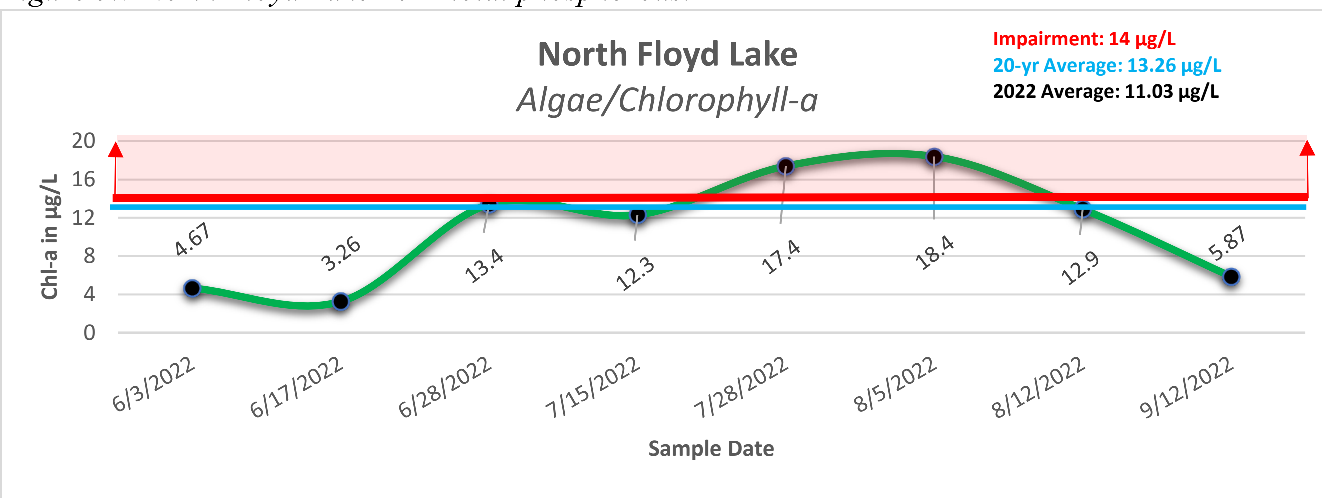


Figure 5.8 North Floyd Lake 2022 chlorophyll-a.

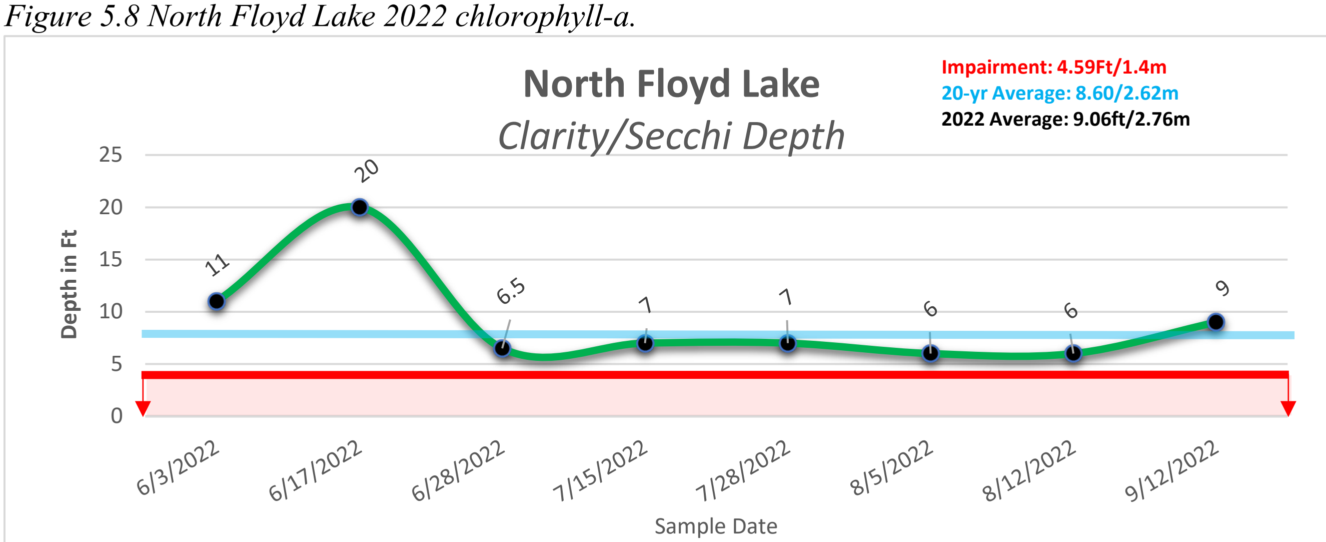


Figure 5.9 North Floyd Lake 2022 secchi depth.

Water Quality - Little Floyd Lake

Little Floyd Lake water quality started off well throughout June, but by the beginning of July water quality started to decline and remained that way towards the end of the monitoring season. Average TP was 26 µg/L, a decline over the 20-year average of 23 µg/L (Figure 5.10). The highest TP reading was July 15th at 34 µg/L which occurred after some very hot days. On July 15th CHL-A also declined from 3.12 µg/L on June 28th to 15.6 µg/L (Figure 5.11). Water clarity readings (secchi) averaged 12.13 feet, which is 2.2 ft worse than the 9.2 feet 20-year average (Figure 5.12).

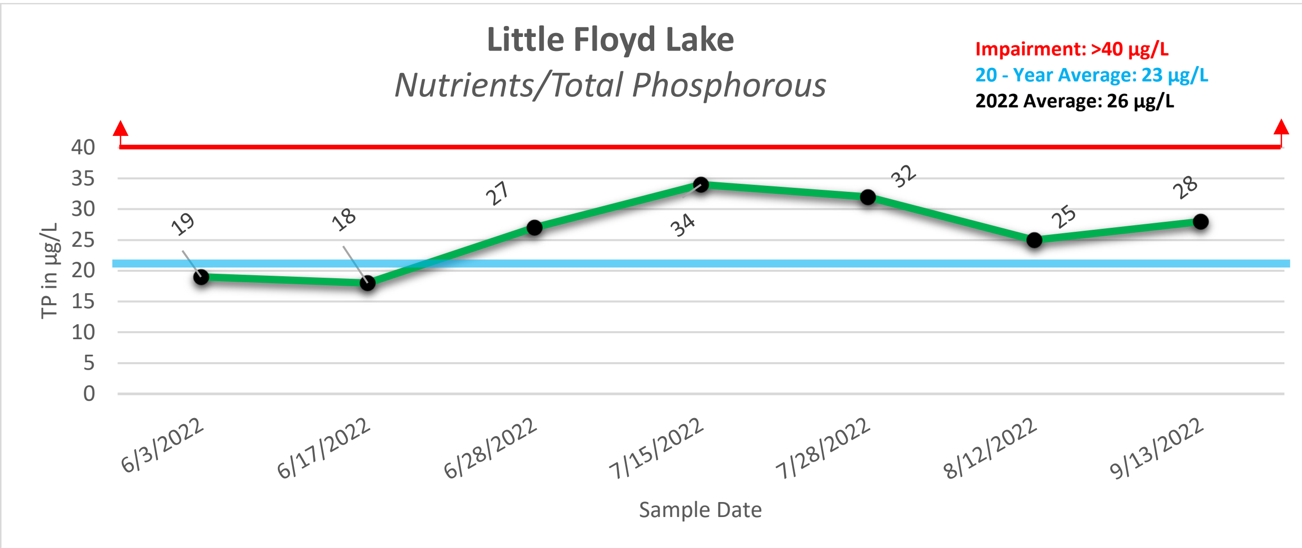


Figure 5.10 Little Floyd Lake 2022 total phosphorous.

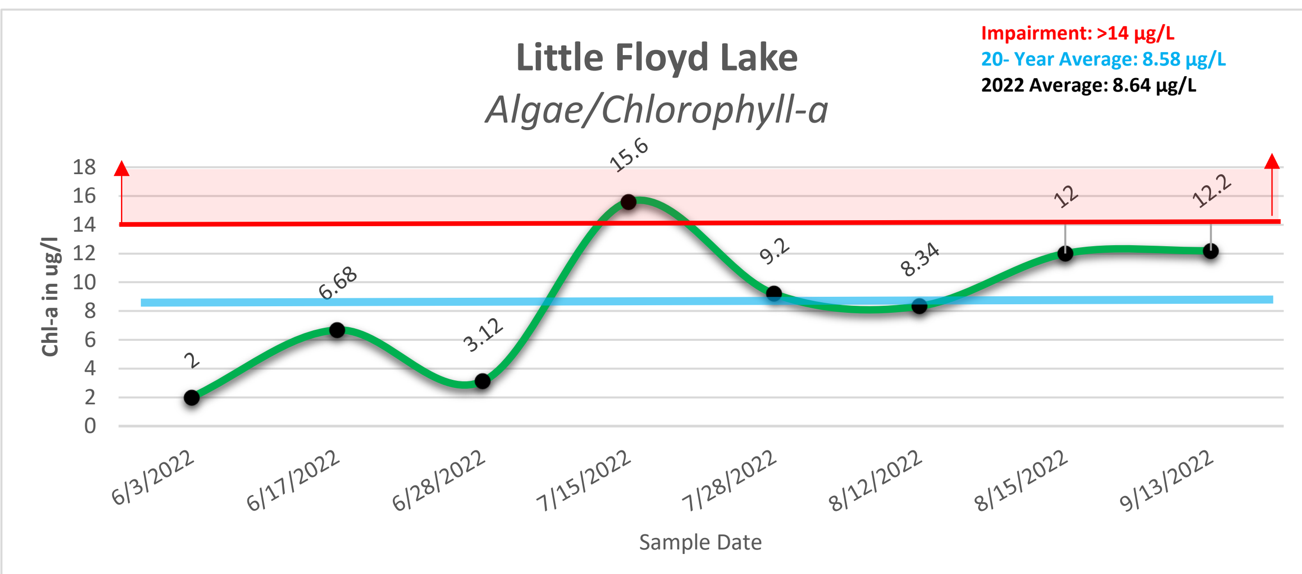


Figure 5.11 Little Floyd Lake 2022 chlorophyll-a.

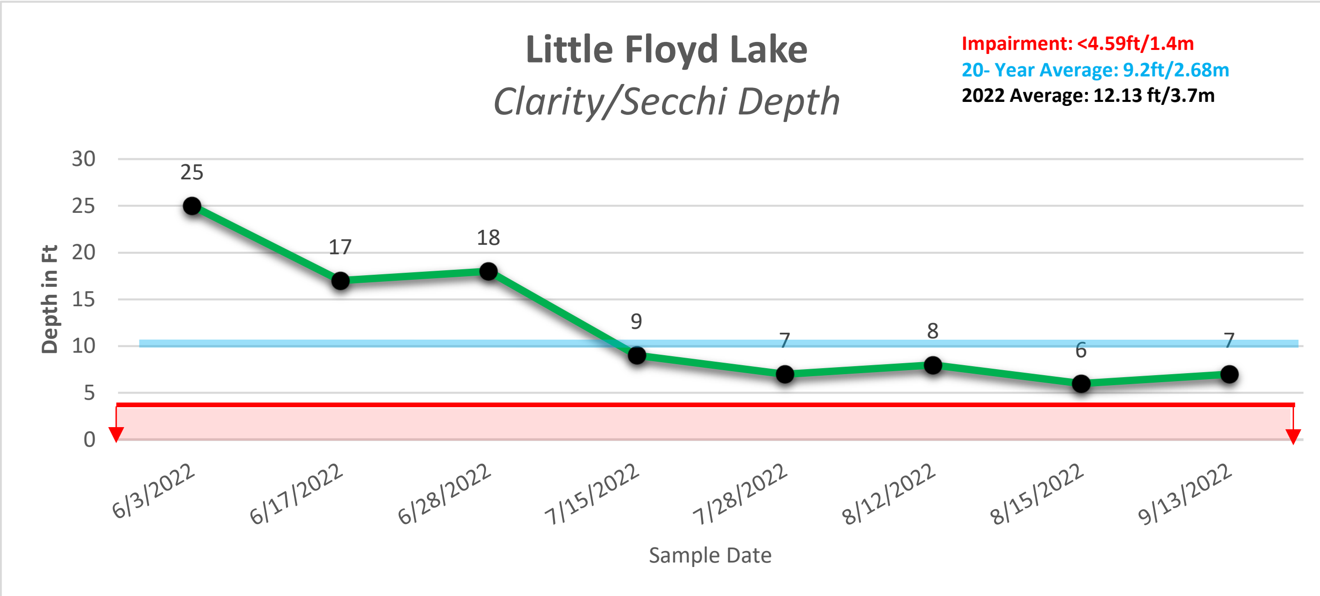


Figure 5.12 Little Floyd Lake 2022 secchi depth.

5.1.2 Sands Lake

Sands Lake is small (104 acres) natural environment lake located North of the Floyd Chain of Lakes (Figure 5.15). Sands is classified as a shallow lake, with a maximum depth of 11 feet and a natural wetland fringe around the edge. Sands Lake is land locked, with no significant surface inlets or outlets. Water quality in Sands Lake is marginal, with a 20-year summer average phosphorous concentration of 30 µg/L and a secchi depth of 9.5ft. Aquatic plant growth is dense throughout, but especially so in depths less than 5ft.

5.1.2.1 Water Quality

Water Quality – Sands Lake

Sands Lake water quality is doing well overall, throughout the monitoring season. Average TP was 19 µg/L, a big improvement from the 20-year average of 30 µg/L (Figure 5.13). The highest TP reading was on June 7th and 27th at 23 µg/L. CHL-A also improved from the 20-year historical average of 7.66 µg/L to 2.86 µg/L (Figure 5.14). That is a difference of 4.8 ppb. Water clarity readings (secchi) averaged 10.875 feet, which is 1.22 ft better than the 9.2 feet 20-year average (Figure 5.15). There were 2 reading (July 28th – 7feet & Aug. 16th – 6 feet) that dipped down below the 20-year average, more than likely due to the higher temps which caused plant growth or algae growth to hinder the secchi readings.

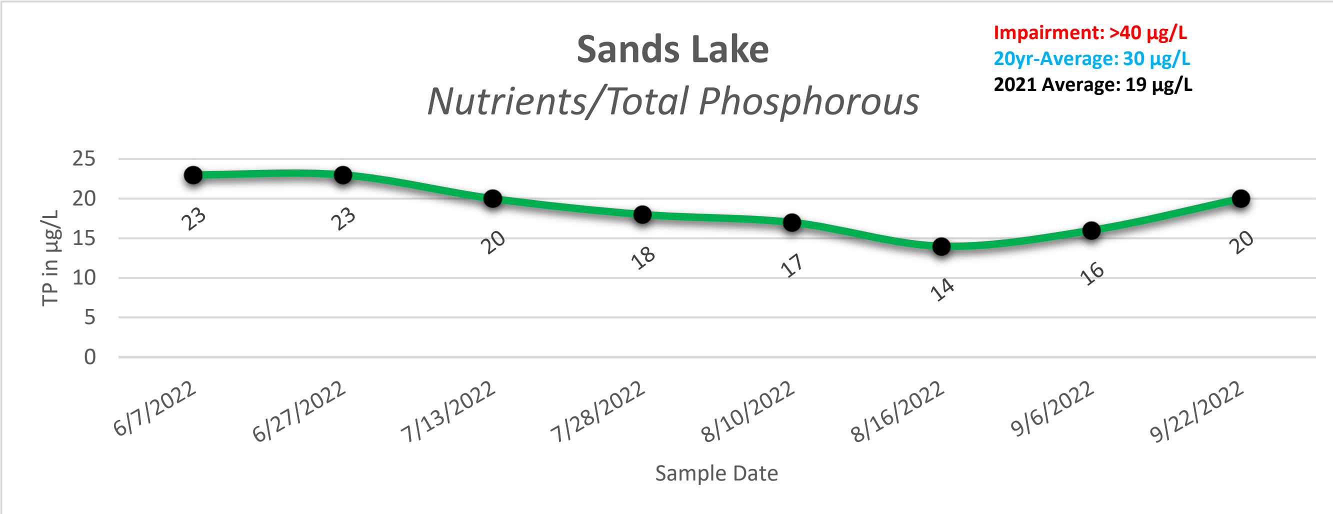


Figure 5.13 Sands Lake 2022 total phosphorous.

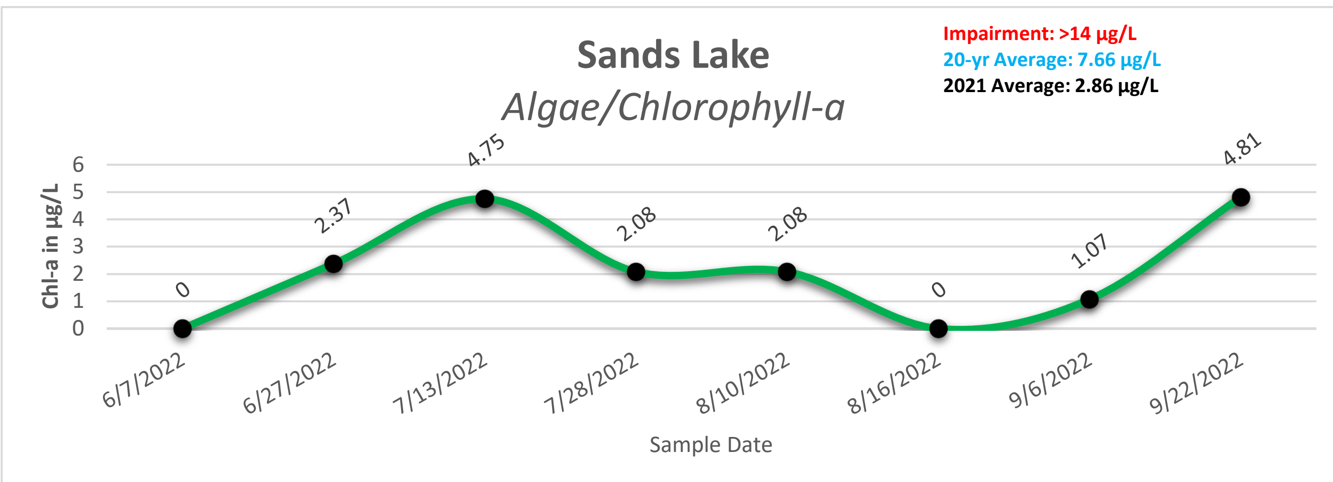


Figure 5.14 Sands Lake 2022 chlorophyll-a.

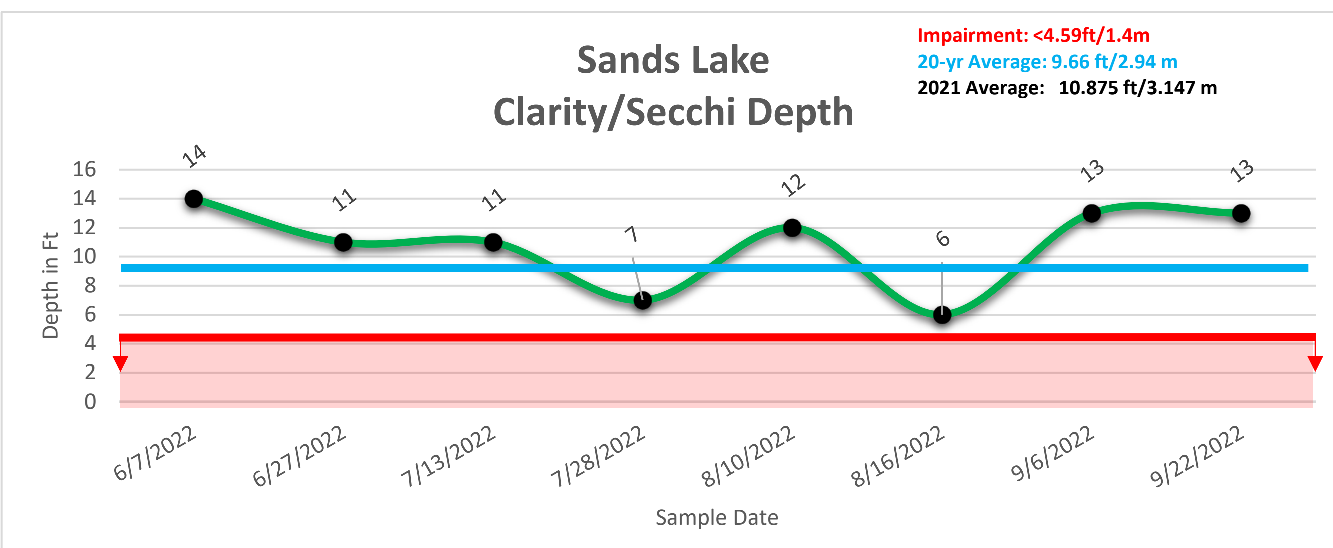


Figure 5.15. Sands Lake 2022 secchi depth.

5.1.3 Fish Lake

Fish Lake is a shallow 68-acre natural environment lake with a maximum depth of 15 feet. It is fed by three inlets, two of which are intermittent, and has an outlet that leads to Becker County Ditch #12. Fish are reported to be in the lake, and it is believed that they come up through the outlet. The lake has one residence and is located 9.5 miles North of Detroit Lakes, in the northwestern part of the Floyd Campbell Water Management Area. It is one of 4 lakes in the 2,992-acre subwatershed. The lake was monitored for 1 year (2022), and by MPCA standards, appears to be impaired. The water quality for this lake will continue to be monitored over the next 10 -years.

5.1.3.1 Water Quality

Water Quality – Fish Lake

This was the first year conducting water quality on Fish Lake. Initial 2022 sampling results are borderline for impairment of TP, Chl-a and Secchi according to the MPCA Water Quality Standards. Sampling results continued to decline through September. Average TP was 116 µg/L, with the highest reading being 161 µg/L on August 10th (Figure 5.16). The MPCA Water Quality Standards consider impairment for TP to be >40 µg/L. CHL-A average was 92.71 µg/L (Figure 5.17), the highest reading was 135 µg/L, on September 6th. The MPCA Water Quality standards consider impairment for Chl-a to be >14 µg/L. Water clarity readings (secchi) averaged 1.25feet (Figure 5.18), The MPCA Water Quality Standards consider impairment for Secchi (clarity) to be <4.59 feet. We will continue to monitor Sands Lake every 5 years according to the 20- year monitoring plan and revise the plan if deemed necessary.

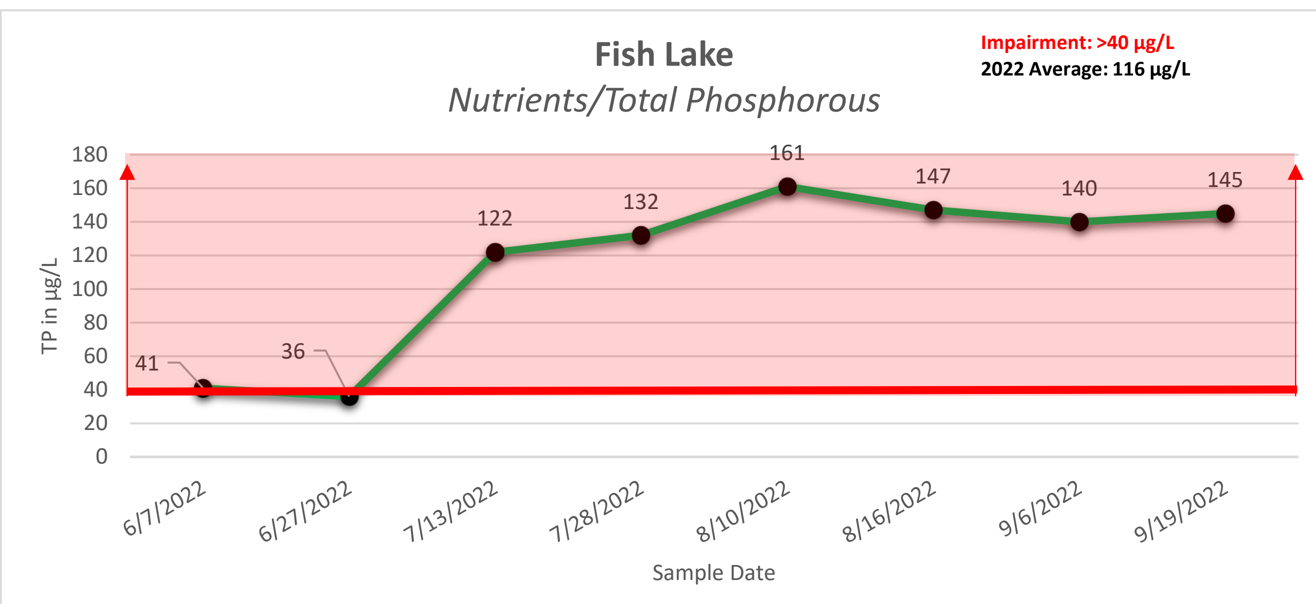


Figure 5.16 Fish Lake 2022 total phosphorous.

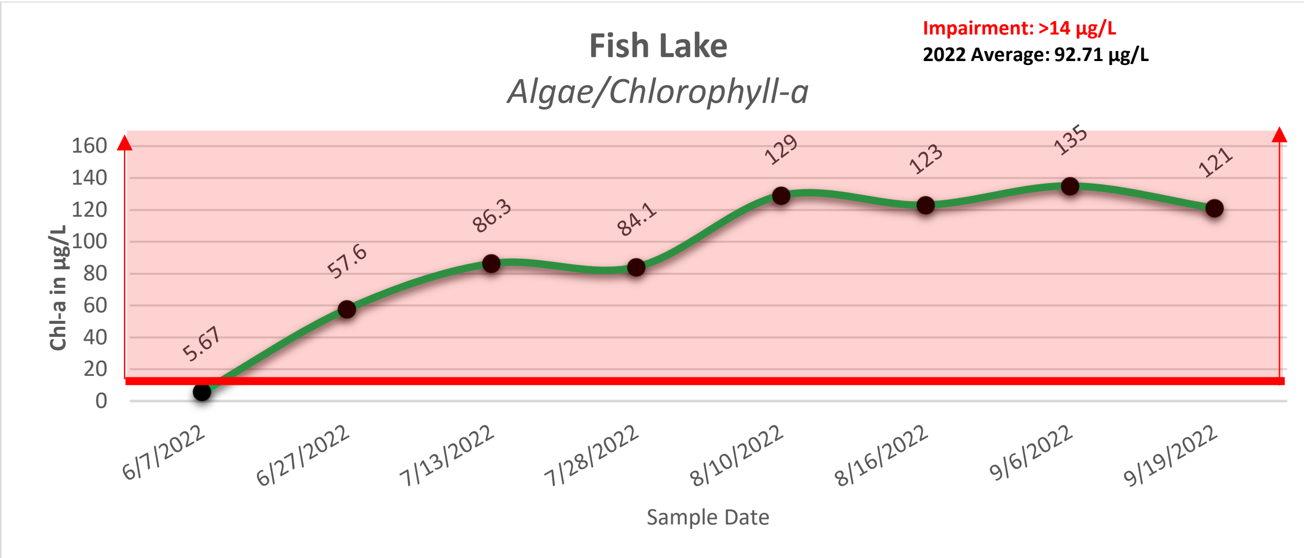


Figure 5.17 Fish Lake 2022 chlorophyll-a.

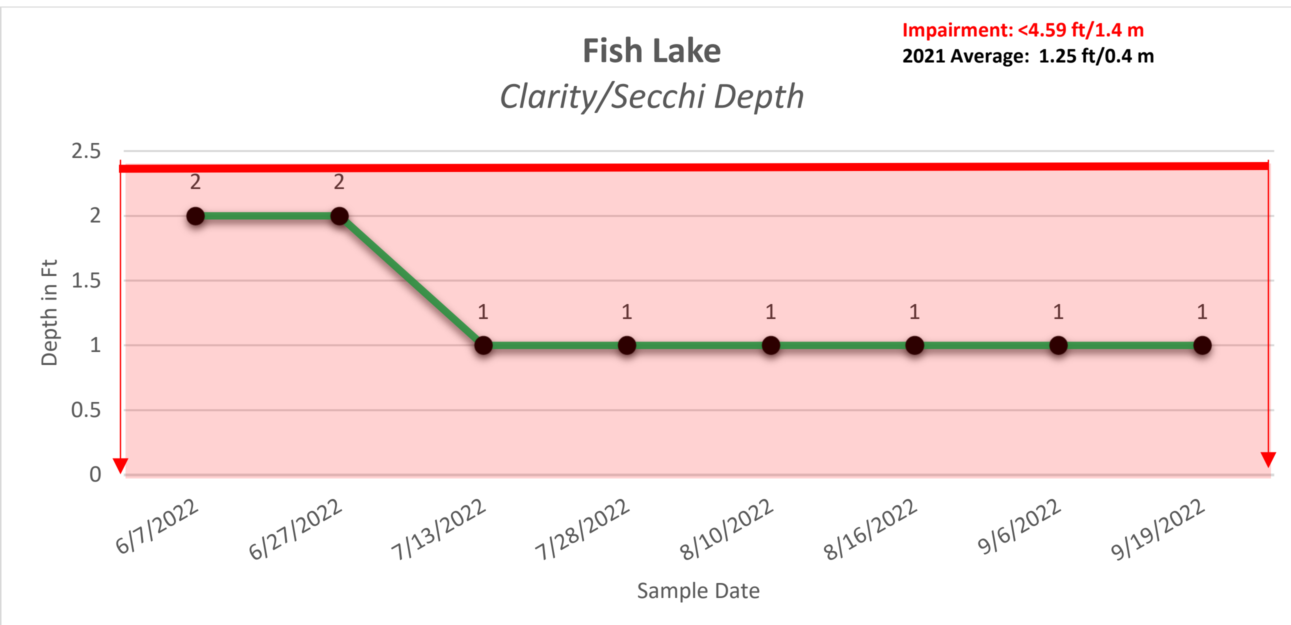


Figure 5.18 Fish Lake 2022 secchi depth.

5.1.4 Kennedy Lake

Kennedy Lake is a shallow, natural environmental lake with a 17-foot max depth. It is located in a 6,281-acre sub-watershed, approximately 5 miles North of Detroit Lakes, in the Southwestern part of the Floyd Campbell Water Management Area. There are six homes on the lake. It has no inlet or outlet. Local residents reported that bullheads have been taken in the past from this lake and is known to winter kill periodically. The lake was monitored for 1-year (2022) for water quality and will continue to be monitored.

5.1.4.1 Water Quality

Water Quality – Kennedy Lake

This was the first year of conducting water quality on Kennedy Lake. The highwater spring runoff initially affected sampling results with readings at the impairment level of MPCA's Water Quality Standards. However, by July water quality improved through September 9th, but it plunged back into impairment levels by mid-September. Average TP was 42 µg/L, with the highest reading at 74 µg/L on June 7th (Figure 5.19). The MPCA Water Quality Standards consider impairment for TP to be >40 µg/L. CHL-A average was 17.93 µg/L. The highest reading was 29.70 µg/L, on June 27th (Figure 5.20). The MPCA Water Quality Standards consider impairment for Chl-a to be >14 µg/L. Water clarity readings (secchi) averaged at 6.13 feet (Figure 5.21), The MPCA Water Quality Standards consider impairment for Secchi (clarity) to be <4.59 feet. We will continue to monitor Kennedy Lake every 5 years according to the 20- year monitoring plan and revise the plan if deemed necessary.

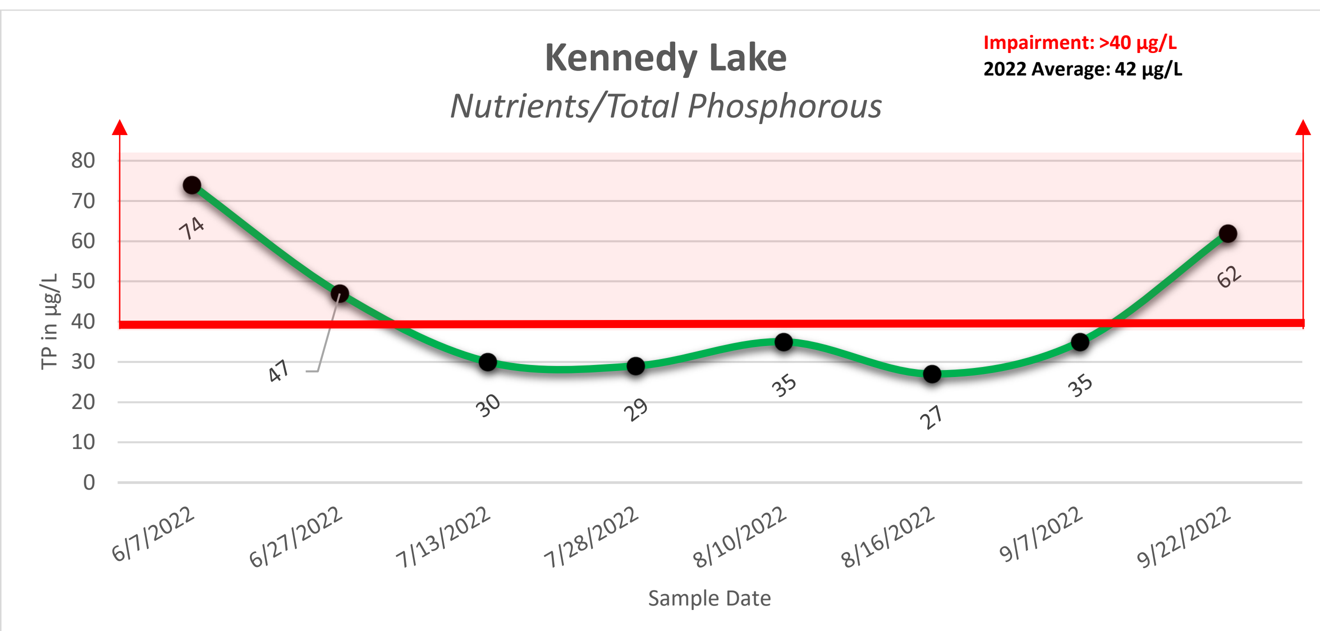


Figure 5.19 Kennedy Lake 2022 total phosphorous.

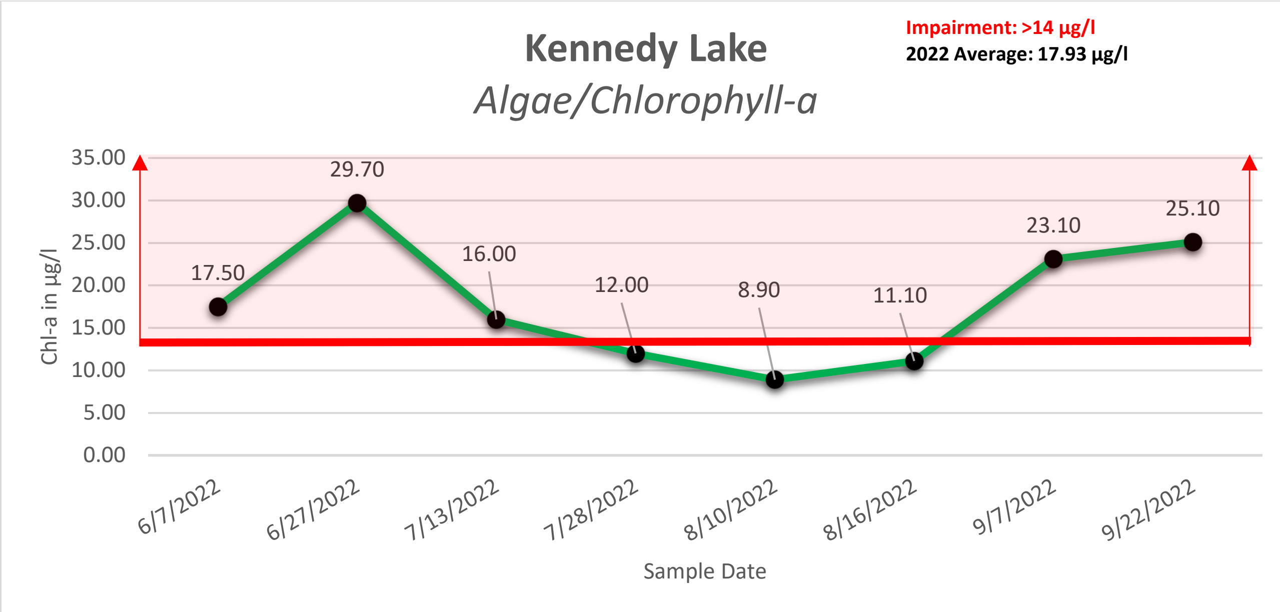


Figure 5.20 Kennedy Lake 2022 chlorophyll-a.

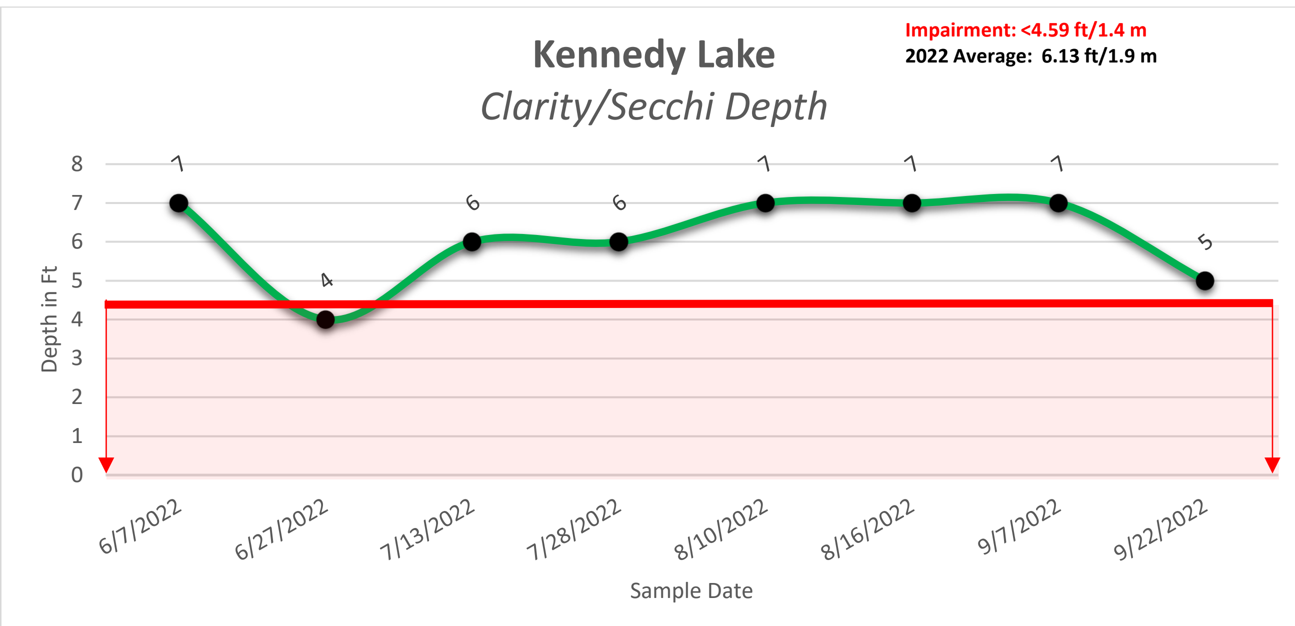


Figure 5.21 Kennedy Lake 2022 secchi depth.

5.2 Streams/Ditches

5.2.1 Campbell Creek (Ditch 11/12)

Campbell Creek is an intermittent, high gradient stream and is the major nutrient source to North Floyd Lake. Sections of Campbell Creek were ditched and straightened in the early 1900s for agricultural benefit and included partially drawing down Campbell Lake and draining surrounding wetland areas. Also known as Becker County Ditch 11-12, Campbell Creek drops almost 80 feet in 2 miles before reaching North Floyd. Through the lower reach, Campbell Creek flows through highly erodible soils, and carries a heavy sediment load to North Floyd.

Extensive conservation work has been completed in the agricultural areas between Campbell Lake and North Floyd Lake including ditch buffers, sedimentation basins, and wetland restorations. These practices have decreased loads of sediment and phosphorous to Campbell Creek, but other issues still need to be addressed. (e.g., drain tile and stream bank erosion).

5.2.1.1 Water Quality/Quantity

Water Quality – Campbell Creek (Ditch 11/12)

Campbell Creek saw one of the worst water quality years in 2022. Increased nutrient loads within Campbell Creek can be attributed to the late spring and the large amount of snow melt and rainfall events that occurred from April – June (Figure 5.23). Nutrient loads at CC2 (Campbell Creek at 230th St) reached 2,043 lbs/yr of TP and 200 tons/yr of TSS (Figure 5.22). Loads of TP and TSS reached 6,132 bs/yr and 1032 tons/yr at station CC1 (Campbell Creek at CSAH 149). The District was not able to compare loads from 2021 due to the mid-summer severe drought conditions and was not able to obtain the minimum (12) required number of flow measurements.

Water Quantity – Campbell Creek (Ditch 11/12)

The majority of the of the District's lakes saw 40-year high record water elevations. Events like this forced water through Campbell Creek causing flushes of sediment and nutrients to find their way to North Floyd Lake. As more and more winters with large amount of wet snow fall and heavy rain events occur, erosion to Campbell Creek increases. The District will be attempting to repair this situation in the coming years by implementing best management practices in Campbell Creek and in the surrounding uplands with the help of local entities such as the MN DNR and Becker County Soil and Water District.

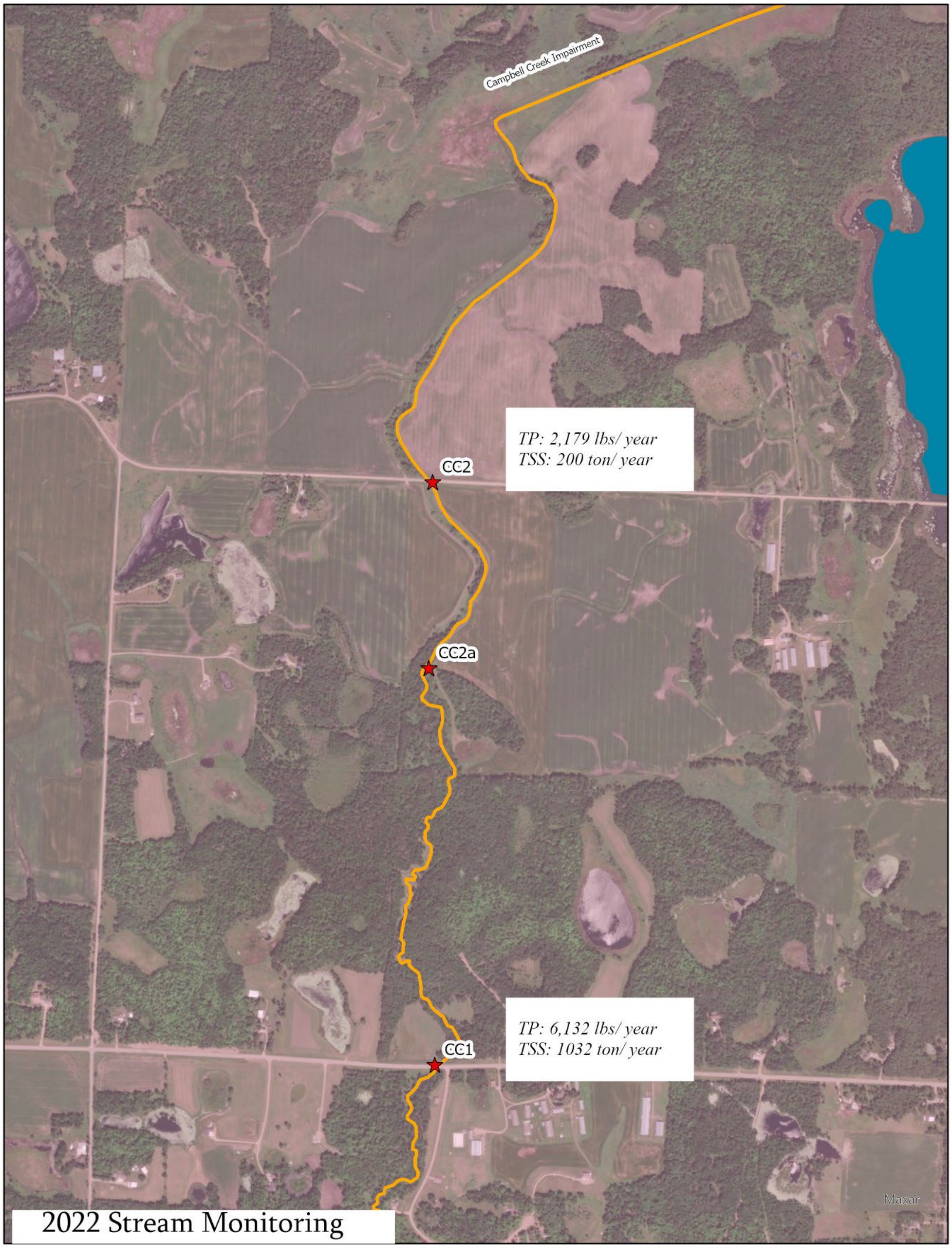


Figure 5.22 Pollutant loading on Campbell Creek.

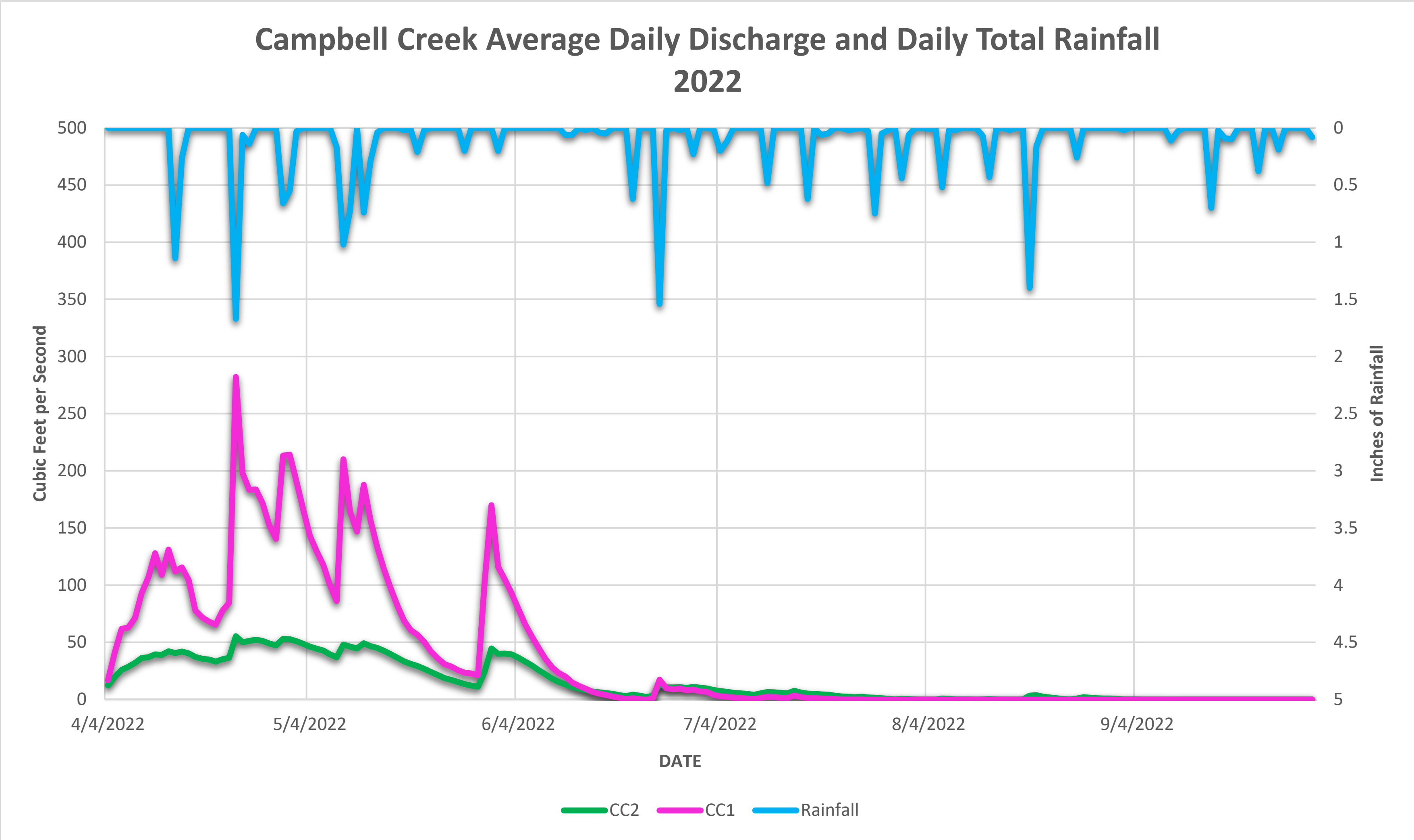


Figure 5.23 2022 Average daily flows in Campbell Creek and Daily Total Rainfall. Data from Campbell Creek at 230th St (CC2) and CSAH 149 (CC1).

5.2.1.2 Ecological Integrity

The District continues its cooperative partnership with the MN DNR to study stream channel erosion on Campbell Creek from Campbell Lake to Floyd Lake. District Staff has obtained some funding through the 319 Grant to help get started on the construction for the much-needed improvements to this area. Staff noted downcutting of the channel bed, undercut banks, and extensive erosion to outer stream banks (Figures 25, 26 and 27). The area North of CSAH 149 is seasonally grazed by livestock, and no exclusion fence is present. Livestock have been destabilizing stream banks and stream riffles. Staff also suspect high stream velocity is to blame. With the planned improvements we have high hopes that this will improve these impairments.

Figure 5.24. Example of bank erosion on Campbell Creek. North of CSAH 149.

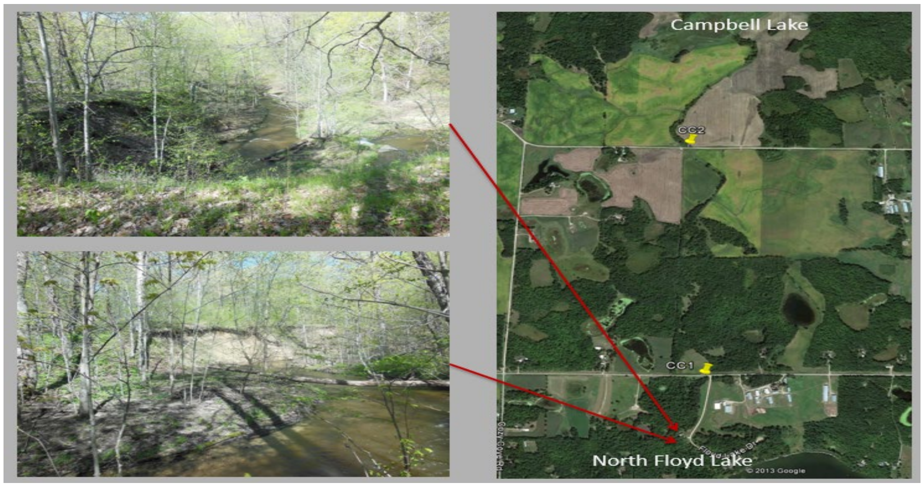


Figure 5.25 Targeted areas of stream channel erosion

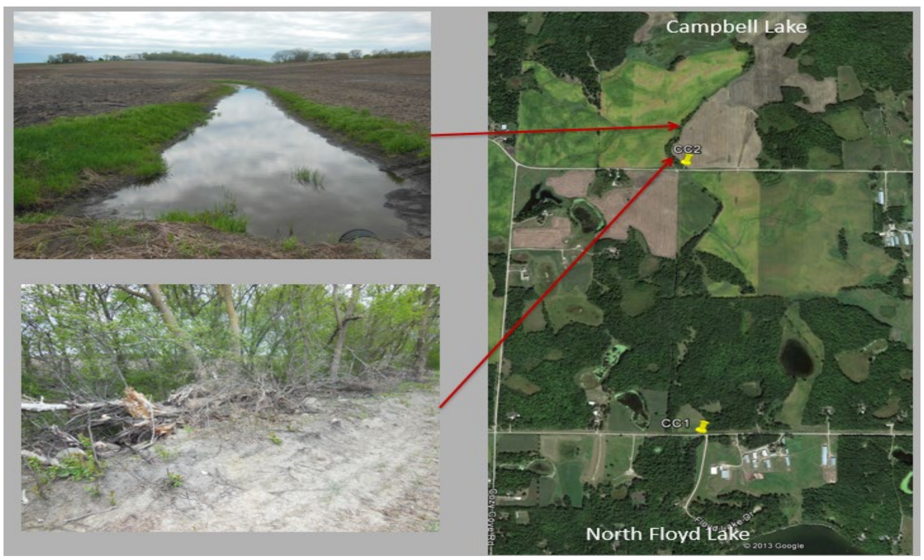


Figure 5.26 Targeted areas of stream channel erosion

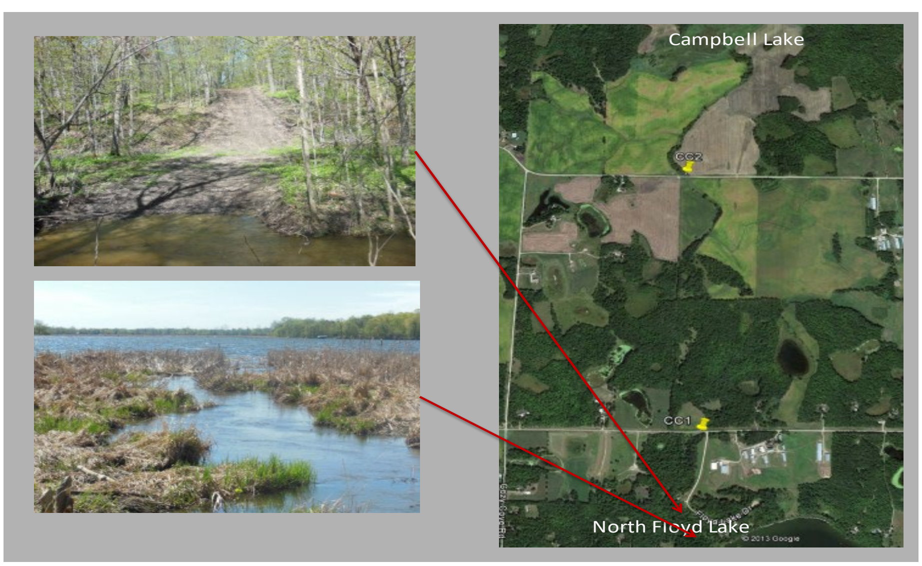


Figure 5.27 Targeted areas of stream channel erosion

6 Detroit/Rice Water Management Area

The Detroit Rice WMA is the largest in the district at about 25,000 acres (Figure 6.1). The Pelican River travels South from its Headwaters in Little Floyd Lake and through the Rice Lake Wetland Complex, a large, drained wetland outside the city limits of Detroit Lakes. From there the Pelican River drains into Detroit Lake from the North. Sucker Creek, a designated trout stream, also drains into Detroit Lake from the Southeast. From Detroit Lake, the Pelican River flows Southwest to the Sallie/Melissa WMA. The main issues facing the WMA is wetland drainage and urban development. The Pelican River from Highway 34 to Detroit Lake is impaired for low fish and benthic macroinvertebrate index of biological integrity (IBI) scores, low DO, and high *E. coli* loads.

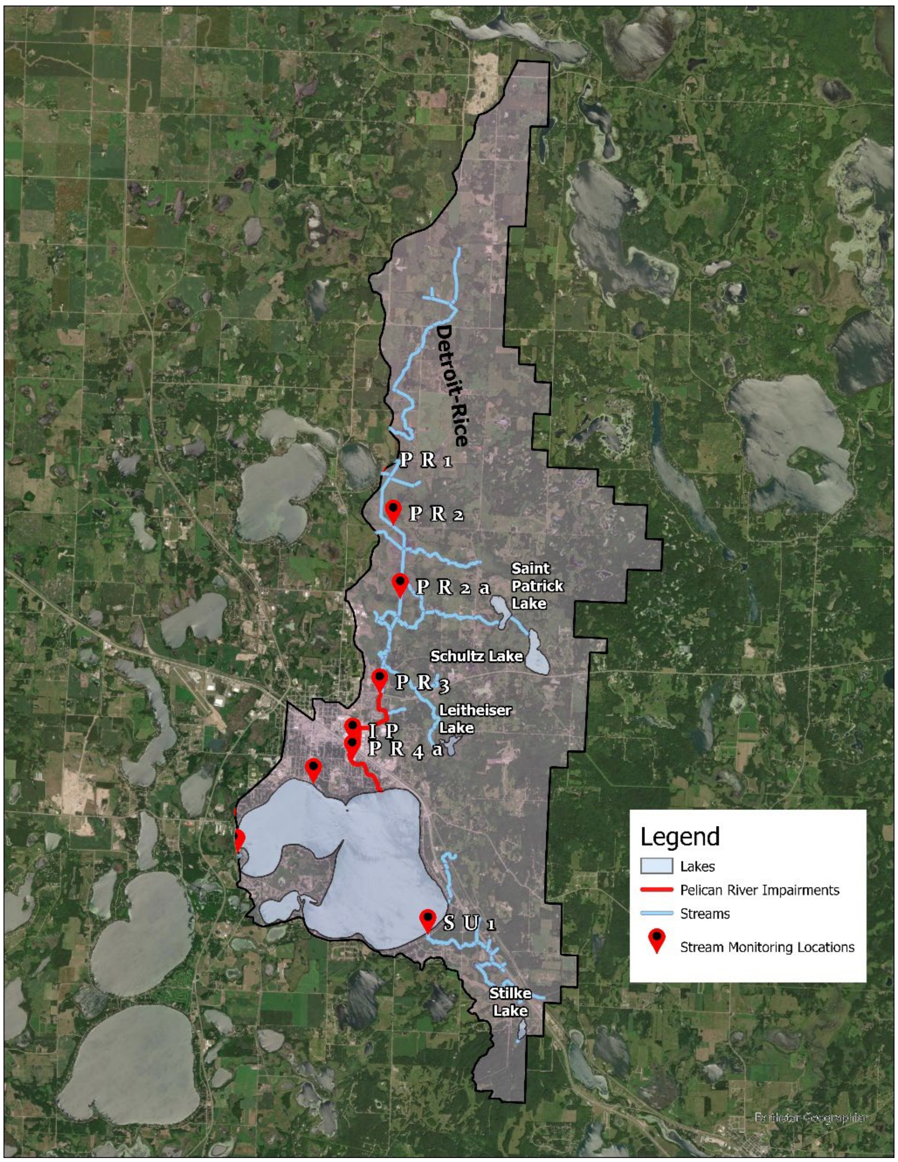


Figure 6.1 Detroit/Rice Water Management Area.

6.1 Lakes

The Detroit/Rice WMA has 5 lakes within its borders (Detroit, Curfman, Saint Patrick, Schultz, Leitheiser, and Stilke), 3 of which will be sampled in the 2020-2030 Monitoring Plan (Saint Patrick, Schultz, and Curfman), and 1 (Detroit) is sampled annually and split into 2 basins (Big Detroit and Little Detroit). In 2022, water quality sampling within the WMA was conducted on Detroit Lake (Big and Little) and St. Clair (1 sample taken on June 9th). In 2023, the District will sample water quality on Detroit Lake (Big & Little), and Curfman. Detroit Lake (Big & Little) and Curfman received chemical treatments for Flowering rush (*Butomus umbellatus)* and Curly-leaf pondweed (*Potamogeton crispus)* in 2022.

6.1.1 Detroit Lake

At 3,067 acres, Detroit Lake is the largest lake within the PRWD, and lies entirely within the City of Detroit Lakes municipal boundaries. As typical with urban lakes, its shoreline is extensively developed with residential homes, commercial businesses, and some industrial buildings. The lakes are heavily used for game fishing, boating, and other summer, and winter recreational activities. The drainage area of Detroit is 9770 acres in size, which is comprised primarily of Forest (42%), Grassland (27%), and Developed Land (18%).

Detroit Lake, locally known as Big Detroit and Little Detroit, has two distinct basins that are separated by a shallow gravel bar. The larger of the two basins, Big Detroit has a maximum depth of 82 feet (18.4-foot average) with 37.5 % of its surface within the littoral area (< 15 ft depth) and has 7.84 miles of shoreline. Little Detroit littoral area (< 15ft depth) encompasses the entire water basin, with a lake depth average of 8.5 feet and a maximum depth of 16 feet, with 4.9 miles of shoreline.

The primary inlet and outlet for Detroit Lake is the Pelican River, flowing into the north side of Big Detroit and exiting the southwest side of Little Detroit. In addition to the Pelican River, Sucker Creek drains to the Lake along with two small wetland flowages, all on the southeast portion of Big Detroit. There are no water control structures, however, the lake level is controlled further downstream by the rock rapids located between Muskrat and Sallie lakes.

Big Detroit is a dimictic lake while Little Detroit is polymictic, however, both exhibit mesotrophic characteristics with moderately clear water and support all recreation/aesthetic uses. Occasionally, after large rain events or during hot summer months, the lake becomes borderline eutrophic with visible algal blooms. This is due, in part, to Rice Lake, an upstream degraded wetland complex which releases phosphorous following large rain events. Urban and residential stormwater runoff are also contributors of nutrients to the lake.

Aquatic Invasive Species (AIS) have a large effect on lake habitat and ecology. Because of the high level of recreational use of Detroit Lake, this makes it very susceptible for invasive species introduction. The aquatic invasive plants Flowering rush and Curly-leaf pondweed are both present in the lake, along with invasive invertebrates Zebra Mussels (2016) and Chinese Mystery snails. Both Flowering rush and Curly-leaf pondweed are assessed and managed annually via herbicide applications. The City of Detroit Lakes recognizes the economic value of the lake and assists the District in managing invasive plants.

Little and Big Detroit were completely frozen over on Saturday, November 19, 2022. That date is about 1 day earlier than the average of 110 years for which record have been kept, and about 9 days earlier than the last twenty years.

The earliest ice-on date was October 25, 1919, but the earliest ice-on in the last 20 years, was November 11, 2020. We had December ice-on in 2001, 2004, 2009, 2016, 2017. Area residents enjoyed 199 days of open water in 2022, about 15 days less than the all-year average and 26 days less than the average of the last 20 years. The longest ice-free season was 256 days in 2016. Based upon the averages, 140-150 days of ice-cover can be expected. The average ice-out date is April 20th.

6.1.1.1 Water Quality/Quantity

Water Quantity – Detroit Lake Levels

The Lakes do share a common outlet and OHW. The water level for Detroit Lake is measured at the outlet under Becker County HWY 6/West Lake Drive. For 2022, water levels were at a 40-year high with the highest level recorded at 1335.76 (NGVD 29) on July 5th, 2022, and remained significantly above the ordinary high-water level (OHWL) of 1334.3 (NGVD 29) for most of the summer when drought conditions in August lowered the water levels closer to Detroit's OHW for the remainder of the year until ice on (Figure 6.2). Towards the end of the year Detroit Lake water levels seemed to continuously drop and fell below the OHW with a reading of 1334.20 on 9/16/22 and continued to drop the remainder of the season (Figure 6.3). The last water level reading was recorded on November 1st, at an elevation of 1334.08 (NGVD 29).

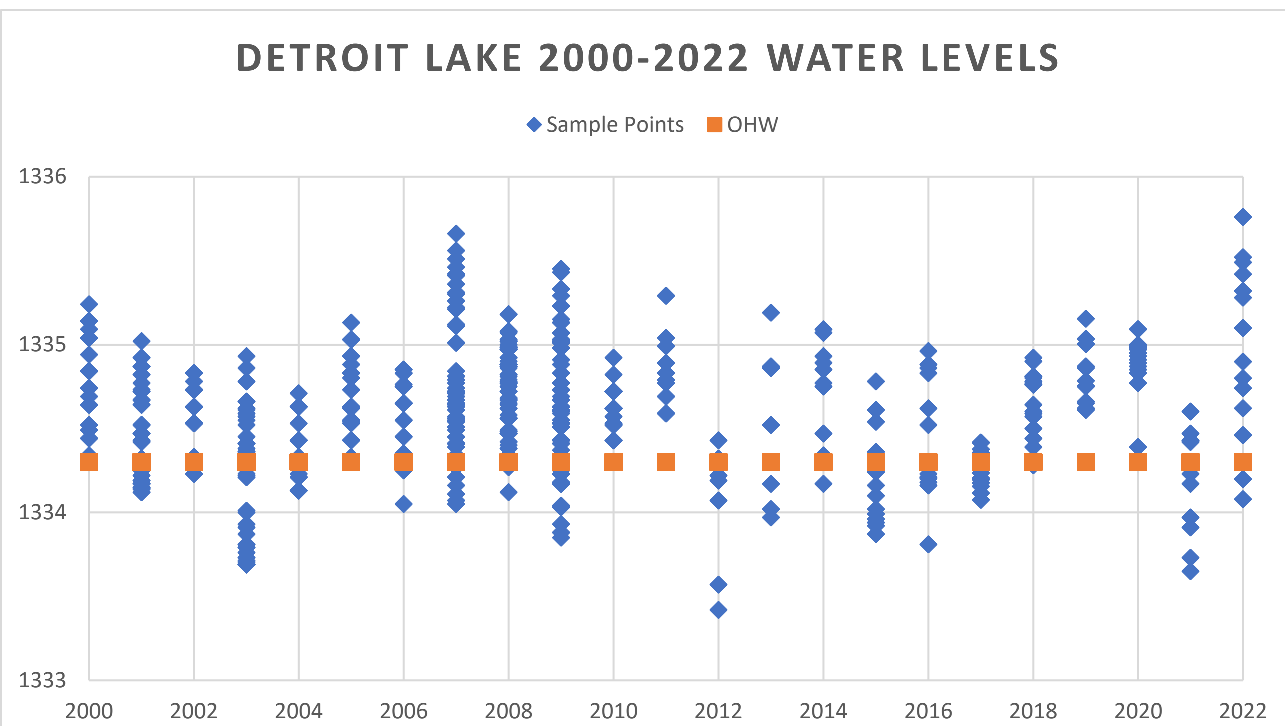


Figure 6.2 Detroit Lake Water Levels from 2000-2022.

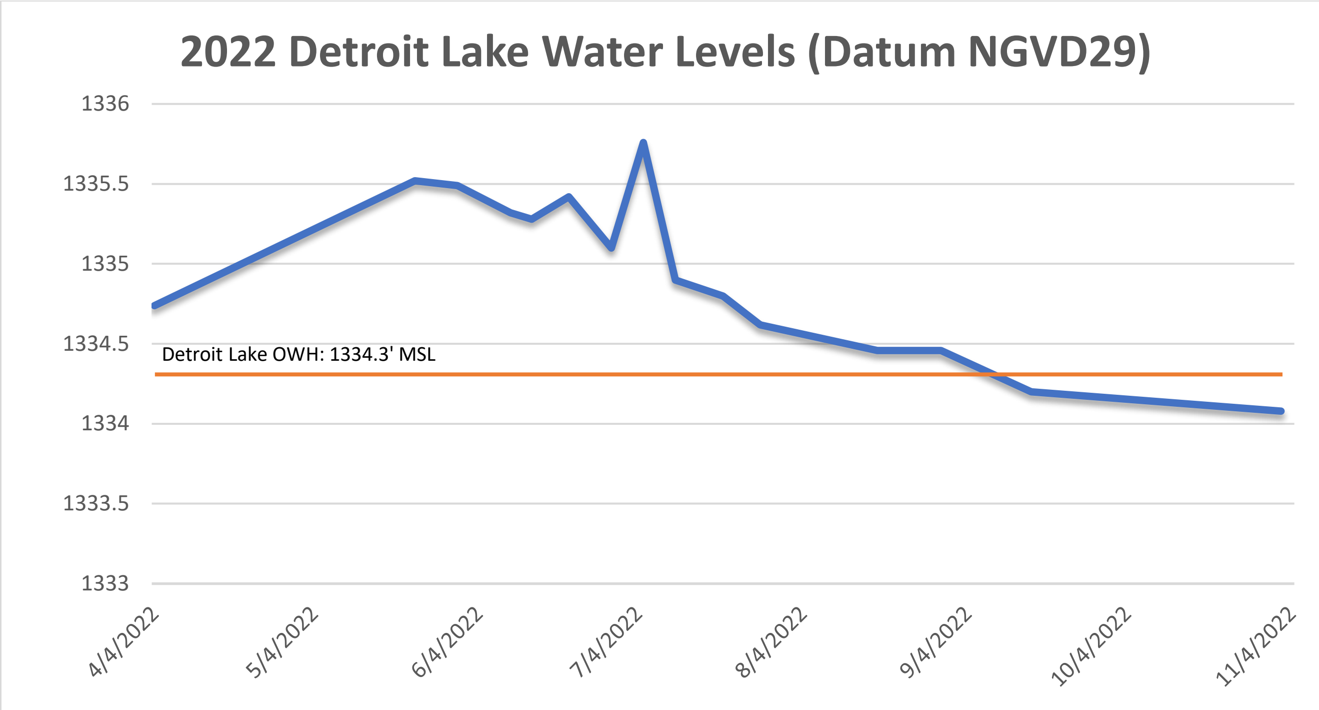


Figure 6.3 Detroit Lake Water Levels in 2022.

Water Quality – Big Detroit Lake

In 2022, Big Detroit Lake had "better than average" water quality for most of the season with total phosphorus (TP) averaging 18 µg/L excluding the 9/12 algae bloom reading. However, after the fall lake water "turnover" event in early September, an algae bloom occurred and TP spiked up to 114 µg/L on September 12th, but by September 30th dropped back to 18 µg/L. The algae bloom in September negatively affected the 2022 TP average (Figure 6.4) 30 µg/L, which is a decline from the 20- year average of 24 µg/L. The District's water quality goal for Detroit Lake is < 20 µg/L TP average.

CHL-a average (Figure 6.5) was 3.55 µg/L, which was an improvement from the 20-year average of 7.86 µg/L and well below the impairment level of 14 µg/L.

Water clarity (secchi depths) averaged 15.14 feet, almost 5 feet of increased clarity from the 20-year average of 10.6 feet (Figure 6.6) and well above the 4-ft impairment level.

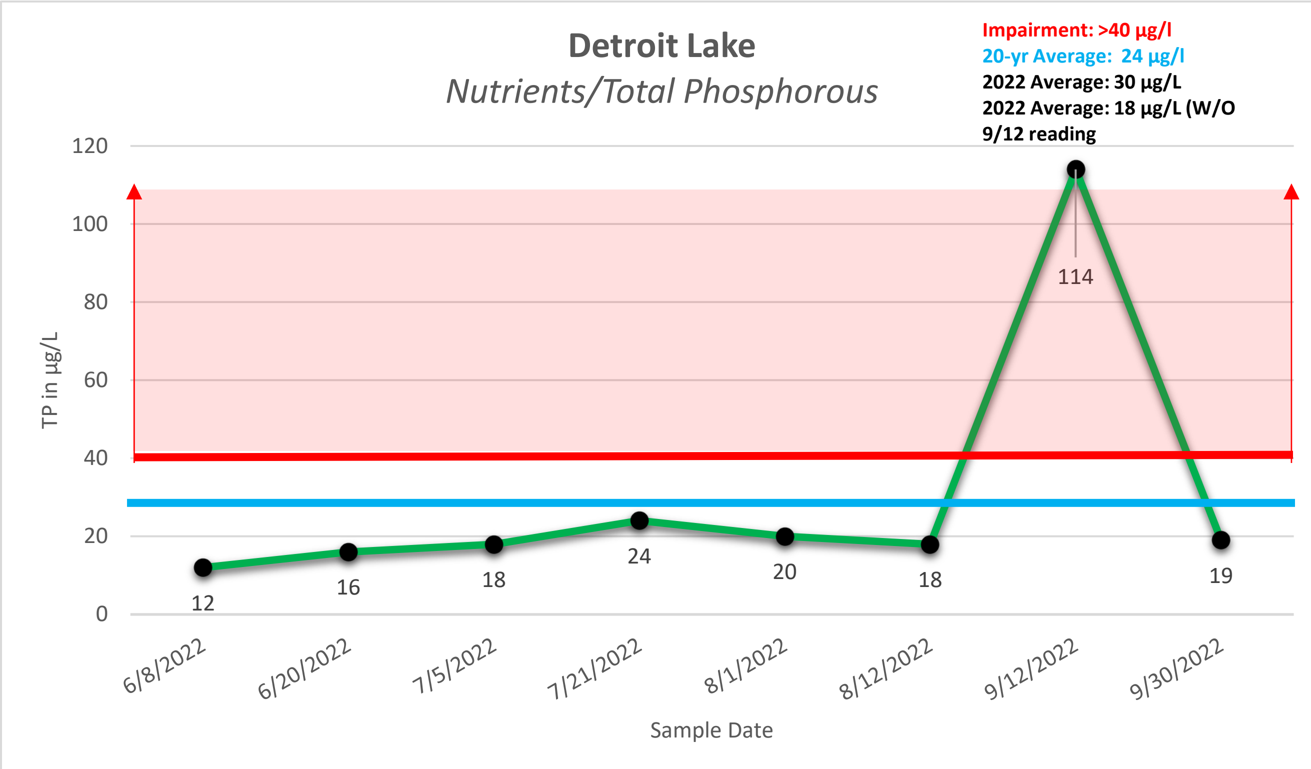


Figure 6.4 Big Detroit Lake 2022 total phosphorous.

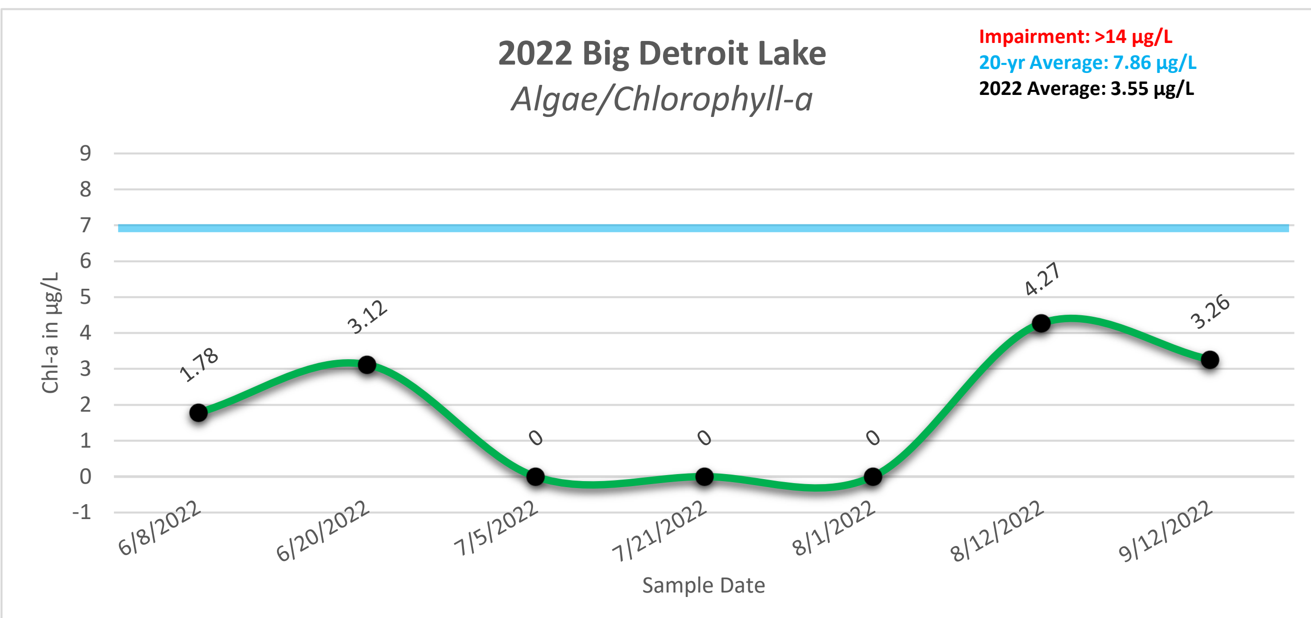


Figure 6.5 Big Detroit Lake 2022 chlorophyll-a.

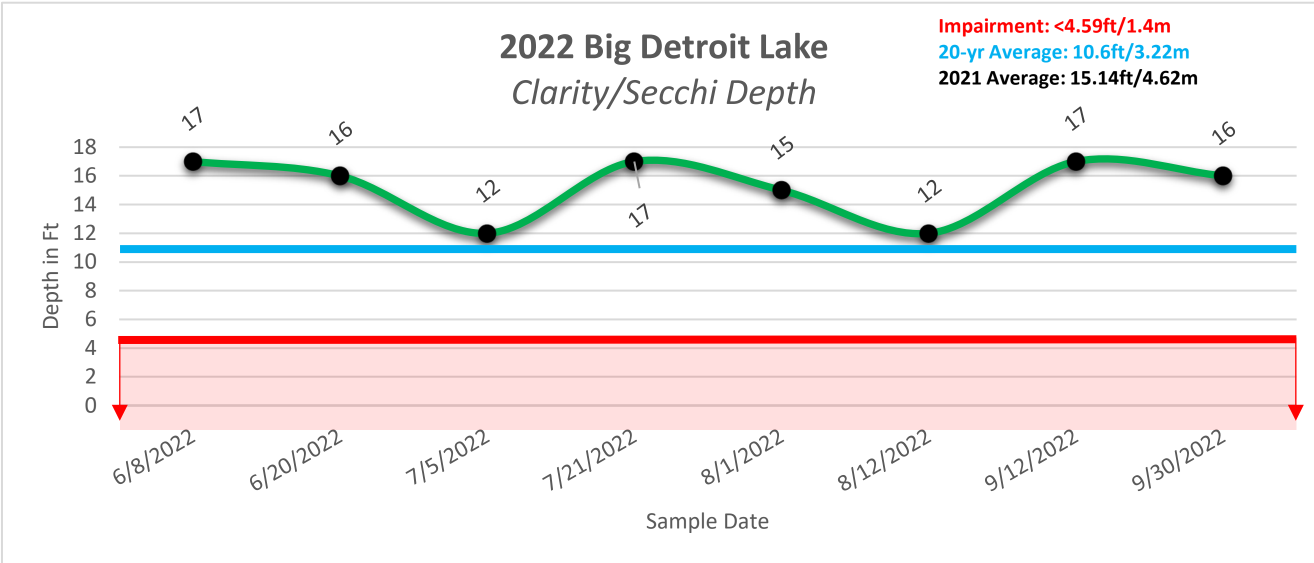


Figure 6.6 Big Detroit Lake 2022 secchi depth.

Water Quality – Little Detroit Lake.

Little Detroit Lake experienced a "better than average" water quality year. The average TP was 16 µg/L an improvement from the 20-year average of 19 µg/L (Figure 6.7). TP readings spiked once during the summer, on July 5th to 39 µg/L.

CHL-A averaged 2.84 µg/L an improvement from the 20-year average of 4.45 µg/L (Figure 6.8). CHL-A lab results from late June – early August were <1.00 µg/L.

Water clarity secchi depth readings averaged 16.2 feet, almost 5-ft deeper than the 20-year average of 11.6 feet and remained above average throughout the monitoring season (Figure 6.9). The highest secchi reading was on August 1st at 18 ft of water clarity.

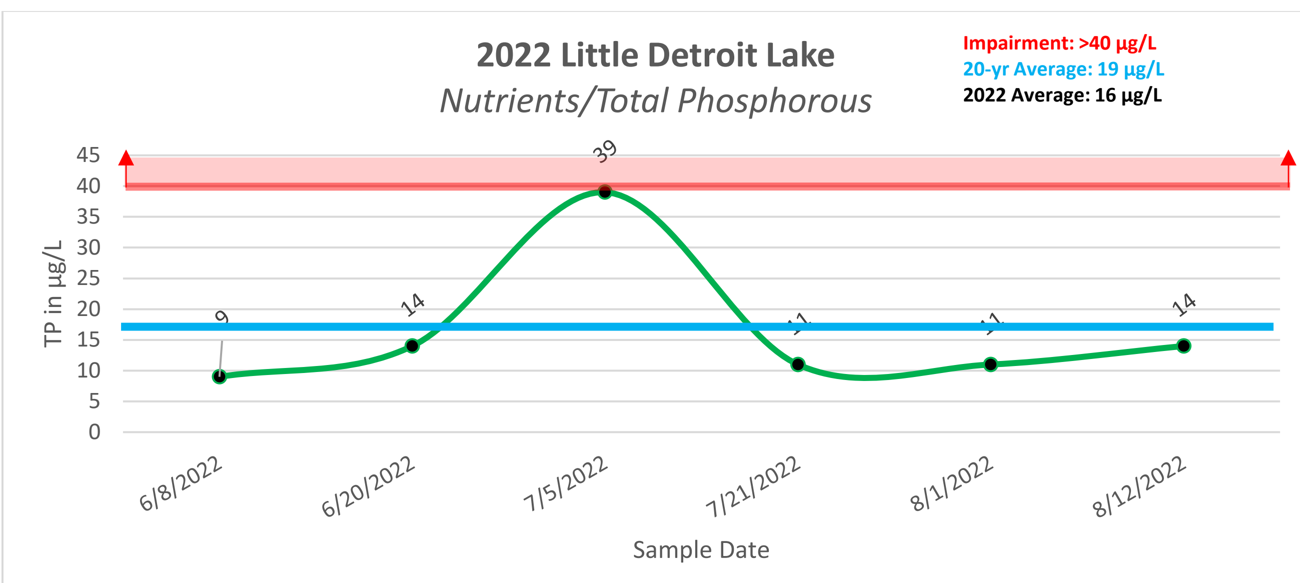


Figure 6.7 Little Detroit Lake 2022 total phosphorous.

Figure 6.8. Little Detroit Lake 2022 chlorophyll-a.

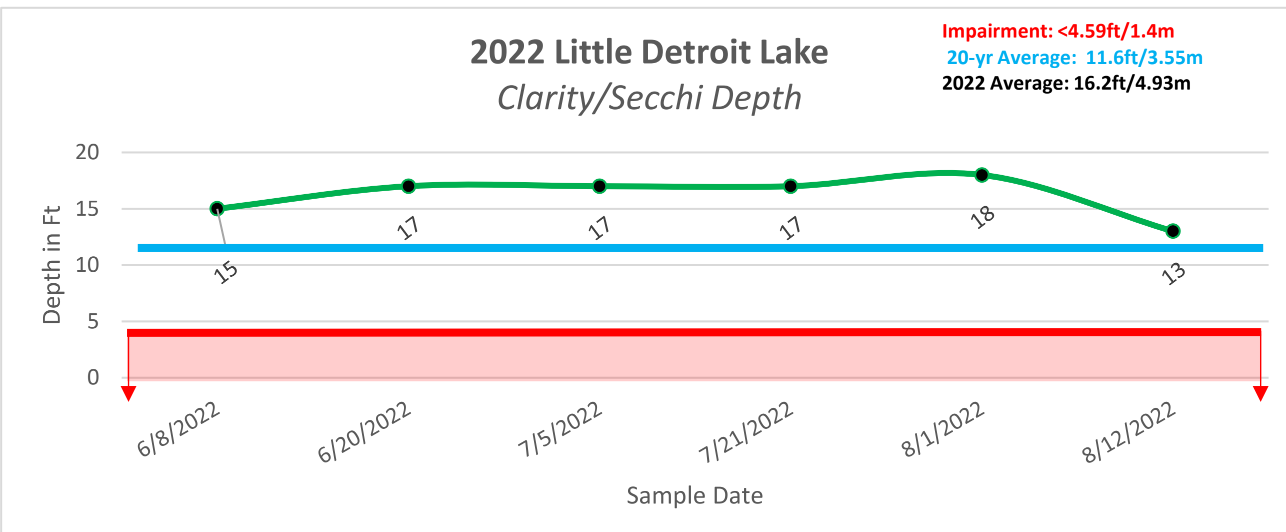


Figure 6.9 Little Detroit Lake 2022 secchi depth.

6.1.1.2 Ecological Integrity

Project 1C – Aquatic Invasive Species (AIS) Management
The District monitors and manages Flowering rush and Curly-leaf pondweed on Detroit (Big & Little) and Curfman lakes.

Flowering rush (FR) **–** The District treated 31.59 acres on Detroit and 7.6 acres on Curfman of Flowering rush in 2022. Treatments were conducted on June 28th and on August 1st (Figure 6.10). In comparison, 49.35 acres of Flowering rush were treated in 2021.

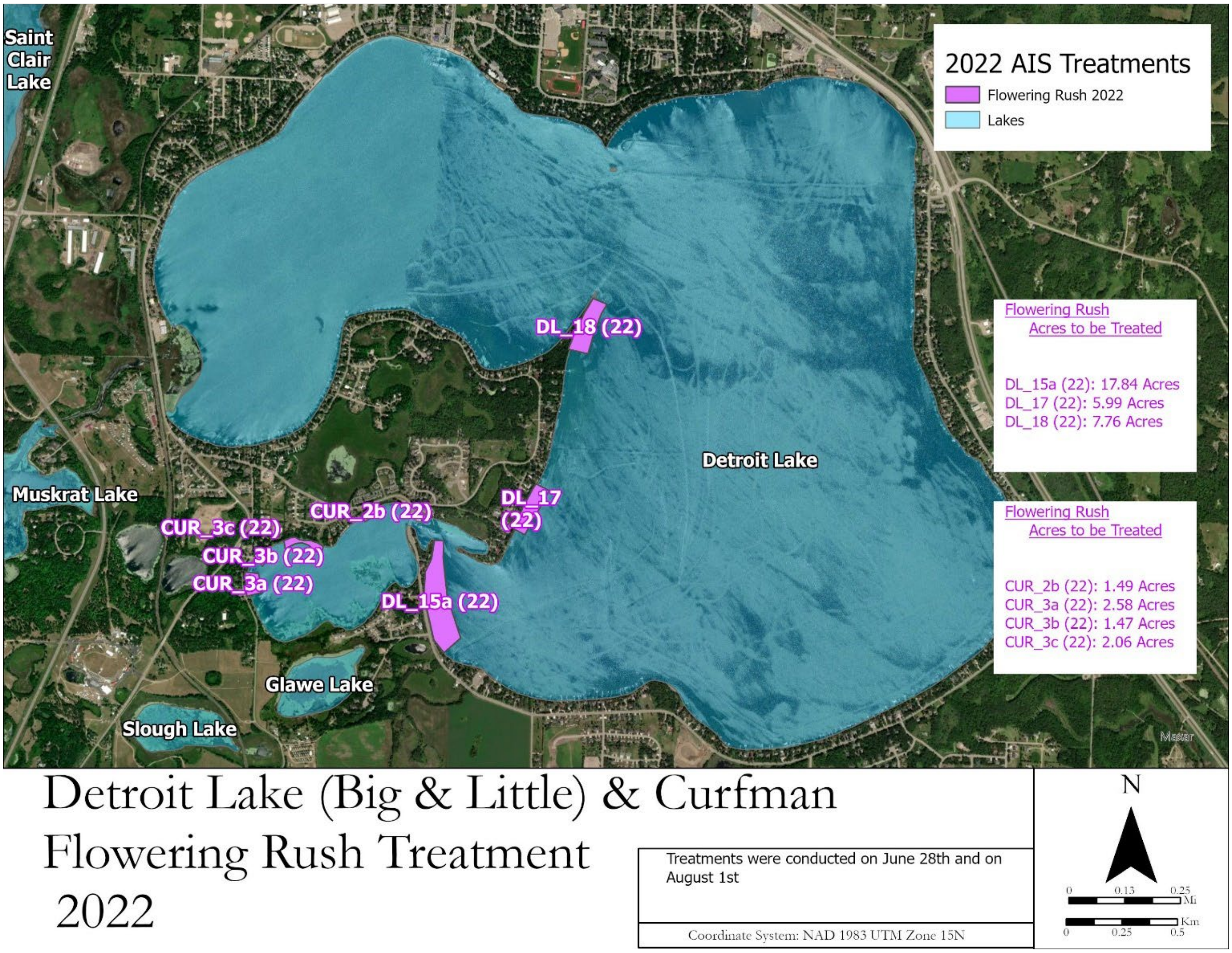


Figure 6.10 Flowering rush treatments on Detroit and Curfman Lakes in 2022.

Curly-leaf pondweed (CLP) - In 2022, the District treated 2.2 acres of Curly-leaf pondweed in the Long Bridge Marina area. District staff reviewed Detroit for CLP twice, but did not find any plants, except for the Long Bridge area – an unusual year. District staff contacted the MN DNR who also reported other lakes were experiencing little to low levels of CLP, most likely due to the late spring weather temperatures which stunted CLP plant growth conditions. In comparison, the District treated almost 8.2 acres on Detroit (Big & Little) and 7.9 acres on Curfman in 2021. On Curfman, the District treated 7.21 acres of CLP (Figure 6.11). Treatments were conducted on June 3, 2022.

FR and CLP treatments are greatly reduced from historic treatments (154.52 acres on Detroit (Big & Little) and 17.45 acres on Curfman of Flowering rush in 2013 and 92.17 acres of Curly-leaf pondweed on Detroit (Big & Little) in 2013 signaling the effectiveness of the District's chemical AIS treatments.

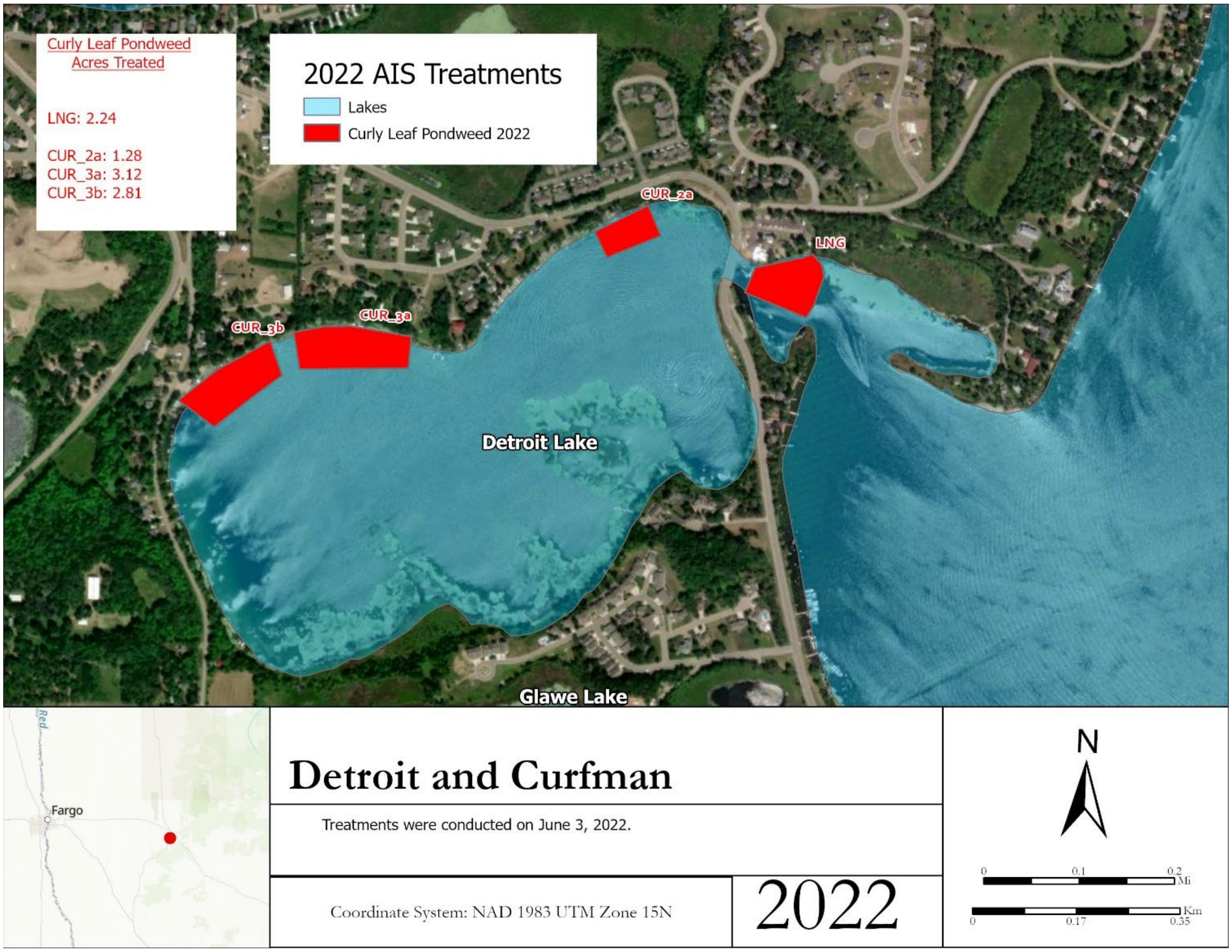


Figure 6.11 CLP treatments on Detroit and Curfman Lakes in 2022

6.1.2 St. Patrick Lake

In 2022, the District conducted water quality sampling on St. Patrick Lake, classified by MN DNR as a Shallow Lake (< 15 ft depth) for the first time to gather initial water quality data.

St. Patrick is an 87-acre shallow lake located about 6 miles northeast of Detroit Lakes. The max depth recorded is 4.5 feet. The lake is highly vegetated throughout, with coontail, white waterlily, wild rice, and flat-stem pondweed observed as the most prominent species. Most of the shoreline is undeveloped, except for two houses (2015) on the north side. All of the shoreline is privately owned and was dominated by cattails.

6.1.2.1 Water Quality/Quantity

Water Quality – St. Patrick Lake

The District collected water quality data on June 9th with results of TP – 24 µg/L, Chl-A 2.67 µg/L; water clarity – secchi reading – 3-Feet.

Unfortunately, this was the only data collected on St. Patrick due to difficulties with accessing open water due to the high densities of emergent lake vegetation. Numerous attempts were made throughout the sampling season.

6.2 Streams/Ditches

6.2.1 Pelican River (Ditch 13)

The Pelican River originates at Little Floyd Lake on the boundary of the Detroit Rice WMA. Also known as Ditch 13, the Pelican River flows south through the Rice Lake Wetland Complex, through the City of Detroit Lakes, before entering Big Detroit Lake on the North Shore. The Pelican River stretches 6 miles between Little Floyd Lake and Detroit Lake, only loosing 20ft of elevation. As the river flows through the Rice Lake Wetland Complex, it picks up heavy loads of phosphorous which it carries to Detroit Lake. The District is currently constructing a wetland restoration project to lower the phosphorus loads from the Rice Lake Wetland into Big Detroit Lake. Phase 1 – Upper Water Control Structure was completed in 2022, and the Lower Water Control Structure will be built in 2023.

The Pelican River is impaired from Highway 34 to Detroit Lake for benthic macroinvertebrate IBI, fish IBI, low DO, and high *E. coli* loads. The District is currently investigating the cause of these impairments to target and correct the issues.

6.2.1.1 Water Quality/Quantity

Water Quality – Pelican River (Ditch 13)

The Pelican River experienced a poorer water quality year in 2022 (Figure 6.12) due to the unusual spring snowmelt and higher than average April rainfall conditions which increased water quantity and water levels to 40-year highs, bringing high loads of nutrients into the river system. Annual phosphorous loading (April – October) at PR4a (last sampling point before Detroit Lake) was 5,653 lbs/yr of total phosphorous, and 2,270 lbs/yr of orthophosphate (plant available phosphorous). In 2020, annual phosphorus loading at PR4a was 3858 lbs/yr of total phosphorous, and 1,704 lbs/yr of orthophosphate (plant available phosphorous). 2021 phosphorus loading data is not available due to insufficient number of flow measurements collected to analyze the data. The District will continue to increase flow measurements in 2023 and beyond. The PR2A monitoring site will be moved to the outlet of Rice Lake Wetland, above the new water control structure.

Concentrations of TP and OP increased from Site PR1 (outlet of Little Floyd Lake) 20 µg/L (TP) and 10 µg/L (OP); Site PR2A to 86 µg/L (TP) and 31 µg/L (OP); Site PR3 (HWY 34/PR) 70 µg/L (TP) and 27 µg/L (OP). Staff noted the presence of beaver dams between the PR2A and PR3 sites in July and August. Upper structure of the Rice Lake wetland restoration project went on-line in fall of 2021.

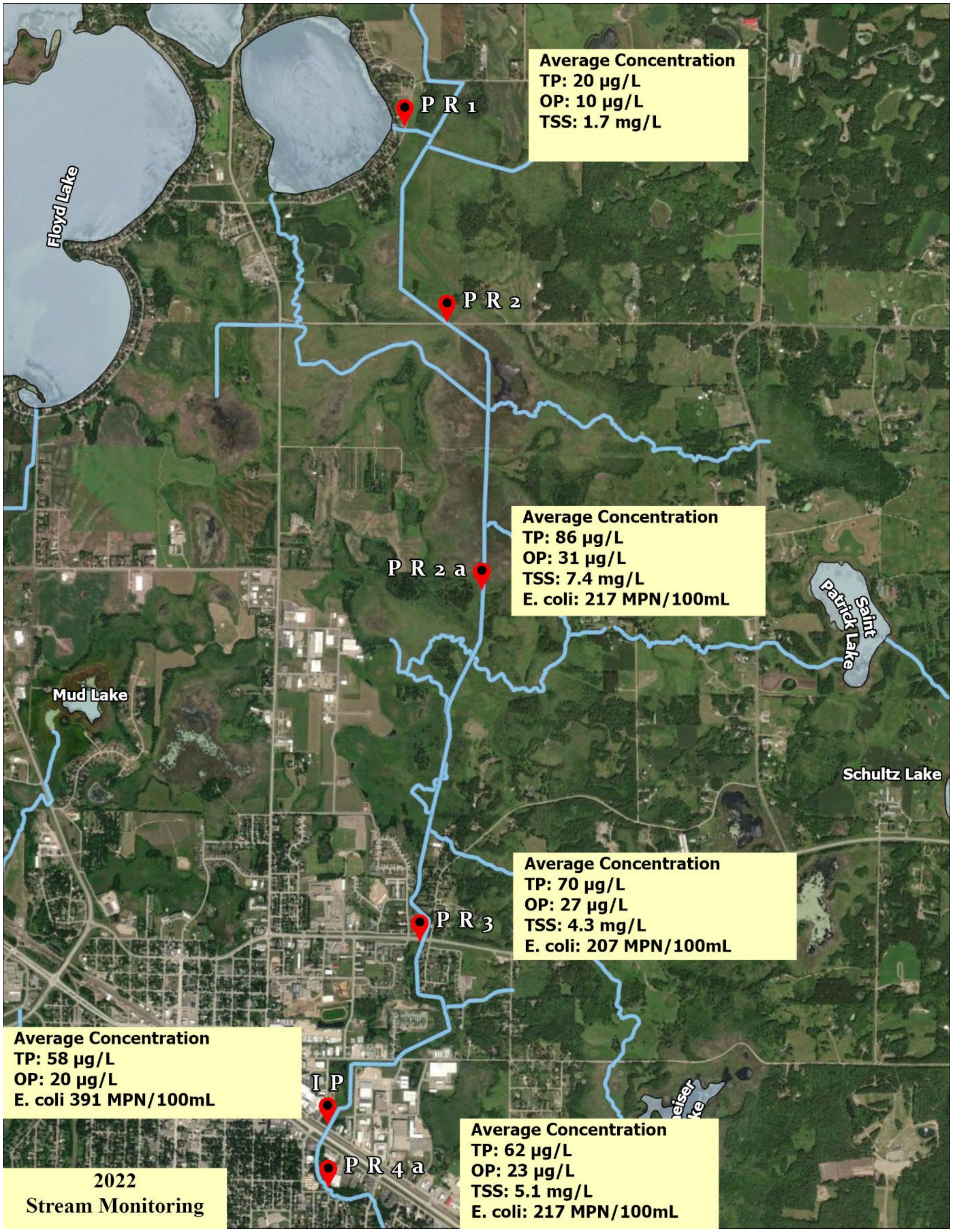


Figure 6. 12 Pelican River sampling in the Detroit/Rice WMA.

In 2022, the District routinely sampled E. coli concentrations at 3 locations (PR2a, PR3, and PR4a;) and after storm events at 1 location (IP). This data (Figure 6.12) supports the MPCA listed impairment for E. coli loads (average >126 MPN/100ml or >10% of sample above 1260 MPN/100ml). E. coli concentrations consistently spike after rain events/storm sampling and then fall back to low levels when "routine" sampling occurs.

The source of the high E. coli loads in the Pelican River continues to evade and perplex environmental agencies. The City of Detroit Lakes surveyed the sanitary sewer system along the Pelican River and did not find/locate any leaks and an E. coli source test in 2018 had inconclusive results (no "smoking gun"). The District continues to sample between HWY 34 and Detroit Lake and will increase sampling in 2023 to locate and investigate possible source areas.

Water Quantity – Pelican River (Ditch 13)

The Rice Lake wetland restoration stabilized springtime downstream high lake water level impacts. Water levels within the City of Detroit Lakes tended to be "flashier" than those at the outlet from Rice Lake (Figure 6.15; Figure 6.16). This is likely caused by less flood plain and water storage capacity through the city combined with increased velocity of inputs (stormwater runoff from impervious surfaces).

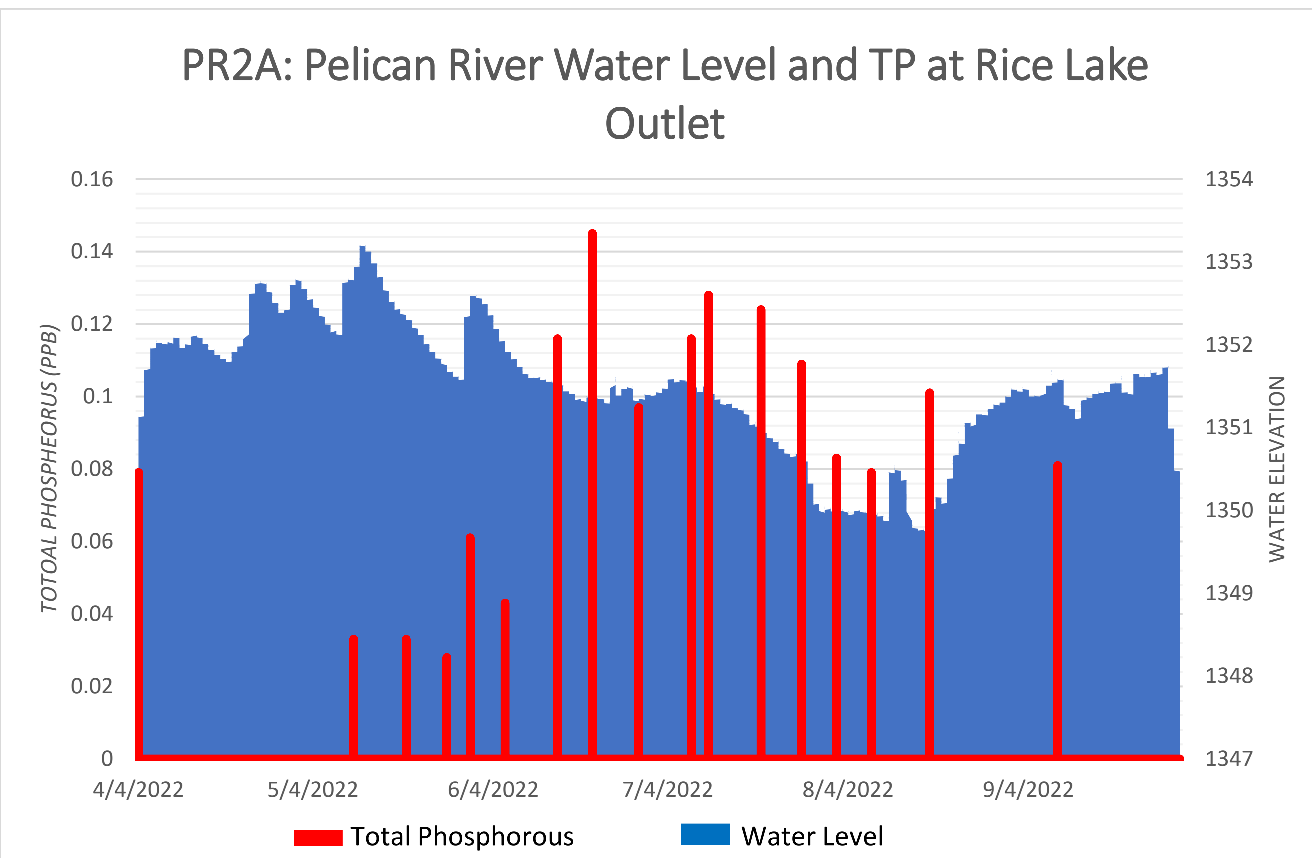


Figure 6. 13 2022 Water Levels and Total Phosphorous at Rice Lake Outlet

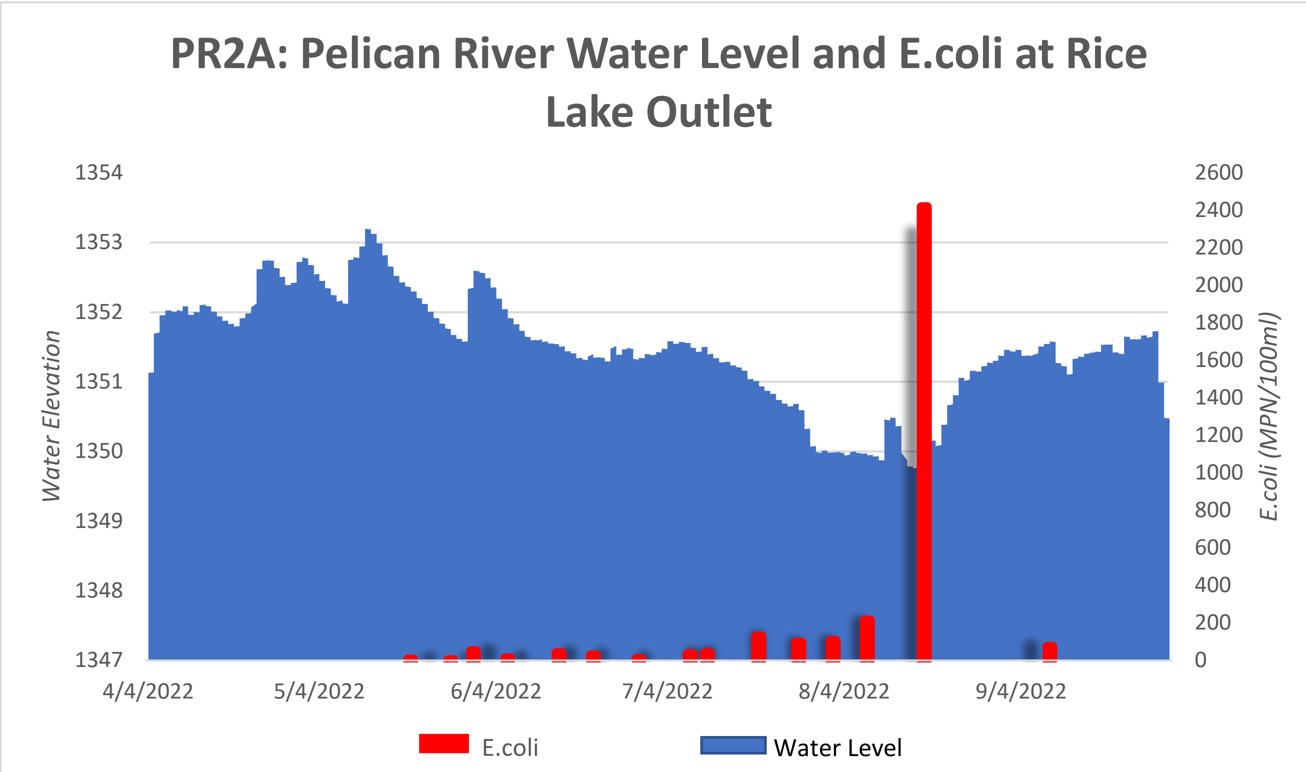


Figure 6. 14 2022 Water Levels and E. coli at Rice Lake Outlet.

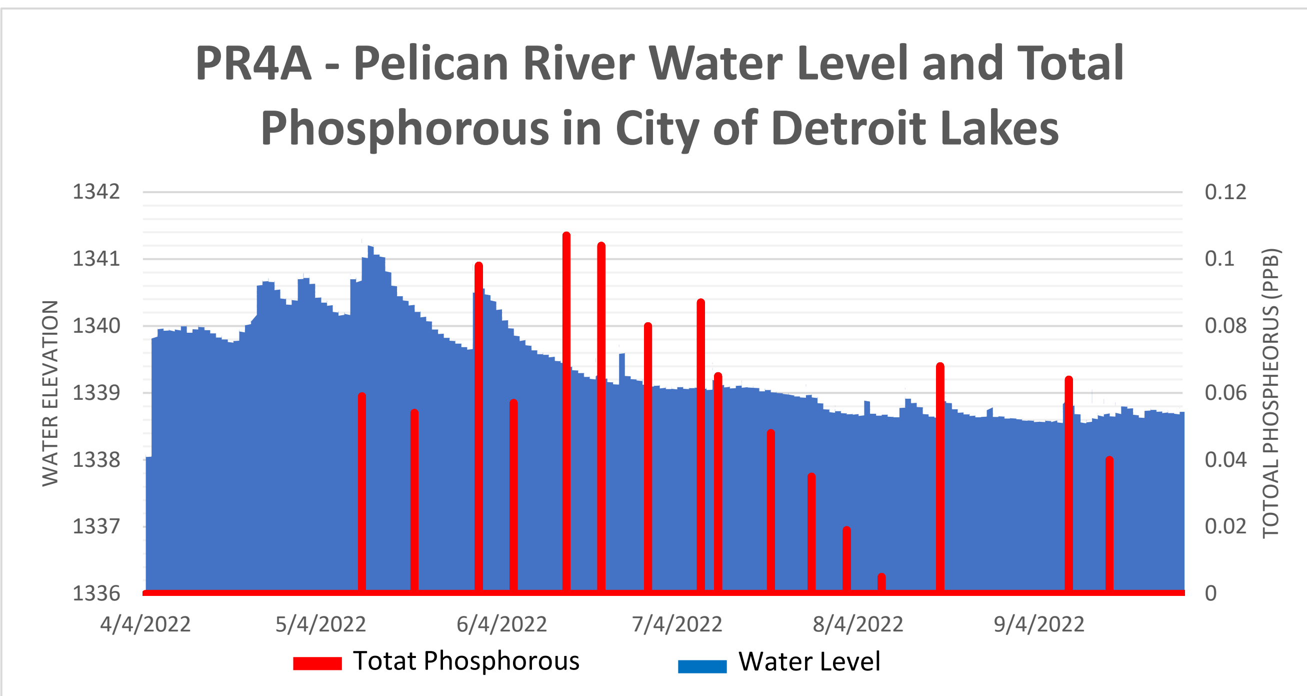


Figure 6. 15 2022 Water levels and total phosphorous in City of Detroit Lakes.

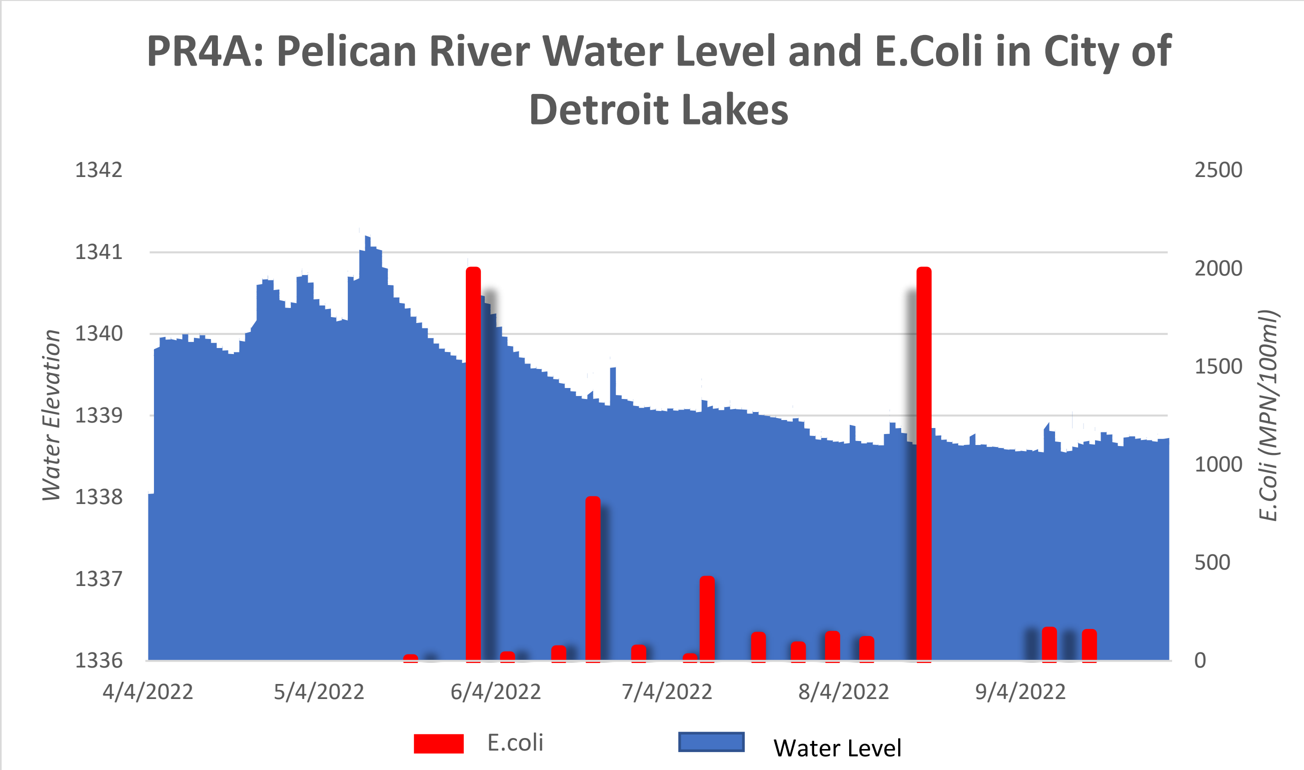


Figure 6. 16 2022 Water levels and E. coli in City of Detroit Lakes.

6.2.2 Sucker Creek

Sucker Creek is the District's only designated trout stream. Sucker Creek is a natural creek that flows into the Southeast shore of Big Detroit Lake. The Sucker Creek Nature Preserve serves as a protection area for Sucker Creek and provides educational kiosks to help educate people about the benefits of natural stream and forest area eco-systems. The District has one monitoring station within the preserve.

Figure 6.17 Sucker Creek sampling location

6.2.2.1 Water Quality

Water Quality – Sucker Creek

Staff collected 11 samples from May – mid August, until the creek stopped flowing. Average TP was at 35 µg/L and OP was at 14 µg/L. TP concentrations consistently spiked during storm events, affecting the annual average concentrations. Dissolved Oxygen (DO) readings averaged 8.5 mg/l, sufficient for trout to use the stream for spawning (Figure 6.17).

7 Sallie/Melissa Water Management Area

The Sallie/Melissa WMA is the last WMA in the District before the Pelican River exits to the south (Figure 4.1). This 11,400-acre WMA contains Lakes Sallie and Melissa, St. Clair Lake, Muskrat Lake, and Mill Pond. The Pelican River leaves Detroit Lake and flows to Muskrat Lake, the reservoir created by Dunton Locks (now Dunton Rapids). From there it flows through Lakes Sallie and Melissa before entering Mill Pond, the reservoir created by Bucks Mill Dam and the last stop in the District. Ditch 14, the ditch draining St. Clair Lake (the former sewage pond for the City of Detroit Lakes) and the numerous wetlands surrounding it, empties into the Pelican River just after it leaves Detroit Lake, dumping a heavy load of phosphorous into the system. St. Clair Lake is impaired by high nutrient loads caused by historic pollution. Half of the City of Detroit Lakes drains into Ditch 14 via the City's Municipal Separate Storm Sewer System (MS4).

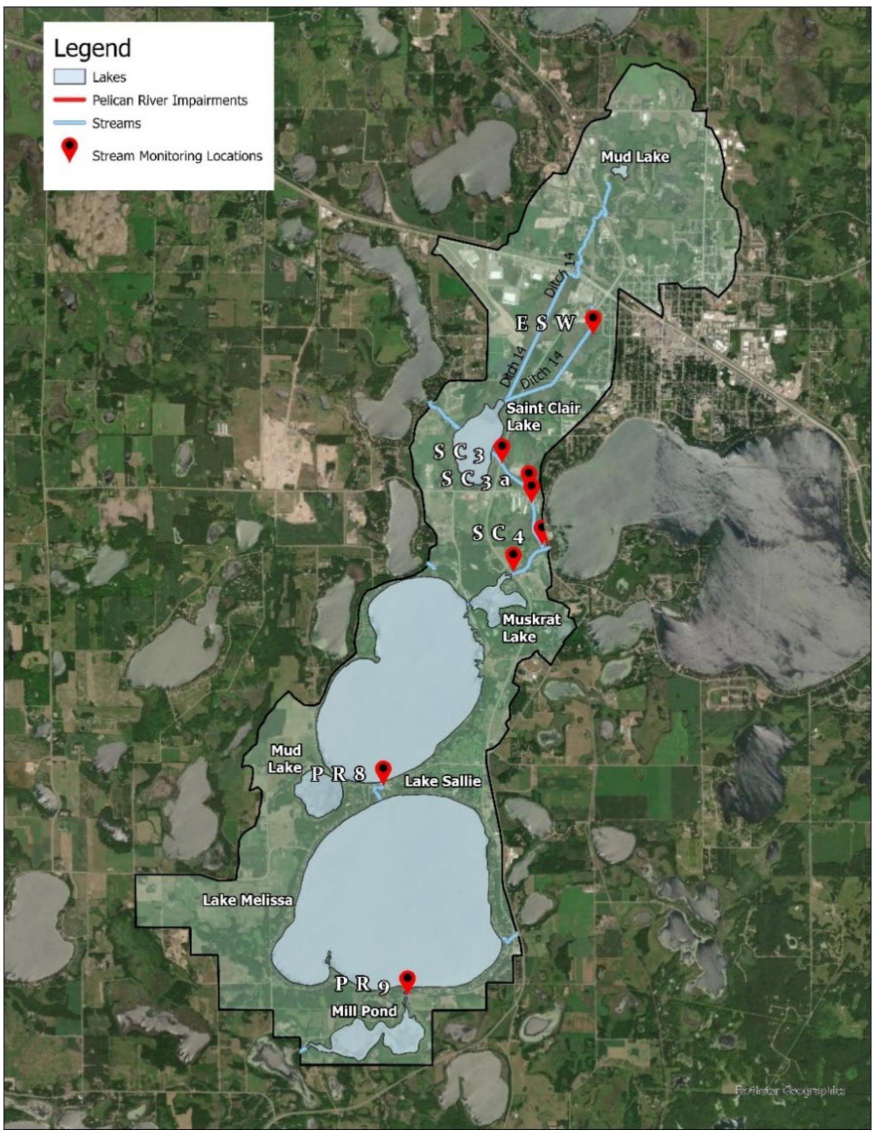


Figure 7.1 Sallie/Melissa Water Management Area.

7.1 Lakes

The Sallie/Melissa WMA has 6 lakes within its borders (Mill Pond, Lake Melissa, Lake Sallie, Muskrat Lake, and St. Clair Lake). In 2022, the District conducted water quality sampling on St. Clair, Sallie, and Melissa. Lake vegetation surveys (point-intercept) were conducted on Mill Pond and Muskrat and shoreline surveys on Sallie and Melissa. Lakes Sallie and Melissa were treated for Flowering rush and/or Curly-leaf pondweed. Muskrat was investigated for AIS treatments, but no AIS was found at levels requiring management.

7.1.1 St. Clair Lake

St. Clair Lake originally was a 591-acre lake located west of the Detroit Lakes. Around 1915 the lake was drained to its present size of 140 acres because of the "awful stench" it presented to the local residents that was caused by more than seventy years of untreated sewage discharge from the City of Detroit lakes. A modern sewage treatment plant was constructed in 1976, which reduced phosphorus loadings to St. Clair by approximately 90%. In 2018, the City broke ground on a state-of-the-art wastewater treatment facility and it came online in 2020. The new facility continues to discharge treated effluent wastewater on the north side of the lake at very low phosphorus concentrations.

Lake bottom sediments are up to 16 feet thick in portions of the lake and are attributed to the lake's history of receiving sewage prior to modern wastewater treatment.

Two ditches bring water to St. Clair, including much of the City of Detroit Lake's stormwater runoff. A natural outlet from Long Lake enters from the west, which contributes only minor amounts of water and nutrient load. St. Clair discharges to the southwest via Becker County Ditch 14 to the Pelican River, entering Muskrat and Sallie Lakes. Ditch 14 flows through a partially drained wetland which contributes additional phosphorus prior to outlet to the Pelican River.

The Pelican River Watershed District applied aluminum sulfate (ALUM) to St. Clair Lake in October 1998. This treatment was a phased approach intended to reduce the unacceptable phosphorus level in Lake Sallie. Following the ALUM treatment, in-lake phosphorus concentrations in St. Clair Lake were reduced by over 50% from 131 µg/L to 72 µg/L, with a similar reduction in orthophosphate. In order to extend the treatment effectiveness, a boat motor restriction ordinance was placed on St. Clair Lake (only non-motorized watercraft allowed). Phosphorus levels began to trend upward beginning in the early 2010's showing that the ALUM treatments effectiveness have begun to weaken.

St. Clair Lake is listed for nutrient impairment (excessive phosphorus). Towards implementing restoration plan, in 2015-16, the MPCA and the District conducted the St. Clair Lake Total Maximum Daily Load (TMDL) study. The total phosphorus (P) loading capacity of St. Clair Lake was calculated by MPCA at 1,005 lbs/year. To meet the TMDL phosphorus load goal of 736 lbs/year and a 10% Margin of Safety (MOS), the total P load to the lake needs to be reduced by 286 lbs/yr (24%) in order to lower the phosphorus levels within St. Clair to meet the P water quality shallow lake standard (< 60 ug/L).

Table 7.1 The following table outlines the P loading goals of the affected areas and implementation strategies. From the St. Clair Lake TMDL Study.

Existing P Load	TMDL P Load Goal	Land Area
	8 lbs/yr	IMPCA Industrial Stormwater (Construction Sand & Gravel, Rock Quarrying and hot mix Asphalt production facilities); **Implementation**: install/maintain required BMPS and local stormwater requirements.
	8 lb./yr	MPCA Regulated Construction Stormwater (NPDES). **Implementation**: install/maintain required BMPS and local stormwater requirements.
342 lbs/yr	437 lbs/yr (198 kg/yr)	City of DL Wastewater treatment plant – load goal is greater to account for population growth projections (planned annexation around Floyd and Sallie lakeshore areas). Projected growth is 20% from 2010 – 2035. MPCA source: 2016: 168 kg/yr; 2017: 206 kg/yr; 2018: 226 kg/yr; 2019: 340 kg/yr; 2020: 271 kg/yr;
560 lbs/year	283 lbs/yr	Land area within City of DL (MS4) Stormwater Treatment within St. Clair Lake direct drainage area, Ditch 14, and Ditch 14 – branch 1 drainage areas. **Implementation:** Ordinances/Rules with rate and volume control – infiltration/filter stormwater. Stormwater Adaption- retrofit/upgrade existing dry/wet stormwater basins with infiltration trenches; reducing polyphosphate for treatment of domestic water supplies; Education/Outreach
178 lbs/year	85 lbs/year	Land area not in City of DL - Stormwater Treatment within St. Clair Lake direct drainage area, Ditch 14, and Ditch 14 – branch 1 drainage areas. **Implementation:** Construction BMPs, Stormwater BMPS, Ordinances/Rules with rate and volume control – infiltration/filter stormwater. Stormwater Adaption- retrofit/upgrade existing dry/wet stormwater basins with infiltration trenches, Education/Outreach

MPCA NPDES Permitted Wastewater Facilities GIS Map
https://www.arcgis.com/apps/Compare/storytelling_compare/index.html?appid=5e26e6c6756d4d0885da0ccadcb84737

7.1.1.1 Water Quality/Quantity

Water Quality – St. Clair Lake

St. Clair Lake started off in June with elevated nutrient readings for Chl-a and water clarity (secchi) but in July plummeted to lowest recorded readings with the yearly average TP at 37 µg/L (Figure 7.2), (20-year average of 84 µg/L), CHL-A average was 14.01 µg/L an improvement from the 20-year average of 38.87 µg/L (Figure 7.3). Secchi depths were 4.25 feet, also an improvement from the 20-year average of

3.2 feet (Figure 7.4). For comparison, 2017 average TP 107/ µg/L 2018 average TP 111/ µg/L: 2019 average TP 82/ µg/L 2020 average TP 57/ µg/L; 2021 average TP 55/ µg/L.

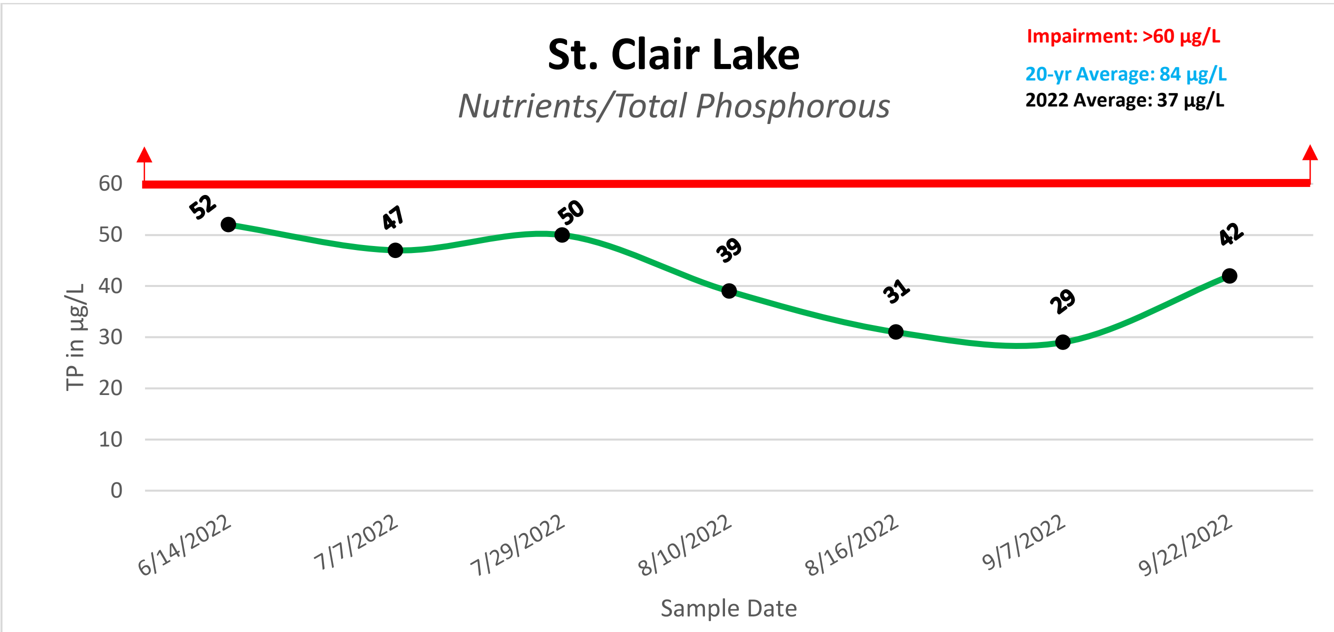


Figure 7.2 St. Clair Lake 2022 total phosphorous.

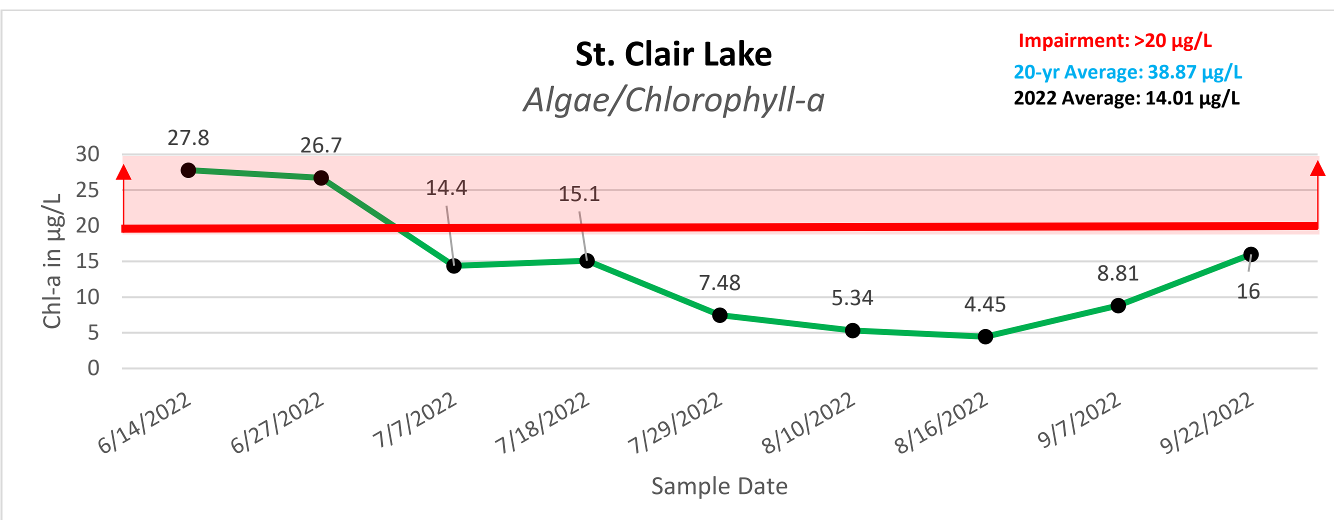


Figure 7.3 St. Clair Lake 2022 chlorophyll-a.

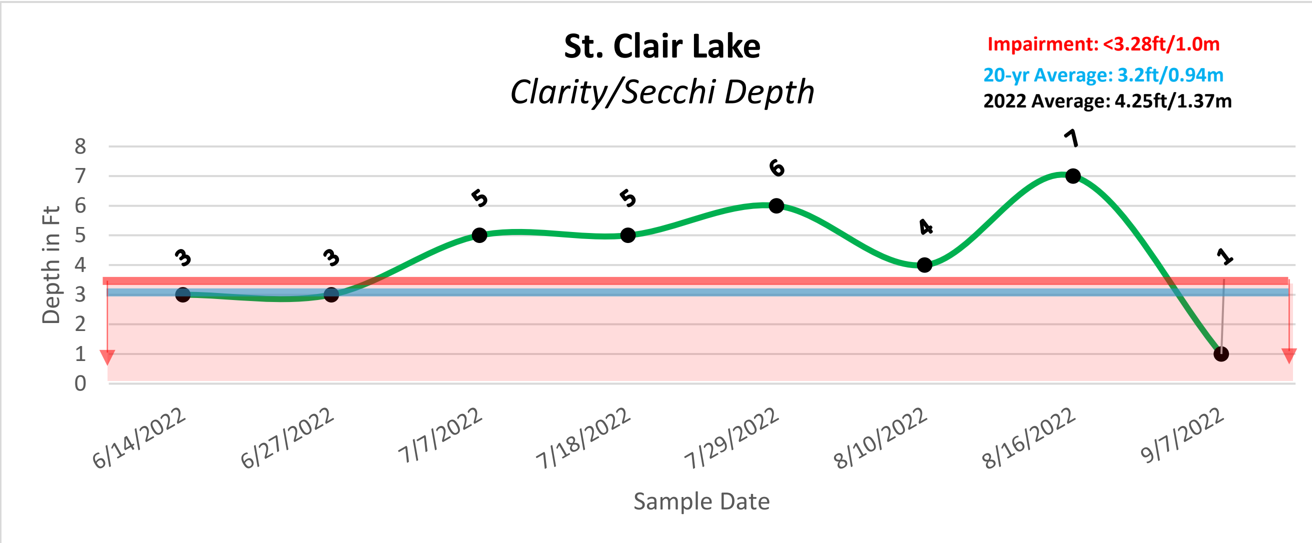


Figure 7.4 St. Clair Lake 2022 secchi depth.

7.1.2 Muskrat Lake

Muskrat is a small lake totaling 69 acres in surface area with 64 of those classified as littoral (<15 feet deep). The maximum depth of the lake is 18 feet. Muskrat lake is located within the Lake Sallie drainage area with the Pelican River flowing through it. Because the river is navigable from Detroit Lake, Muskrat has experienced more aggressive development than is typically observed on similar lakes. A tram was constructed to allow the movement of watercraft from Muskrat to Lake Sallie, which would otherwise not be possible due to a constructed rapid between the two lakes. The shallow lake is fertile with aquatic plants that grow to the surface in the deepest region of the lake.

A concrete lock-and-dam system (Dunton Locks) was installed during the depression era by the Civilian Conservation Corps between Lake Sallie and Muskrat Lake to replace a historic lock-and-dam used to allow steamboat transport down the Pelican River. This structure was removed in 2001 and replaced with a constructed rock rapids outfall at the historic water outlet elevation and no longer allows for any water level manipulation. The primary goal of the barrier removal was to allow for fish passage from Sallie to Muskrat (and Detroit via the Pelican River). The rapid has become a valuable asset for the MN DNR, which has a fisheries facility located in the area. Annual walleye netting is conducted for egg takes, which are grown and released back into area lakes which are not capable of sustaining a high enough rate of natural reproduction. The passage has also aided in the muskellunge (*Esox masquinongy*) fishery by allowing the passage between the lakes.

Water quality in Muskrat Lake is variable and highly influenced by the nutrient load from discharge from Detroit Lake via the Pelican River and from St. Clair Lake via Ditch 14. The lake is classified as mesotrophic; however, it tends to exhibit some eutrophic tendencies (lake wide algal blooms and dense macrophyte growth) during warmer summer months. Beginning in 2018 the City of Detroit Lake upgraded the WWTP which discharges wastewater effluent into St. Clair Lake. While the water is low in nutrients, the volume increased to about 1 million gallons per day, which was previously land applied during summer months.

7.1.2.1 Ecological Integrity

Vegetation Survey – Muskrat Lake

The first vegetation point-intercept survey of Muskrat Lake (EQuIS# 03-0360-00-201) conducted by the PRWD occurred on July 25th, 2022. Plants were rooted to a maximum depth (95%) of 15.1 feet, with depths ranging from 0 – 18 feet. However, since 64 acres is considered the littoral zone (< 15 feet deep and where aquatic plants are likely to be found) it was very rare to find any rooted plants deeper than 15 feet. 84% of the points had submersed native vegetation (Table 7.2) with a mean submersed native taxa per point of 2.1. Muskrat Lake has up to 6 submersed native taxa and one non-native submerged taxa (Curly-leaf pondweed) and one non- native emergent taxa (Flowering rush). However, there were little to no non-native plants detected during the 2022 point-intercept survey (Table 7.3).

*Table 7. 2 Point-intercept Metrics***.** *Summary of PRWD point-intercepts metrics Muskrat Lake, Becker County (EQuIS# 03-0360-00-201). Shaded values were calculated from littoral depth range (0-15 feet).*

Metric	JULY 2022
Surveyor	PRWD
Total # Points Sampled	102
Max depth of growth	15
Depth Range of Rooted Veg (ft.)	0.0 – 15.0
Max Depth of Growth (95%) (ft.)	15
# of Vegetated Points in Max Depth Range	88
# Points in Littoral (0-15 feet)	102
% Points w/ Submersed Native Taxa	84
Mean Submersed Native Taxa/ Point	2.1
# Submersed Native Taxa	5
# Submersed Non-Native Taxa	0
% Points w/ Submersed Non- native Taxa	0

Based on the 2022 point-intercept survey, the native plant community within the littoral area in Muskrat Lake was primarily dominated by Coontail (*Ceratophyllum demersum*) 64%, Flat-stem Pondweed (*Potamogeton zosteriformis*) 61%, Star Duckweed (Lemna trisulca) 40%, Northern Watermilfoil (*Myriophyllum sibiricum)* 26%, and Sago Pondweed (Stuckenia pectinate) 15%. These aquatic plants are central to a healthy fish population, offering shelter and providing food and habitat to wildlife. Flowering rush and Curly-leaf pondweed (Aquatic Invasive Species) have been present in the lake, although not found during the 2022 survey. The District will continue to monitor annually for AIS.

Muskrat Lake has an average of two species per sampling site. Figure 7.5 displays the spatial distribution and species richness (# of species per sample point) of all native submersed species from the 2022 point-intercept survey.

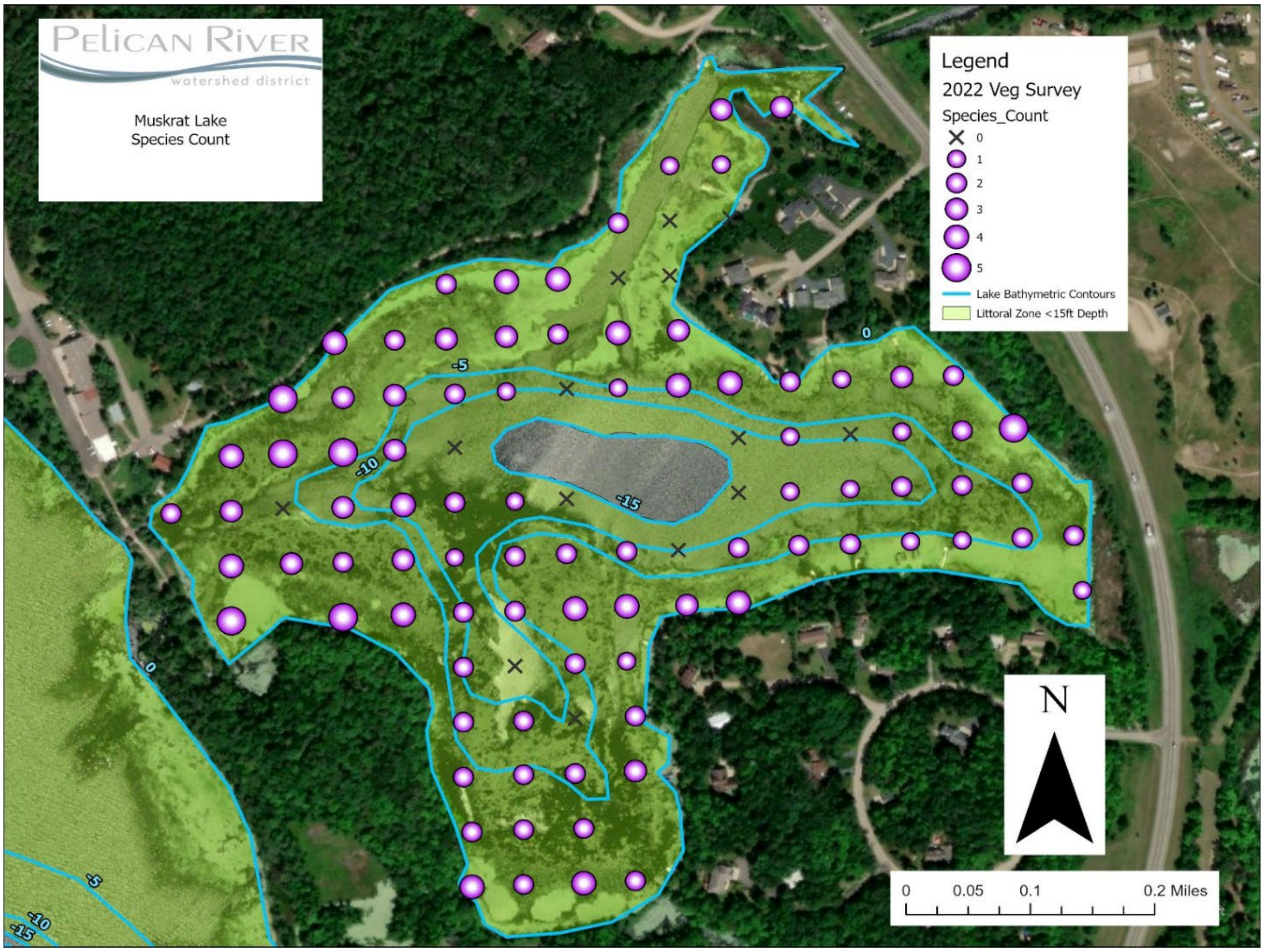


Figure 7.5 Number of species at each site from the 2022 point-intercept survey on Muskrat.

Table 7.3 Results from 2022 Muskrat Lake vegetation survey.

Lake Muskrat 2022 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	2.75	65	64%
Hydrilla verticillata	Hydrilla	2.15	27	26%
Drepanocladus spp.	Aquatic Mosses	3.00	1	1%
Potamogeton zosteriformis	Flat-stem Pondweed	2.92	62	61%
Nymphaeaceae spp.	Water Lilies	1.00	5	5%
Stuckenia pectinata	Sago Pondweed	2.47	15	15%
Potamogeton praelongus	White-stem Pondweed	1.88	8	8%
Lemna trisulca	Star Duckweed	2.29	41	40%
Empty Points	-	-	14	14%
Total Points	-	-	102	100%

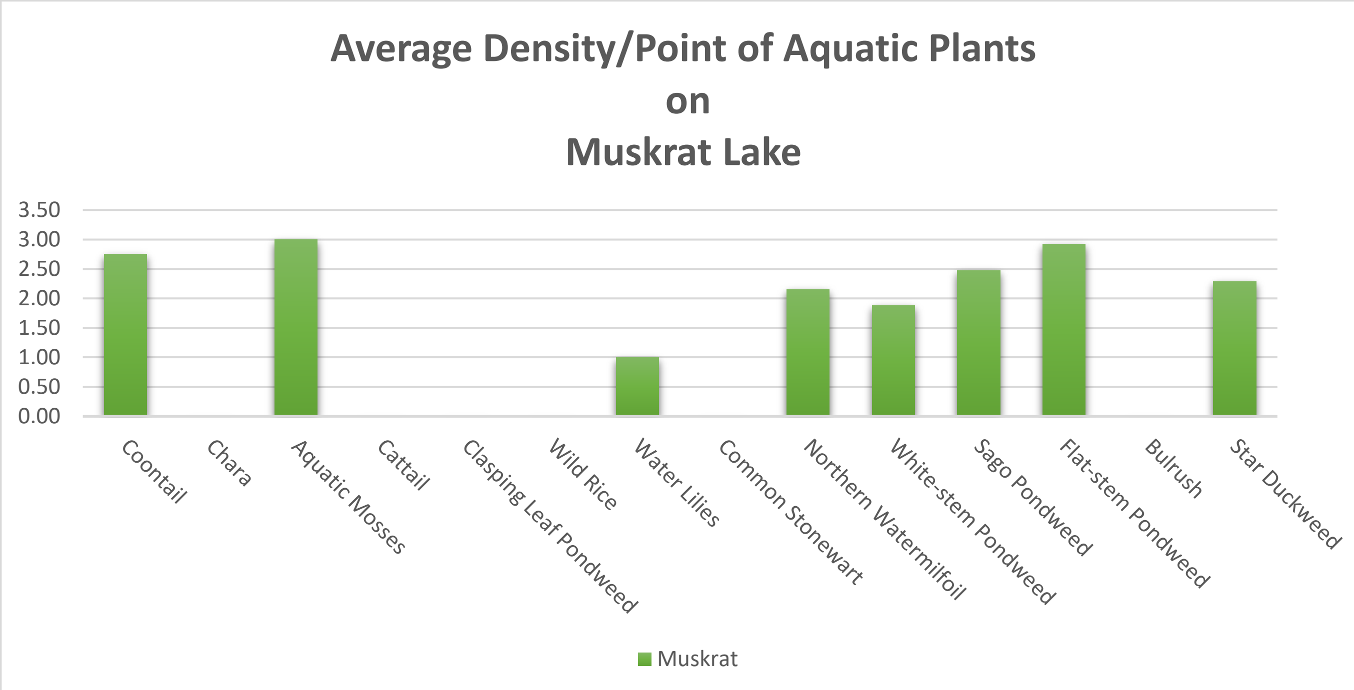


Figure 7.6 2022 Muskrat Lake density of aquatic plants.

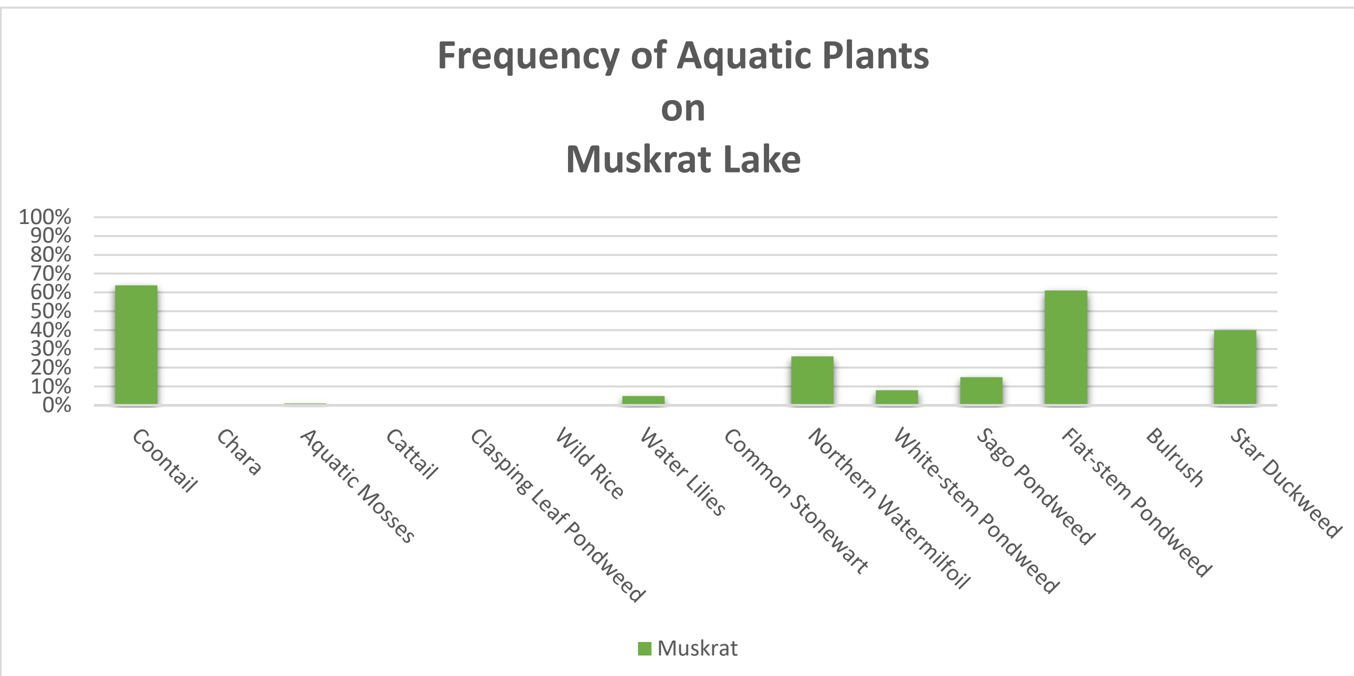


Figure 7.7 2022 Muskrat Lake frequency of aquatic plants.

7.1.3 Lake Sallie

Lake Sallie is a 1,273-acre polymictic lake which reaches a maximum depth of 50 feet, with 45% of its surface area considered littoral. Lake Sallie is classified as a borderline eutrophic lake, vulnerable to nutrient impairment. The Pelican River passes through the lake, entering from Muskrat to the North and exiting to Melissa on the south.

Historically, Lake Sallie has had poor water quality, partly due to the City of Detroit Lakes use of upstream St. Clair Lake as a discharge point for wastewater. Prior to the construction of the original WWTP in 1929, untreated wastewater was discharged into Lake St. Clair, which resulted in phosphorus levels in Lake Sallie approximately 54 µg/L, nearly 3 times that of similar lakes. In 1979, the WWTP was upgraded. Sallie responded with a decline in phosphorus levels ranging from 46 µg/L to 48 µg/L. In 2002, the WWTF was upgraded, and phosphorus loads were further reduced, resulting in Lake Sallie's current mean summer TP levels between 35 µg/L and 37 µg/L. In 2020, the City of DL WWTP underwent another major upgrade with the installation of European technology.

While Sallie has greatly improved since the 1970's, moderate to severe algal blooms are common, often continuous in July and August. These appear to be brought on in part by internal nutrient recycling, whereby nutrient rich water from the bottom layers is brought to the oxygen rich upper layers during lake mixing periods, often triggered by storm events and high winds.

Much of the nutrient load comes from upstream sources, specifically from nutrient rich water from partially drained Lake St. Clair via Becker County Ditch 14. An alum treatment in Lake St. Clair conducted in 1998 reduced internal loading to the lake, and in effect, reduced nutrient loading to downstream Muskrat and Sallie Lakes. Stormwater Best Management Practices in the City of Detroit Lake has also aided in Lake Sallie improvements by reducing stormwater runoff loads to Little Detroit Lake, which outlets to Sallie.

In the fall of 2016, zebra mussels were located at the public access of the lake. The District continues to monitor how the infestation impacts water quality. Water clarity has increased to a summer average of 13'-14' (compared to the previous 10-year average of 7 ft.).

A concrete lock-and-dam system (Dunton Locks) was installed during the depression era by the Civilian Conservation Corps between Lake Sallie and Muskrat Lake to replace a historic lock-and-dam used to allow steamboat transport down the Pelican River. This structure was removed in 2001 and replaced with a rock rapid at the historic water outlet elevation and no longer allows for any water level manipulation. The primary goal of the barrier removal was to allow for fish passage from Sallie to Muskrat (and Detroit via the Pelican River). The rapid has become a valuable asset for the MN DNR, which has a fisheries facility located in the area. Annual walleye netting is conducted for egg harvesting. The harvested eggs are grown and released back into area lakes to increase the rate of walleye recruitment. The passage has also improved the muskellunge fishery by allowing passage between the lakes.

The Pelican River flows out to Lake Melissa through a culvert under Becker CSAH 22 approximately 200' downstream of Lake Sallie. The velocity of flow between the outlet of Sallie and the culvert suggests that the elevation of the culvert may be slightly lower than the true water level in the Lake. There is also a slight hydraulic restriction that appears to control lake level.

7.1.3.1 Water Quality/ Quantity

Water Quality – Lake Sallie

In 2022, the summer time TP average was 25 µg/l, an improvement from the 20-year average of 32 µg/L (Figure7.8), CHL-A averaged 5.95 µg/L, an improvement from the 20-year average of 11.66 µg/L (Figure 7.9) and secchi depth was 12.1 feet, another improvement from the historic average of 8.73 feet (Figure 7.10).

The District has performed extensive work in the area upstream of Lake Sallie to reduce the nutrient load reaching the lake. Multiple projects reducing the phosphorus loading to Lake St. Clair has directly affected the phosphorus loading to Lake Sallie. As the load has been reduced entering the lake, the lake has had the opportunity to flush nutrients out downstream.

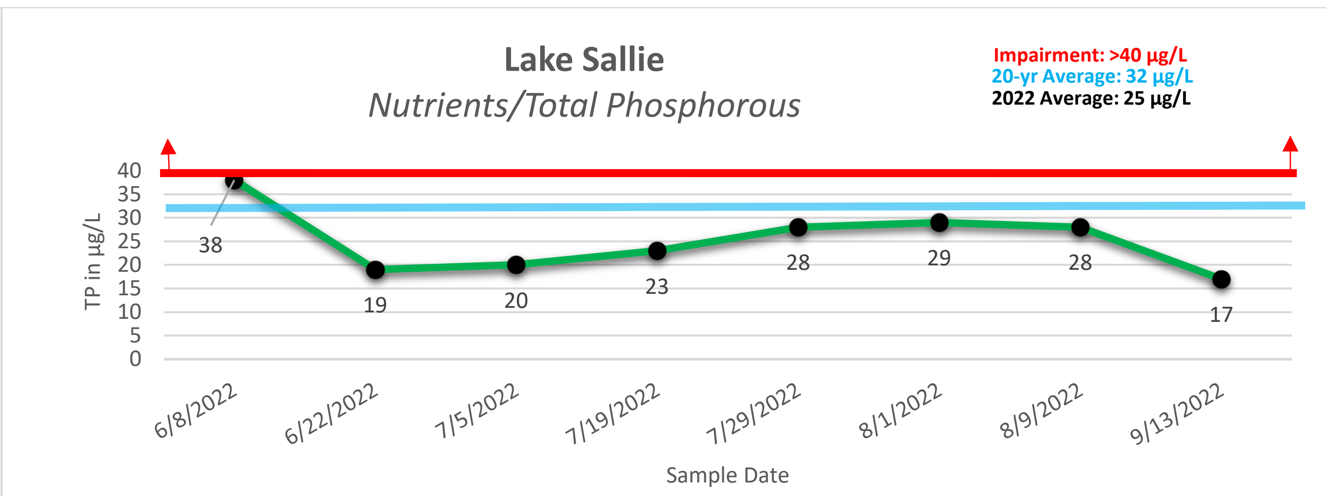


Figure 7.8 Lake Sallie 2022 Total Phosphorous.

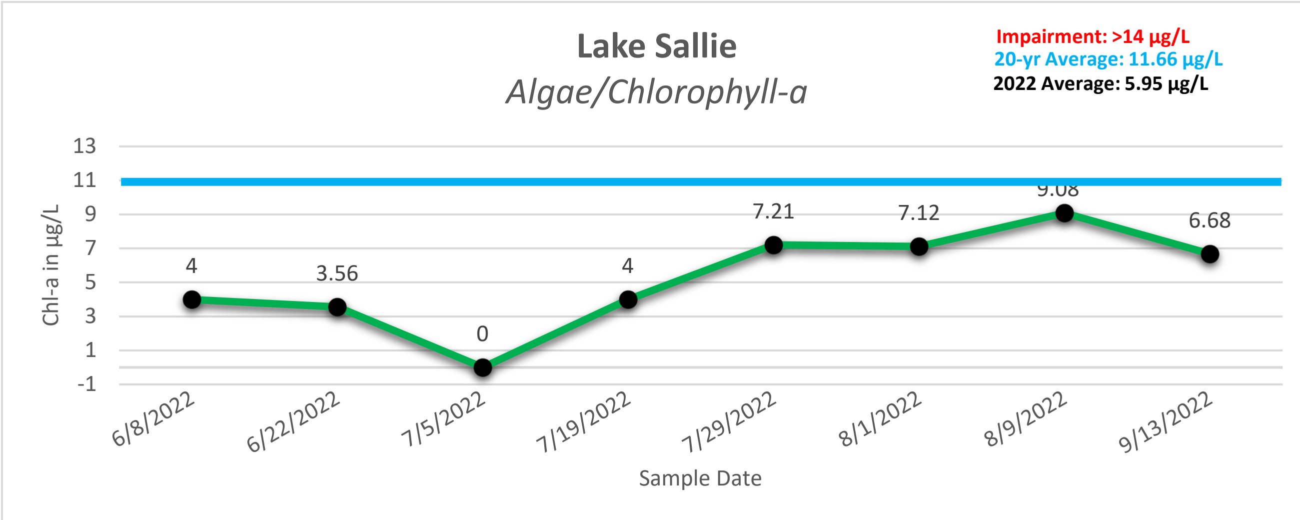


Figure 7.9 Lake Sallie 2022 Chlorophyll-a.

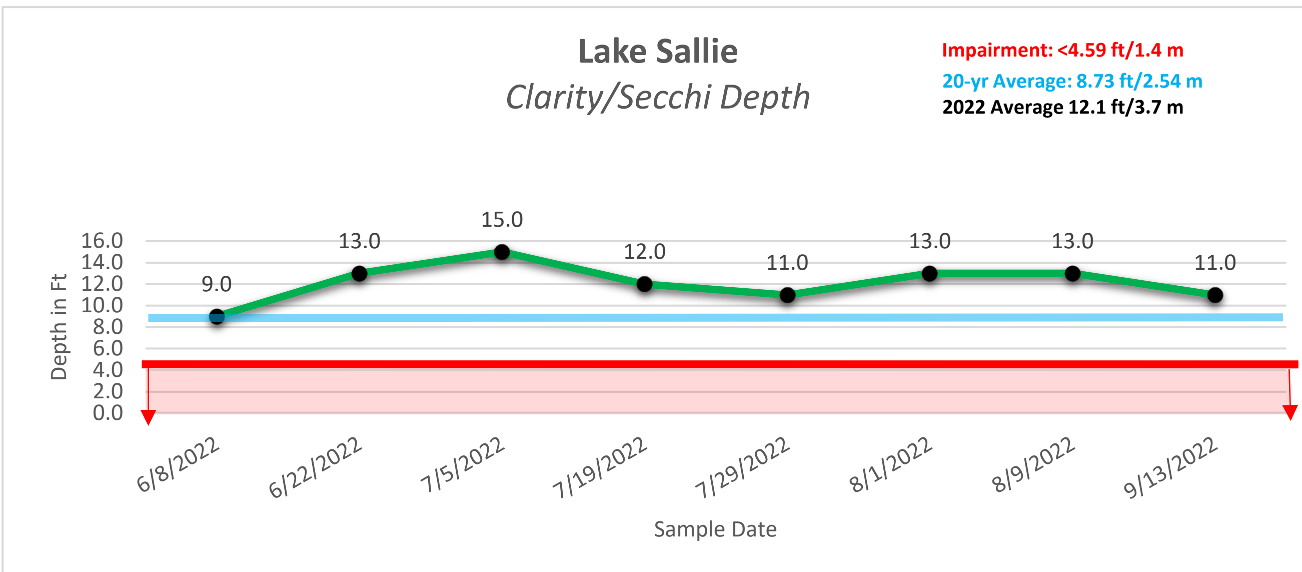


Figure 7.10 Lake Sallie 2022 Secchi Depth.

Water Quantity – Lake Sallie

Water levels on Lake Sallie are recorded at the outlet, at County HWY 22. Water Levels in 2022 were extremely high (Figure 7.11), staying way above the OHW for the majority of the year (Figure 7.12). Water levels dropped below the OHW towards the end of July with one little jump above the OHW in late August but then fell back below the OHW during early September and continued to decrease the remainder of the monitoring season.

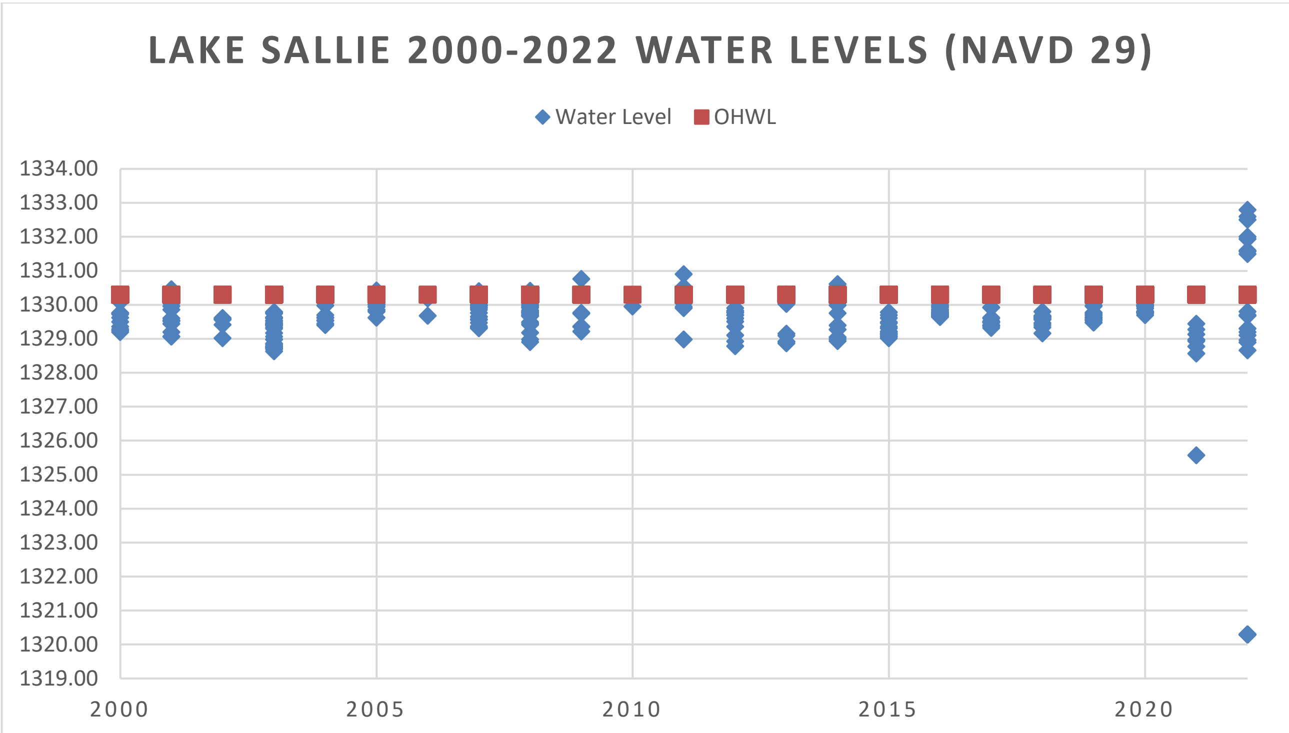


Figure 7.11 Lake Sallie water levels from 2000-2022.

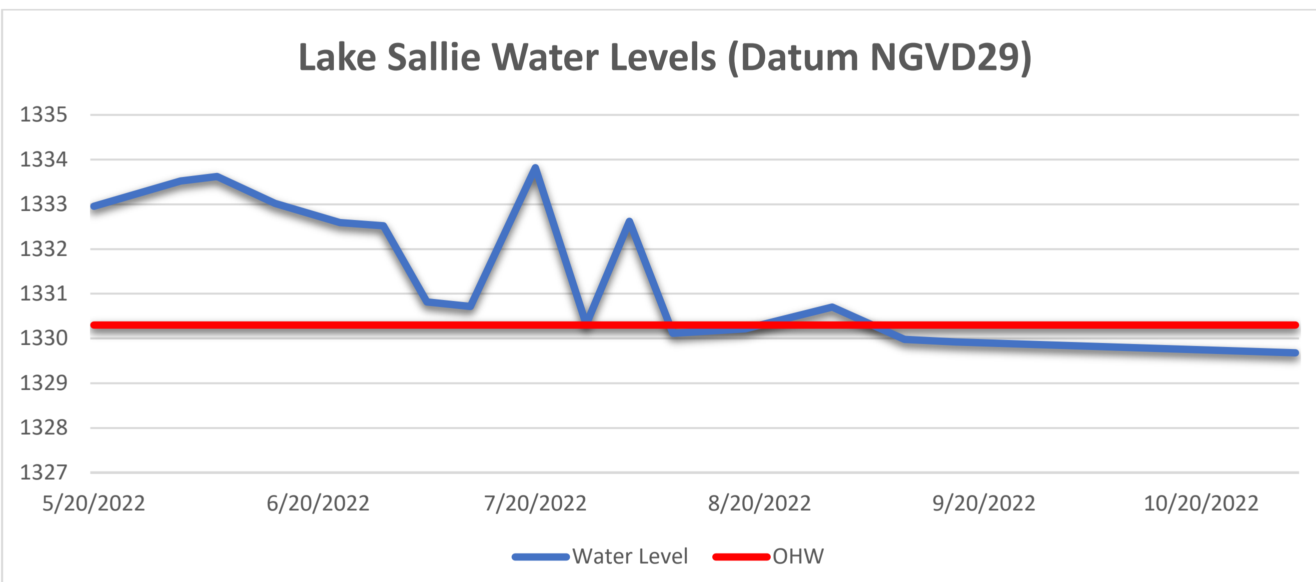


Figure 7.12 Lake Sallie water levels in 2022.

7.1.3.2 Ecological Integrity

Aquatic Invasive Species Control – Lake Sallie

The District performed reduced chemical treatments of Flowering rush and Curly-leaf pondweed on Lake Sallie in 2022 (Figure 7.13). The Flowering rush was reduced from 35.88-acres in 2021 to 31.03 acres in 2022. Two treatments were performed with Diquat (June 28th and August 1st) to help control these areas. There is a small patch of Flowering rush where the Pelican River drains into Lake Sallie, but due to the flowing water it has created a problem. We are working to come up with a solution to effectively control the flow of water and increase contact time between the chemical and the plant to successfully treat it. We were contacted by the Army Corp of Engineers to help assist us with coming up with possible methods to treat these difficult areas that have flowing water. A Small patch (7.57 acres) of Curly-leaf pondweed was treated on Lake Sallie on 06/03/2022.

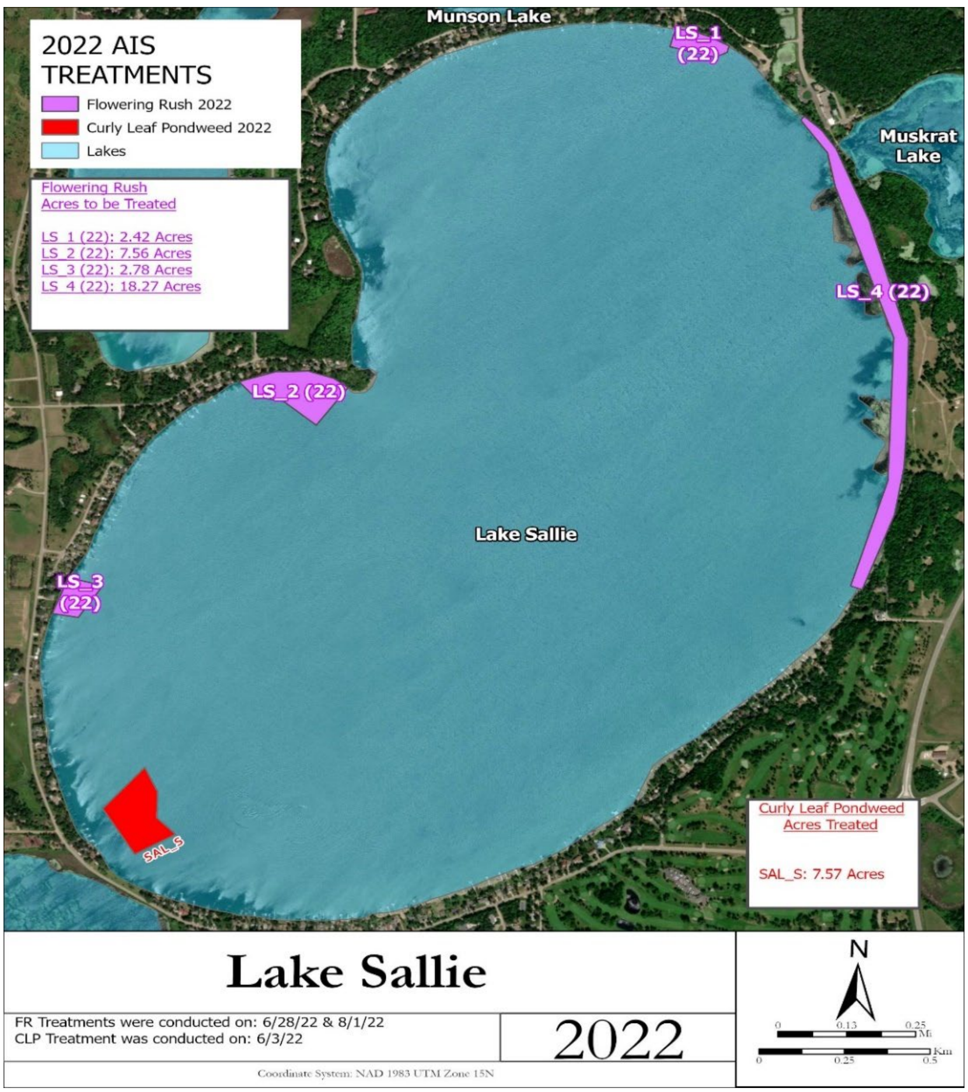


Figure 7.13 Aquatic invasive species treatments on Lake Sallie in 2022.

Table 7.4 AIS Treatment costs on Lake Sallie in 2022.

	CLP #1 Trmt Acres 6/3/2022	CLP #1 Trmt Cost	FR #1 Trmt Acres 6/28/2022	FR #1 Trmt Cost	FR #2 Trmt Acres 8/1/2022	FR #2 Trmt Cost	Totals Per Lake
Sallie	7.6	$1273.00	31.1	$5,209.25	31.1	$5,209.25	$11,691.50

Shoreline Survey – Lake Sallie, 224 Parcels

Photos were taken of all 224 parcels during mid-July of 2022.

7.1.4 Lake Melissa

Lake Melissa is the second largest lake within the Pelican River Watershed District. It totals 1,850 acres and reaches a maximum depth of 37 feet, with about half of its surface area littoral. Lake Melissa is classified as a mesotrophic lake with good water quality. The Pelican River passes through the lake, entering on the north end from Lake Sallie, with an outlet on the south end to Mill Pond. Late summer algal blooms have been observed, typically caused by nutrient movement from the borderline eutrophic Lake Sallie through the Pelican River.

The invasive zebra mussel was observed in Lake Melissa in 2014. Since then, there has been a significant increase in water clarity. Prior to the infestation, mean summer clarity ranged from 8 to 12 feet (9.5 feet average). Subsequent years after the infestation, clarity increased to 12.5 (2015), 14.5 (2016), 16.5 (2017), and 18 (2019). There has also been a significant reduction in chlorophyll level, indicating a shift from free floating to benthic (bottom dwelling) algae, which is common with infested lakes.

Lake Melissa is also known to be infested with the invasive aquatic plant Flowering rush and Curly-leaf pondweed. The District actively surveys and chemically treats nuisance population annually to manage the plant density and minimize recreational and environment impacts.

The shoreline on Lake Melissa has been experiencing intense development in recent years to what was already a highly developed lake shore. There has also been a conversion from small, seasonal cottages, to larger, year-round homes. Residential lots are relatively small, which also contributes to the dense development and shoreline modifications.

There are several water control structures in the Lake Melissa vicinity. The remnant of a lock and dam system is located approximately 100 feet upstream of Lake Melissa. This lock is no longer active and there are no water level manipulation abilities with the remnant structure, which does not inhibit fish passage. There is a bridge located at the outlet of lake Melissa that forms a slight hydraulic constriction. There are no other dam components, such as piers, stops, or concrete crest present. Approximately 300 feet downstream of the outlet is a large culvert below South Melissa Drive. There is a noticeable difference between the headwater and tailwater elevations at the culvert. Also, the velocity of flow in the channel from the lake to the culvert suggests that the headwater elevation at the culvert is slightly lower than the actual elevation of Lake Melissa.

Bucks Mill Dam is approximately 1.35 miles downstream of lake Melissa. Historically, a water wheel was utilized at the original dam for Buck's Mill, which is no longer present. At a later date, a second dam was constructed approximately 100 feet upstream of the original. The new dam is used to adjust water level in Mill Pond and provide water to a downstream MN DNR Fisheries rearing pond. Due to the difference in water lever, this dam has virtually no impact on Lake Melissa water levels.

7.1.4.1 Water Quality/Quantity

Water Quality – Lake Melissa
Lake Melissa experienced a better than average water quality year in 2022. The 2022 average for TP was 15 µg/L an improvement from the historic average of 20 µg/L (Figure 7.14). The average CHL-A of 4.06 µg/L also improved from the historic average of 6.52 µg/L (Figure 7.15) and water clarity (secchi depth) averaged 13.5 feet – almost 2-feet of clarity depth better than the historic average of 11.4 feet (Figure 7.16).

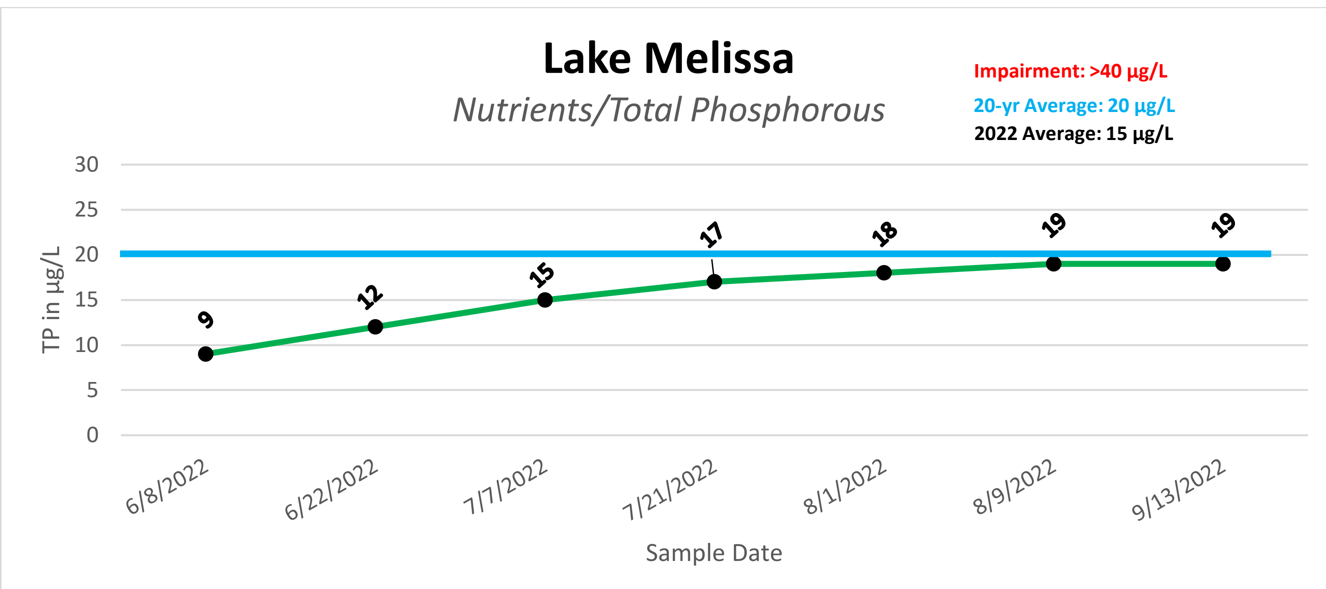


Figure 7.14. Lake Melissa 2022 total phosphorous.

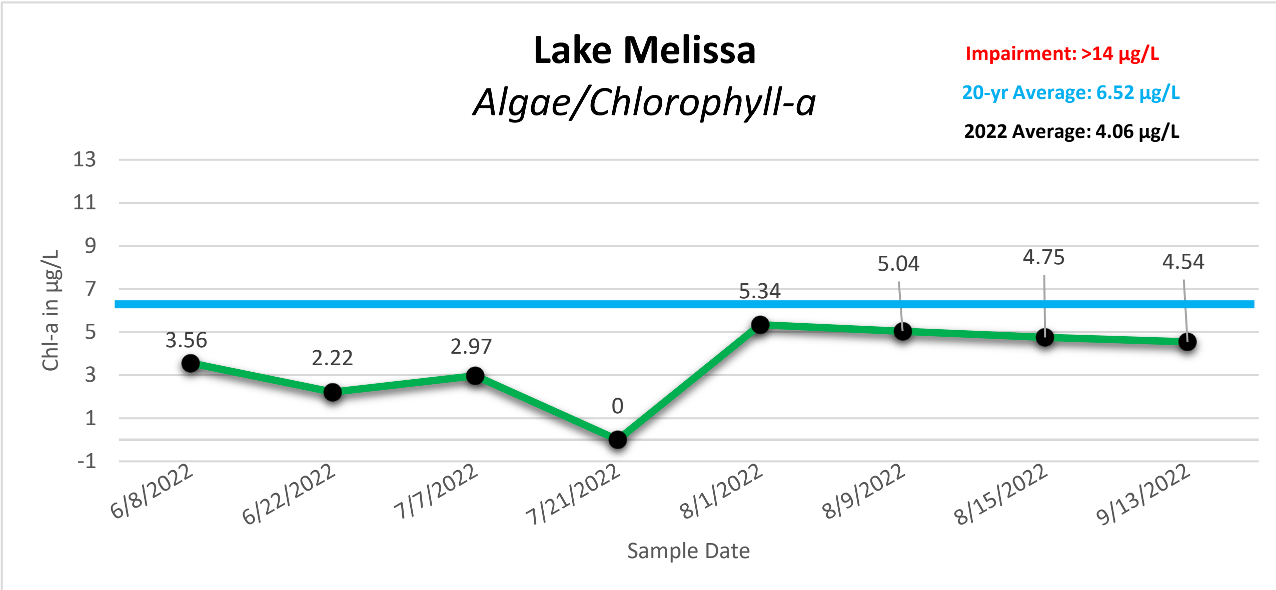


Figure 7.15. Lake Melissa 2022 chlorophyll-a.

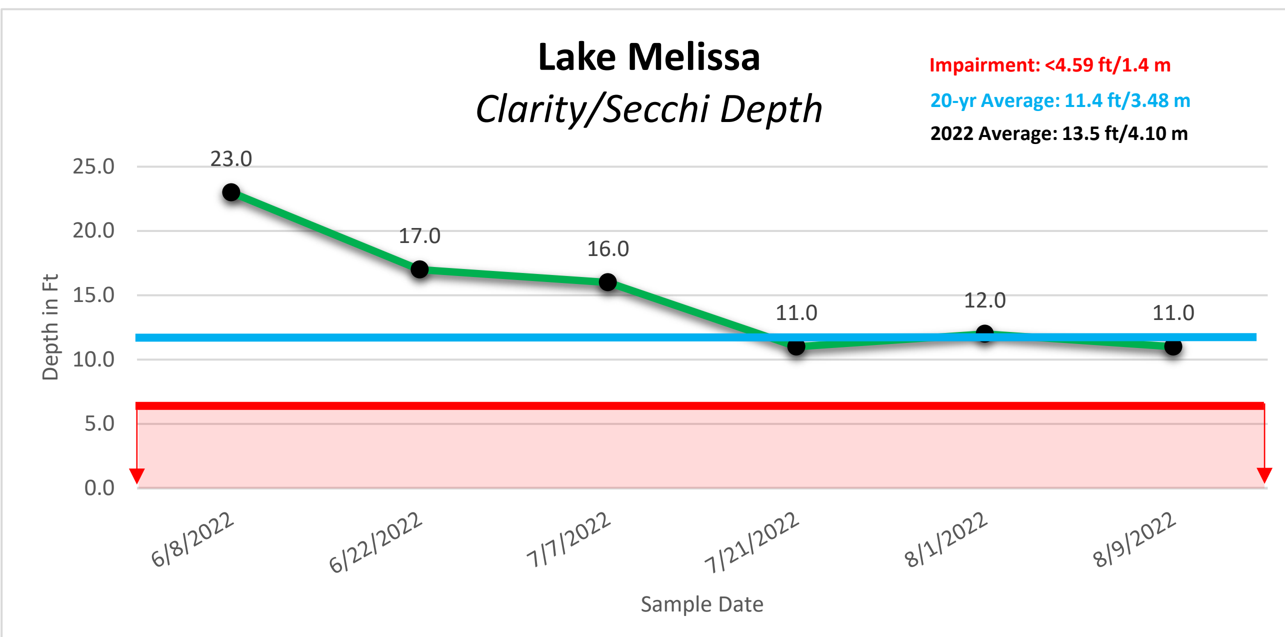


Figure 7.16 Lake Melissa 2022 secchi depth.

Water Quantity – Lake Melissa

Water Levels on Lake Melissa in 2021 were very low and stayed below the OHW for the season (Figure 7.17). Water levels fluctuated between 1328.26' MSL and 1327.50' MSL throughout the season (Figure 7.18).

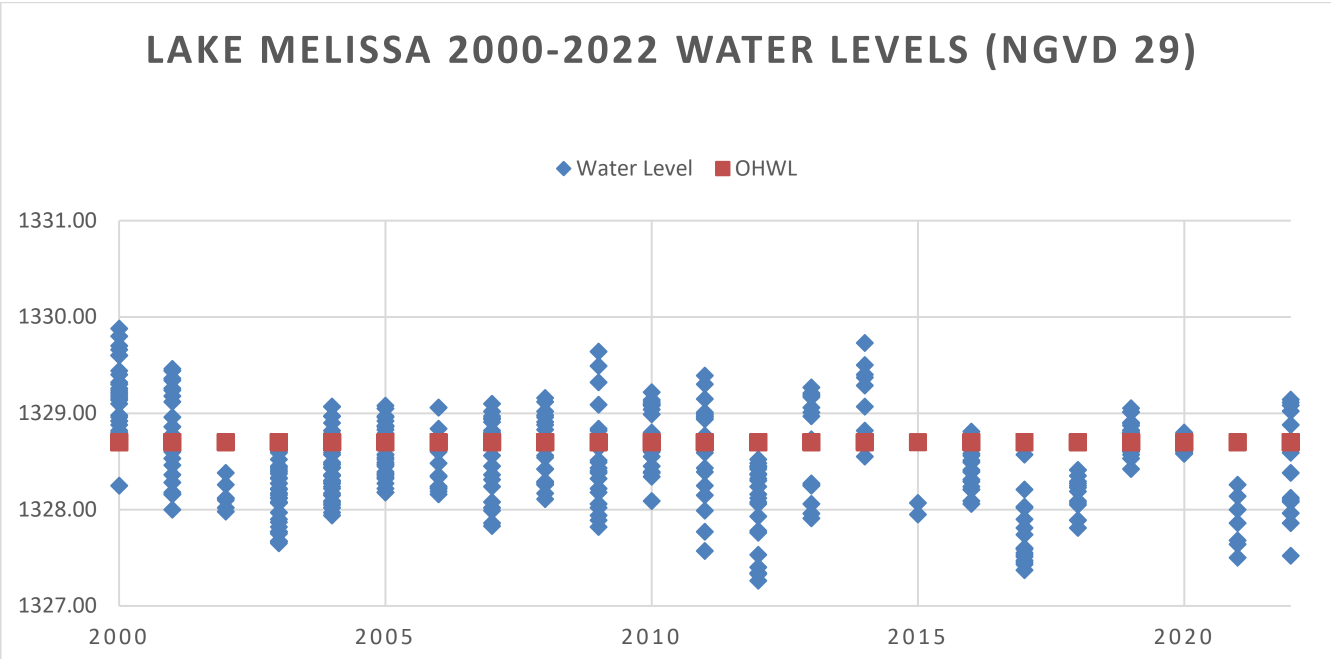


Figure 7.17. Water levels on Lake Melissa from 2000-2021.

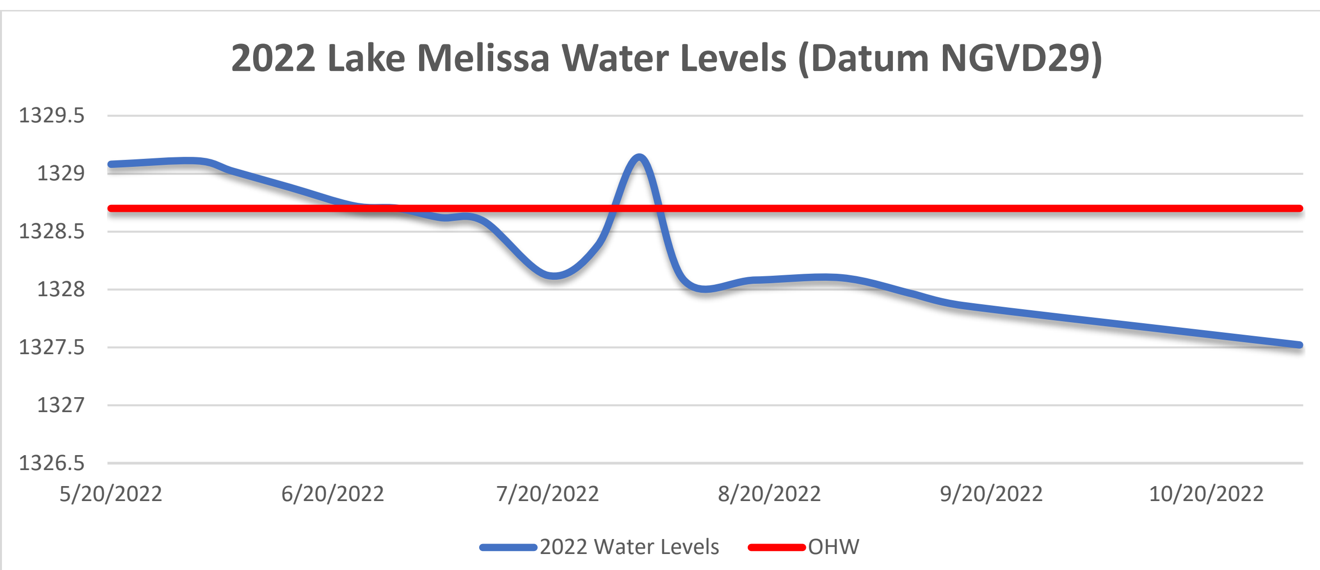


Figure 7.18 Water levels on Lake Melissa in 2022.

7.1.4.2 Ecological Integrity

Aquatic Invasive Species Control – Lake Melissa

No chemical treatments for Curly-leaf pondweed were required in 2022. The only treatments the District performed were for Flowering rush, a total of 24.12 acres were treated twice (June 28th and August 9th). (Figure 7.19). The District will continue to assess the lake for Flowering rush and Curly-leaf pondweed in 2023.

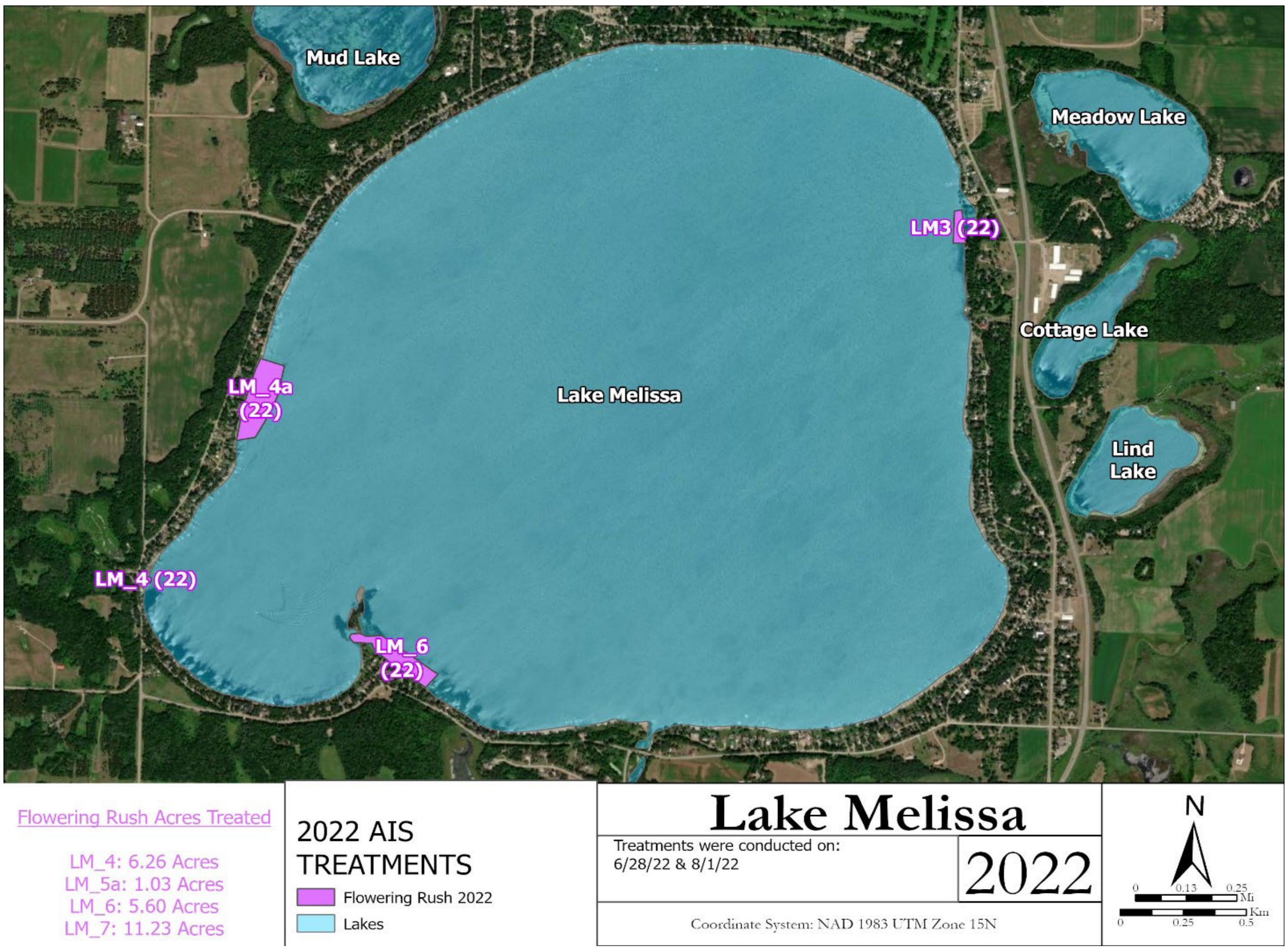


Figure 7.19 Aquatic invasive species treatments on Lake Melissa in 2022.

Table. 7.5 AIS Treatment costs on Lake Melissa in 2022.

	FR #1 Trmt Acres 6/28/2022	FR #1 Trmt Cost	FR #2 Trmt Acres 8/1/2022	FR #2 Trmt Cost	Totals Per Lake
Melissa	15.75	$2,638.13	15.75	$2,638.13	$5,276.26

Shoreline Survey – Lake Melissa, 398 Parcels

Photos were taken of all 398 parcels during mid-July of 2022.

7.1.5 Mill Pond Lake

Mill Pond is a shallow, natural environment lake. Technically, Mill is a reservoir because of a downstream dam (Bucks Mill Dam) which maintains the water level about 6 feet above the natural lake elevation. The east half of the lake is densely vegetated except for the channel where the Pelican River flows through. The west basin contains open water and reaches a maximum depth of 10 feet.

Mill has no designated boat ramp, but the lake can be accessed via Lake Melissa with canoes, kayaks, or small watercraft. There are some single-family homes, primarily in the west basin.

Historically, a dam located downstream from where the current dam exists, was used to provide waterpower for the adjacent mill. This dam has been removed, however, the original dam embankments where the water wheel would have been, remain intact. The current dam sits approximately 100 feet upstream from the historic location and is used to control water levels on Mill Pond, which is used as a MN DNR rearing pond. In 2019, Becker County and the MN DNR began discussions of possibly removing the outlet structure and replacing it with a rock weir rapid and a 2024-5 construction target is set pending land acquisition.

Water quality was monitored for a three-year period from 2007-2009, with total phosphorus levels at 20ppm and water clarity at 7.5 ft. The nutrient levels were found to be very similar to Lake Melissa, which drains through Mill Pond.

Due to its connection to Lake Melissa, the lake is also infested with Zebra Mussels and Flowering rush. In past years, the Pelican Group of Lakes Improvement District (PGLID) has managed Flowering rush in Mill Lake by chemical and hand removal in an attempt to minimize propagation to downstream lakes (Pelican Lake).

7.1.5.1 Ecological Integrity

Vegetation Survey – Mill Pond Lake

The first vegetation point-intercept survey of Mill Lake (EQuIS# 03-0358-00-201) conducted by the PRWD occurred on August 11th, 2022. Plants were rooted to a maximum depth of 10 feet, with depths ranging from 0 –10 feet. However, since all 155 acres is considered the littoral zone (< 15 feet deep and where aquatic plants are likely to be found) it was very rare to find any rooted plants deeper than 10 feet. 74% of the points had submersed native vegetation (Table 7.6) with a mean submersed native taxa per point of 4.2. Mill Lake has up to 3 submersed native taxa (Table 7.7).

Table 7.6 - Point-intercept Metrics. Summary of PRWD point-intercepts Mill Pond Lake, Becker County (EQuIS# 03-0377-00-201). Shaded values were calculated from littoral depth range (0-15 feet).

Metric	**August 2022**
Surveyor	PRWD
Total # Points Sampled	45
Max depth of growth	10
Depth Range of Rooted Veg (ft.)	0.0 – 10.0
Max Depth of Growth (ft.)	10
# of Vegetated Points in Max Depth Range	49
# Points in Littoral (0-15 feet)	50
% Points w/ Submersed Native Taxa	74
Mean Submersed Native Taxa/ Point	4.2
# Submersed Native Taxa	3
# Submersed Non-Native Taxa	0
% Points w/ Submersed Non- native Taxa	0

Based on the 2022 point-intercept survey, the native plant community within the littoral area in Mill Pond Lake was primarily dominated by Coontail (*Ceratophyllum demersum*) 82%, Sago Pondweed (*Stuckenia pectinate*) 54%, and Clasping-leaf Pondweed (*Chara Contraria)* 2%. These aquatic plants are central to a healthy fish population, offering shelter and providing food and habitat to wildlife. Mill Pond Lake also has the following floating leaf and emergents: Water Lilies (*Schoenoplectus* sp.) 69%, Cattail (*Typha sp.*) 4%, Wild Rice (Zizania palustris) 16% and Star Duckweed (*Lemna trisulca) 6%* These floating and emergent plants are especially good at preventing shoreline erosion, habitat and providing food sources for waterfowl. Plants also absorb nutrients and reduce algae, thereby improving water quality.

Mill Pond Lake has an average of ten species per sampling site. Figure 7.20 displays the spatial distribution and species richness (# of species per sample point) of all native species from the 2022 point-intercept survey.

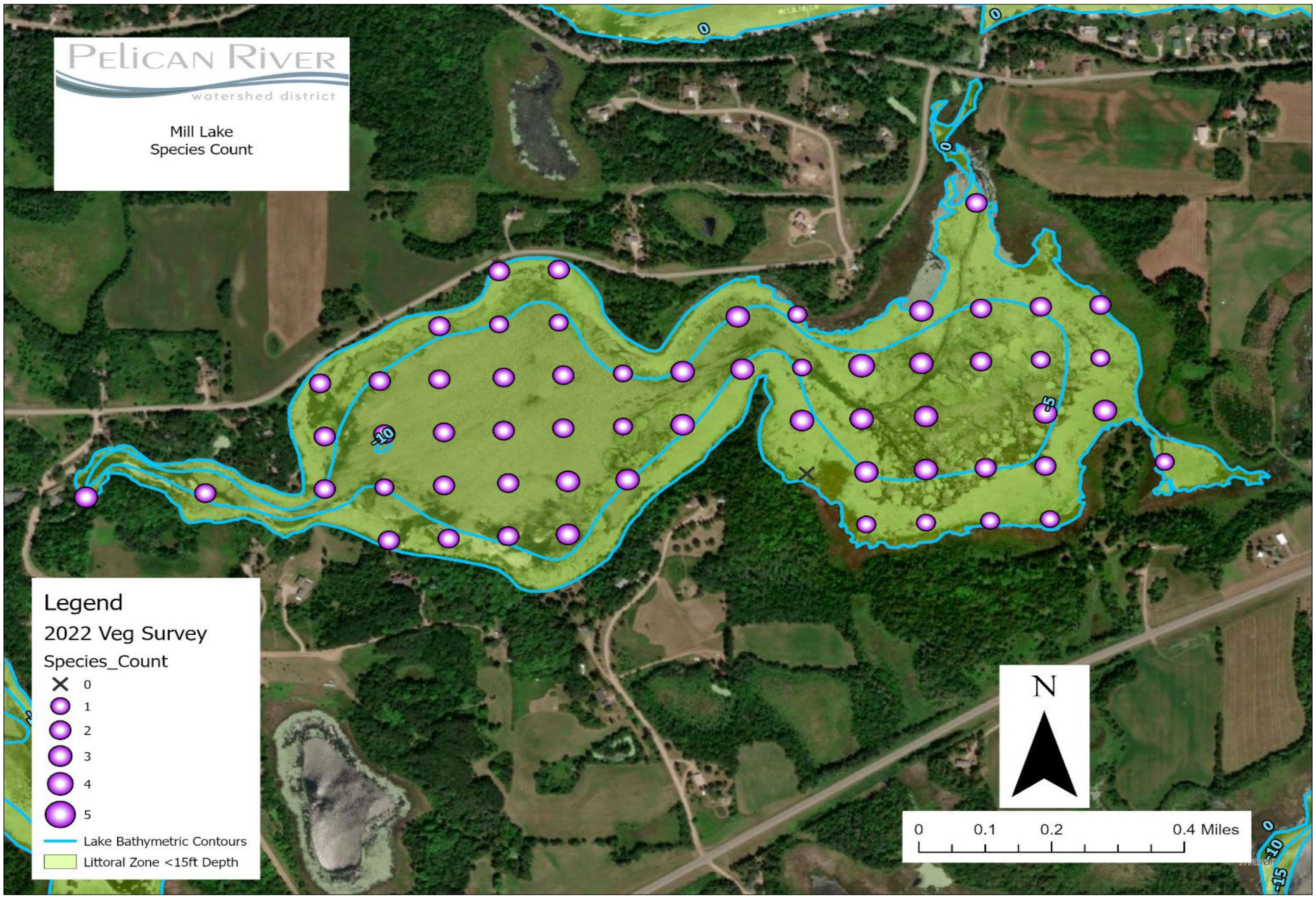


Figure 7.20 Number of species at each site from the 2022 point-intercept survey on Mill Pond Lake.

Table 7.7 Results *from 2022 Mill Pond Lake vegetation survey.*

Mill Lake 2022 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	2.51	41	82%
Stuckenia pectinata	Sago Pondweed	2.81	27	54%
Typha sp.	Cattail Species	3.00	2	4%
Potamogeton perfoliatus	Clasping-leaf Pondweed	1.50	8	16%
Zizania palustris	Wild Rice	2.13	8	16%
Nymphaeaceae spp.	Water Lilies	3.00	34	69%
Lemna trisulca	Star Duckweed	3.00	3	6%
Empty Points	-	-	1	2%
Total Points	-	-	50	100%

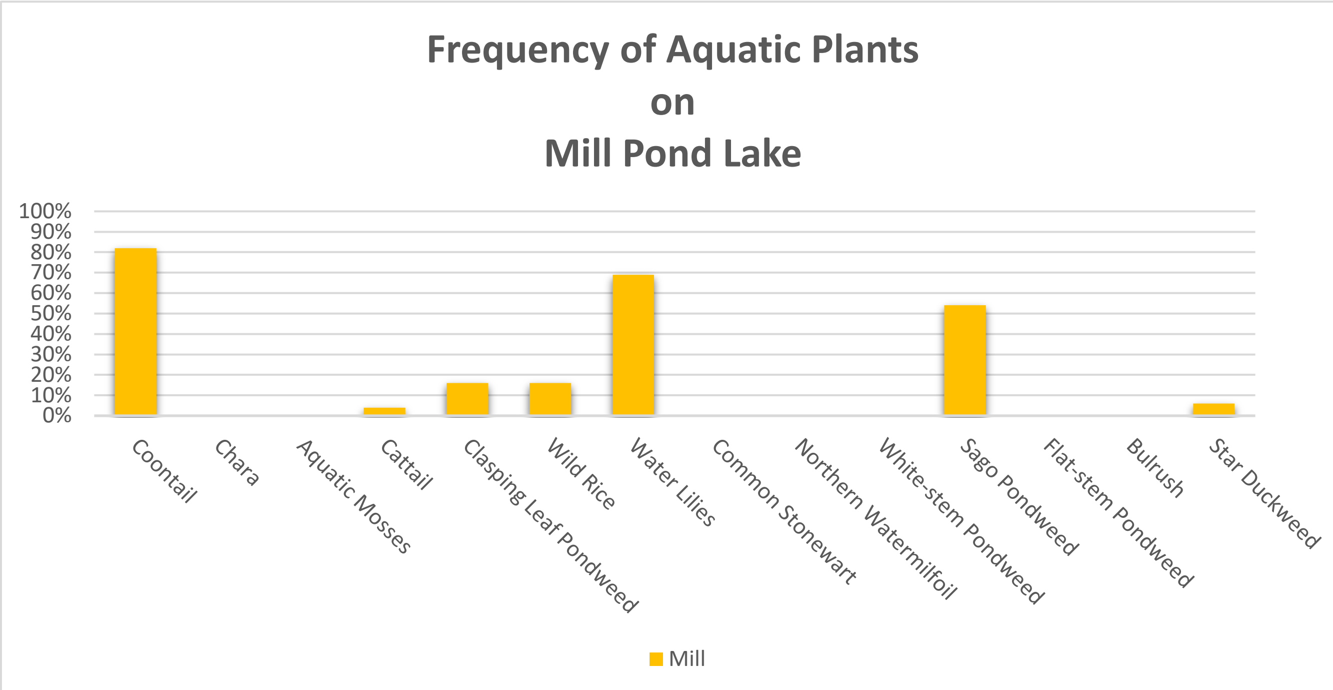


Figure 7.21 2021 Mill Pond Lake Frequency of Aquatic Plants

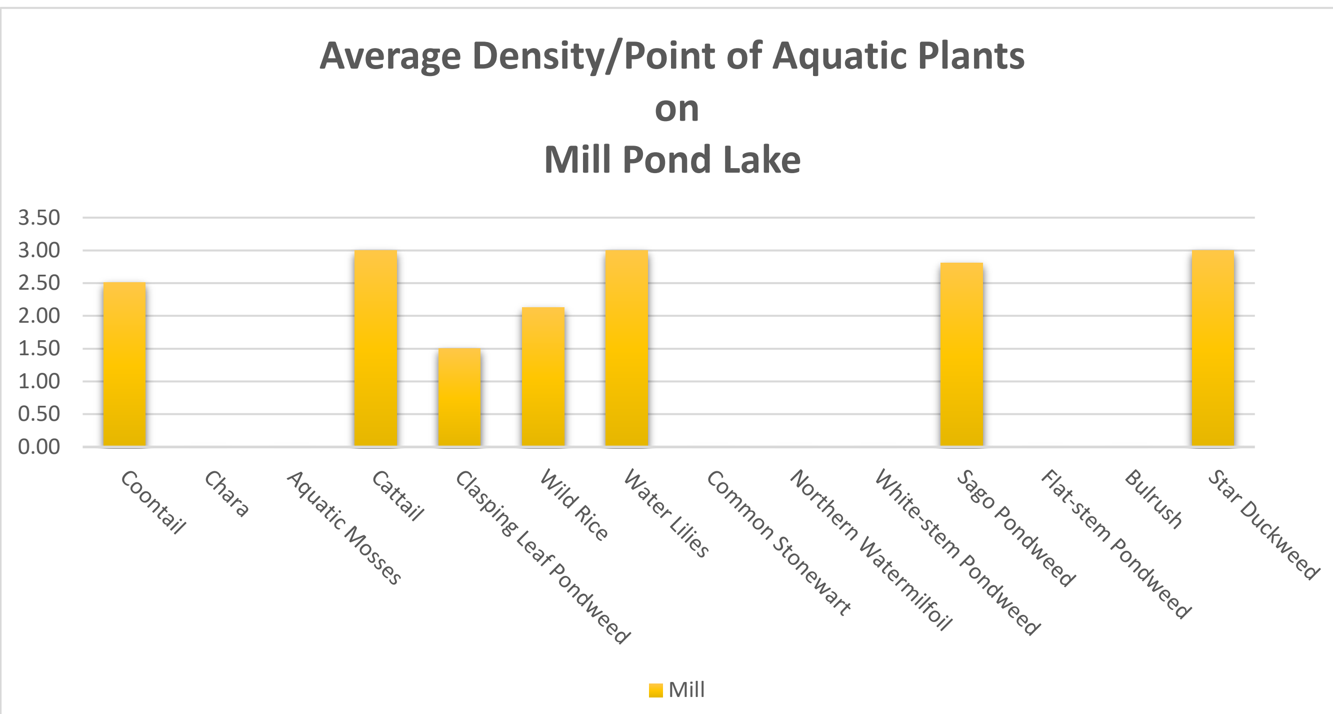


Figure 7.22. 2021 Mill Pond Lake Density of Aquatic Plants

7.1 Streams/Ditches

The District monitors 8 locations along the streams and ditches in the Sallie/Melissa WMA. Half of these sites are along Ditch 14 and the other half on the Pelican River.

7.2.1 Ditch 14

Ditch 14 carries heavy phosphorous loads from Lake St. Clair into the Pelican River, which passes the phosphorous onto Lake Sallie. The location at the outlet of Detroit Lake (PR6) sets the tone for water quality in the WMA. Water quality here is similar to that of Detroit Lake, generally giving the same readings. The same can be said for the sites at the outlet of Lake Sallie (PR8) and Lake Melissa (PR9). Total suspended solids are not measured in the WMA due to insignificant readings (water flow is not enough to cause shoreline erosion or carry sediments in the water column).

7.2.1.1 Water Quality/Quantity

Water Quality – Ditch 14

Ditch 14 receives the heavy phosphorous loads from Lake St. Clair and the wetlands between St. Clair and the Pelican River. Phosphorous concentrations in Ditch 14 from the outlet of St. Clair decreased by 27% by the time it reaches the inlet of Muskrat Lake (Figure 7.23). Concentrations of OP also decreased as it flows through these wetlands, by almost 6%. Specific conductance, a surrogate for chlorides, remains high throughout the ditch (most lakes are around 400 micro-siemens, Ditch 14 runs about 786 micro-siemens), possibly caused by residential water softeners, road salt, and fertilizer runoff.

Water Quantity – Ditch 14

The District took minimal samples (5 samples) during storm events from the Fairgrounds Stormwater Basin. This stormwater basin was built by the City of Detroit Lakes to treat the effluent from the Municipal Separate Storm Sewer System (MS4) and treats about half of the City of Detroit Lake's stormwater runoff before discharging into the Ditch 14 wetlands North of St. Clair. Concentrations of TP and OP out of this basin were quite high, averaging 149 µg/L and 34 µg/L respectively (n=5). Specific conductance was also high, averaging 692 micro-siemens. A low number of samples were taken, possibly skewing results, but all readings were high. The District will continue to take more samples in 2023 to assess this issue.

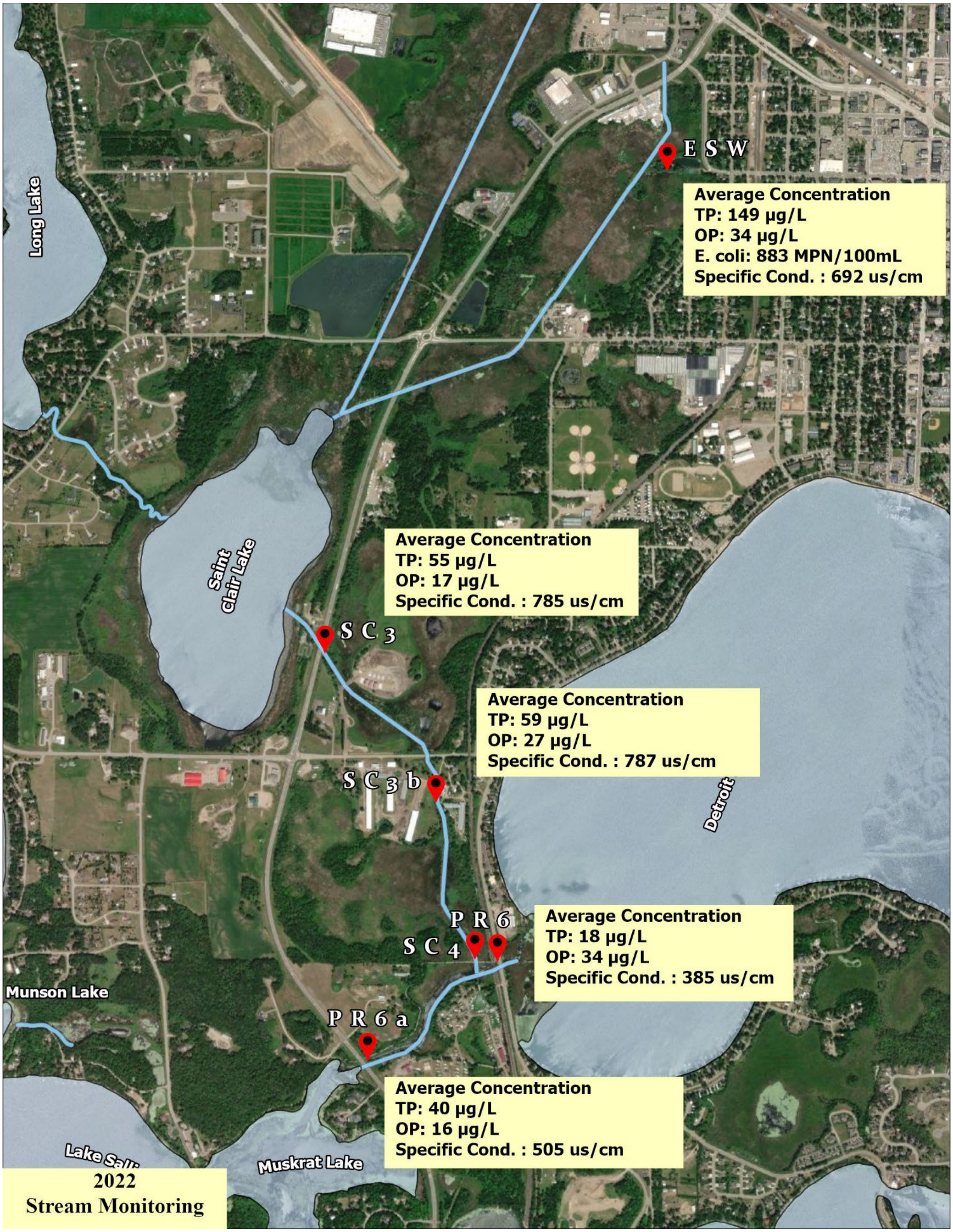


Figure 7.23. Nutrient concentrations on Ditch 14 in 2022.

8 Brandy Water Management Area

The Brandy WMA contains about 3,000 acres (Figure 8.1). Four named lakes exist within this area; Brandy, Wine, Oak, and Oar, however several small unnamed lakes and wetlands also dot the WMA. Brandy Lake is the largest lake, at 323 acres. The other lakes are smaller and have small watersheds. Land in the Brandy WMA is mostly used for cultivated crops or pasture, and shoreline along the lakes is mostly undeveloped. This is partly because the shallow nature of these lakes makes them ill-suited for recreation. Approximately 10 percent of the WMA is owned by the U.S. Fish and Wildlife Service. Brandy Lake historically suffered from poor water quality from the former Becker County Landfill but has improved through remediation. Wine Lake is impaired due to excess nutrients, and the District will work with MPCA to develop a TMDL. Oak lake was sampled in 2020 for water quality.

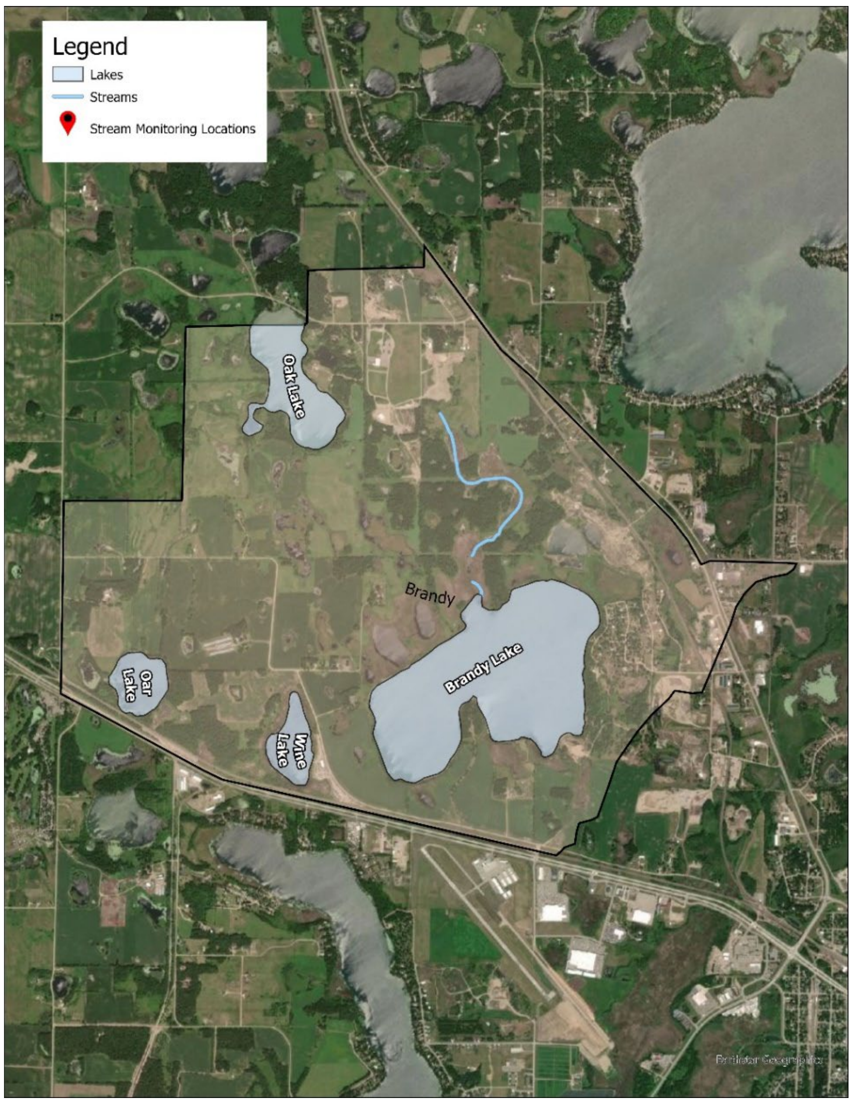


Figure 8.1 The Brandy Water Management Area.

8.1 Lakes

There are 4 lakes in the Brandy WMA, 3 of which are assessed by the District. Brandy Lake is improving from historical pollution from the Becker County Landfill, Wine Lake was found to be impaired from eutrophication and is being assessed for a TMDL, and Oak Lake was sampled for the first time in 2020.

8.1.1 Oak Lake

Oak Lake is an 86-acre, natural environment lake with a maximum depth of 16ft (Figure 8.1). The lake is boarded by United States Fish and Wildlife Service property on the Northwest and Southeast sides of the lake, with some private land ownership. Little is known about Oak Lake other than a vegetation survey performed by the MN DNR in 2018. The survey found plants only in area less than 8ft deep, indicating poor water clarity. A nearby landowner indicated water levels had increased in last 50 years, and livestock were previously kept in an area currently flooded, possibly causing internal loading.

8.1.2 Brandy Lake

Brandy Lake is a shallow lake located just northwest of the City of Detroit Lakes. The lake is listed as a priority shallow lake with the MN DNR. The lake consists of 100% littoral area with extensive macrophyte growth throughout the lake. Water quality has been increasing over the past 20 years, with a summer mean water clarity of 7.5 feet and 23ppb phosphorus concentration (2008-2017). The prior ten years (1998-2007) exhibited lower water quality with 5-foot water clarity and 44ppb phosphorus concentration. This increase in water quality is primarily attributed to Becker County landfill groundwater remediation. The remediation efforts reduce polycyclic aromatic hydrocarbons (PAHs) by aerated contaminated groundwater prior to discharge to Brandy Lake.

There are only two residential homes that currently access the lake; however, one area on the southeast portion has been platted but not yet developed. A second-tier residential development is located on the east portion of the lake, which does not have individual lake access, but does contain a commons area for lake use. This commons area is in a natural condition, except for one unpaved boat access.

8.1.2.1 Water Quality/ Quantity

Water Quality – Brandy Lake

Brandy Lake experienced an “average water quality year” in 2022. The TP averaged 40 µg/L, just under the historic average of 41 µg/L, Chl-a was 7.19 µg/L almost identical to the historic average of 7.95 µg/L and water clarity (secchi) average was 5 feet in comparison with the 20-year historic average of 5.3 feet.

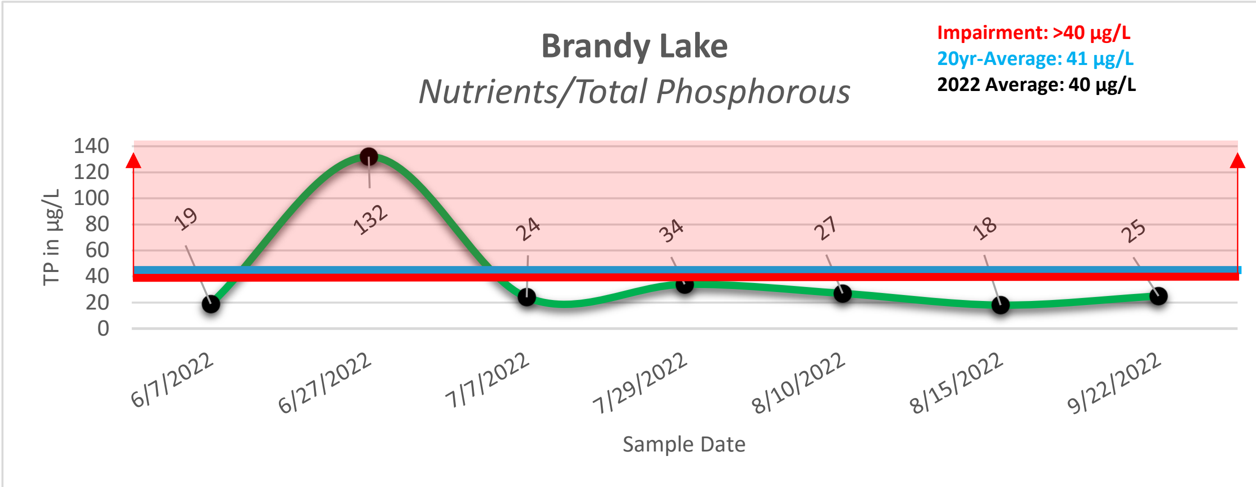


Figure 8.2 Brandy Lake 2022 Total Phosphorous.

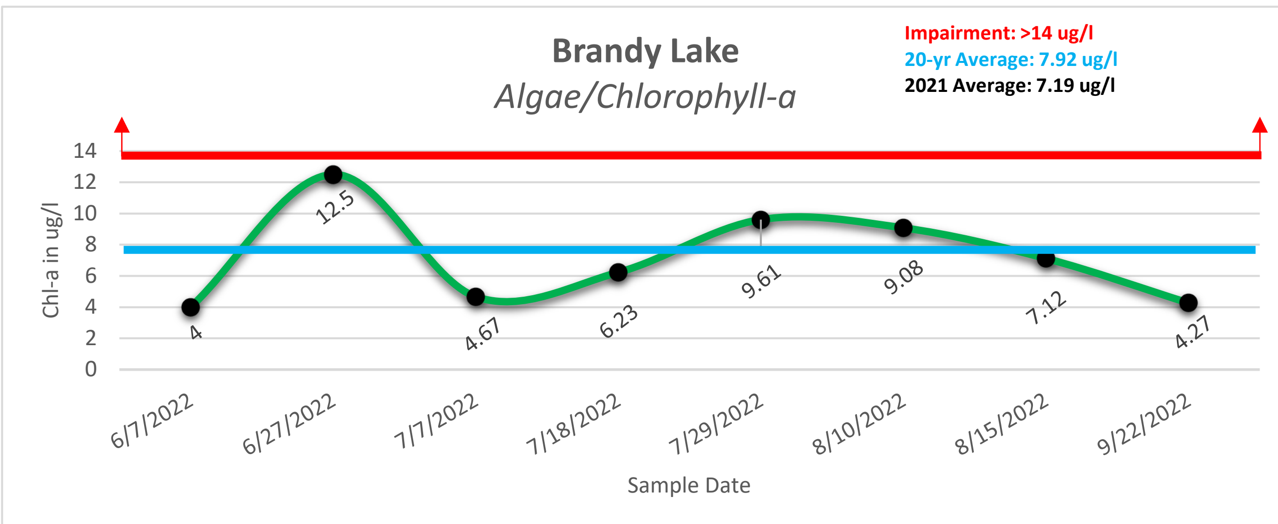


Figure 8.3 Lake Melissa 2022 Chlorophyll-a.

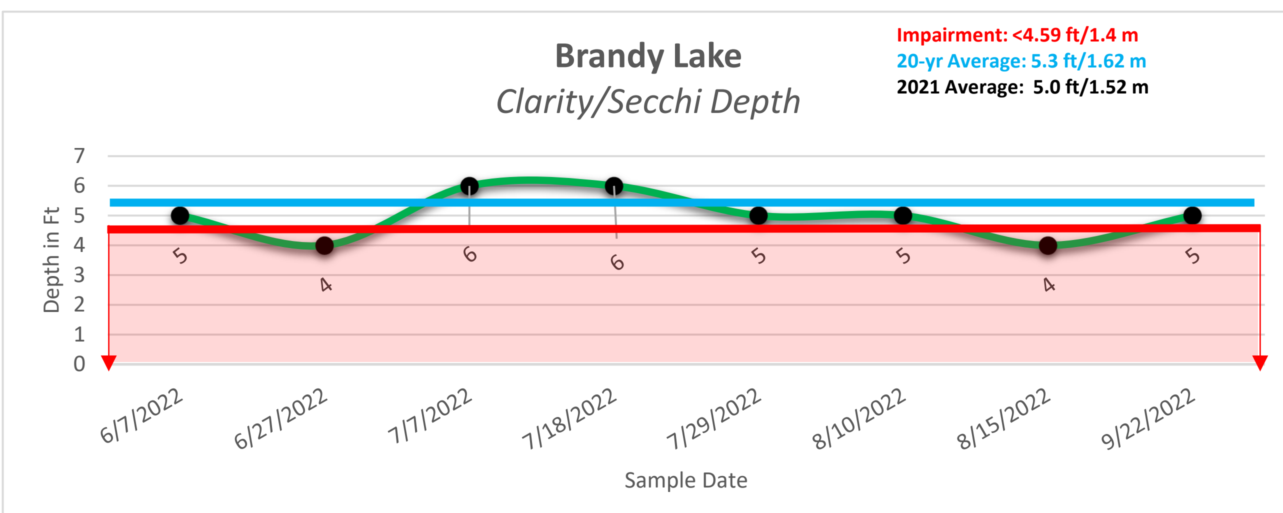


Figure 8.4 Brandy Lake 2022 Secchi Depth.

8.1.3 Wine Lake

Wine Lake is a small natural environment lake located just north of the City of Detroit Lakes. There is one commercial business located on the east shoreline that uses the lake for watercraft testing. Wine lake is listed as a nutrient impaired lake with average summer phosphorus levels of 87 μg/L and water clarity of 3 feet, which exceeds the shallow lake standard of 60 μg/L and 1 meter (3.28ft).

The lake was monitored for water quality for 3 years (2009-2011). The lake has no surface water inlet and is recharged by stormwater runoff and groundwater interaction. Wine Lake is a landlocked basin with no residential development, and therefore is low priority for water quality monitoring.

9 Long Water Management Area

The Long WMA is 2,384 acres and includes Long and Strunk Lakes. Strunk Lake, a small 24-acre basin, drains to Long Lake via a series of wetlands, but little is known about the lake itself. Long Lake is the main lake in this WMA, with 407 acres and 6 miles of shoreline. Most of Long Lake's water comes from groundwater sources, although there is some surface flow from its direct watershed and from wetlands near Strunk Lake. Long Lake eventually drains through a small outlet to St. Clair Lake.

Most of the land in the Long Lake WMA has been greatly altered. Gravel mining takes place in this WMA, and highways have impacted drainage patterns. Shoreline along Long Lake has also been greatly modified. The lake has had shoreline development for decades, but in the last 10 years, conversion of resort land to residential land has further increased shoreline development. There are some important areas of shoreline wetlands and emergent aquatic plants on Long Lake that need special protection from development, namely Long Lake's three aquatic management areas located on the west and north sides of the lake. Recreational pressure on the lake is also very high. Boat traffic and noise have sometimes emerged as issues, especially with the advent of wake surfing boats.

The water quality in Long Lake is very good. There is some evidence that clarity has decreased in recent years, but other eutrophication indicators are either unchanged (e.g., chlorophyll-a) or improved (e.g., total phosphorus). Residents have complained of shoreline erosion and other water quality issues resulting from boat traffic, but a 1997 District study could not detect the impact of boating on turbidity or phosphorus levels. However, wakeboard boats have been introduced since that time. Phosphorus loading from septic systems is not an issue because most areas along and near Long Lake's shores are served by sanitary sewer. Watershed nutrient loading is the largest threat to Long Lake's water quality at present. The watershed is becoming more impervious, native shoreline vegetation is being removed, drainage is being altered, etc., all of which promote nutrient runoff.

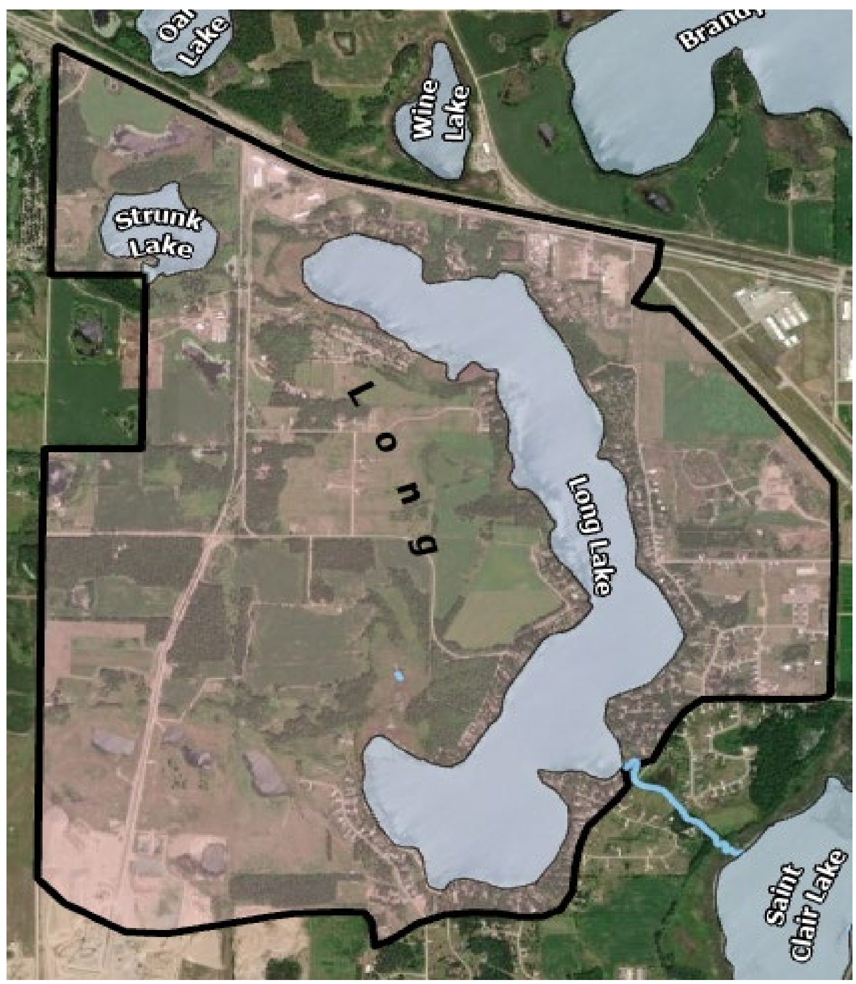


Figure 9.1. Long Water Management Area

9.1 Lakes

9.1.1 Long Lake

Long Lake is a 408-acre recreational development lake located at the head of its watershed area, with no surface water inputs, such as a river or a stream. Long Lake is fed primarily by stormwater runoff and groundwater interactions. It is a narrow, deep lake, with a maximum depth of 61 feet and with 37% of the lake surface area classified as littoral. Though a small lake relative to others which attract a large clientele, its elongated shape gives it a shoreline length that is exceeded in the District only by Big Detroit and Melissa.

Long Lake has good water quality with annual phosphorus levels ranging from 11 µg/L to 16 µg/L, and water clarity between 12 and 19 feet. 10-year summer mean for phosphorus and clarity is 12 µg/L and 4.5 feet, respectively.

Long Lake is known for its abundance of Northern Pike and Bluegill. The 2016 assessment showed Pike catches were higher than average and higher than other ecologically similar lakes. While there are no special regulations for Long Lake, anglers are encouraged to release Northern Pike over 24 inches. Since 2001, a Walleye stocking research study has been underway to attempt to determine the best stocking method for a given lake type, despite the efforts, Walleye abundance has continued to decline.

Long Lake outlets via Joy Creek to St. Clair Lake, a lake impaired for excessive nutrients.

Long is a deep lake, with nearly 37% (11,690 feet) of the shoreline sloping steeply toward the lake. The natural shoreline has been greatly modified, including installation of riprap, sand blankets, and vegetation removal. Of the 183 parcels surveyed in 2010, 30 contained a retaining wall within the shore impact zone. 96 parcels (52%) were recorded as having moderately to greatly altered shorelines, including 83 with rip-rap shorelines and 60 with beach sand blankets. 87 parcels (47%) of the parcels remained in a natural or minimally altered condition.

The City of Detroit Lakes annexation of Long Lake has provided water and sewer to the east and south sides of the lake with services on the north completed in 2019. It is still unknown when City utilities will be connected on the west side of the lake. It is likely that improved water quality will continue to be observed with the transition from individual lot septic system to City sanitary sewers.

In the past 20 years, several resorts have been converted to large residential lots and all have been connected to City water and sewer. One RV campground still exists on the northwest side of the lake, and it is likely that it too will be subdivided. The City of Detroit Lakes owns Long Lake Park which contains over 2,200 feet of shoreline, located on the east side of the lake that, except for the public access, will remain in its natural condition. Along the west side of the lake, another parcel, owned by Concordia College, will also remain in an unaltered condition that will protect over 2000 feet of shoreline.

There is an active gravel mine in the southern portion of the Long Lake watershed. In recent year, there has been interest by the company to expand to the north and west, closer to the lake. In 2018, Becker County denied a conditional use permit request to expand the mine, including gravel extraction below the water table.

In 2003, a water control structure was installed on a wetland outlet on the north side of the lake, allowing the wetland to serve as a water detention area significantly reducing nutrient loading from the wetland. This project drastically reduced localized nuisance algal blooms on the north side of the Lake and caused an increase in mean summer water clarity by nearly 2 feet.

9.1.1.1 Water Quality/ Quantity

Water Quality – Long Lake

In 2022, Long Lake had a better than average year for water quality. Total Phosphorus (TP) average for 2022 was 9 µg/L which was an improvement from the 20-year average of 14 µg/L. CHL-A (algae) was 2.89 µg/L with a 20-year average of 4.05 µg/L and water clarity (secchi depths) averaged 17.8 feet, 3.7 feet better than the 20-year average of 14.1 feet.

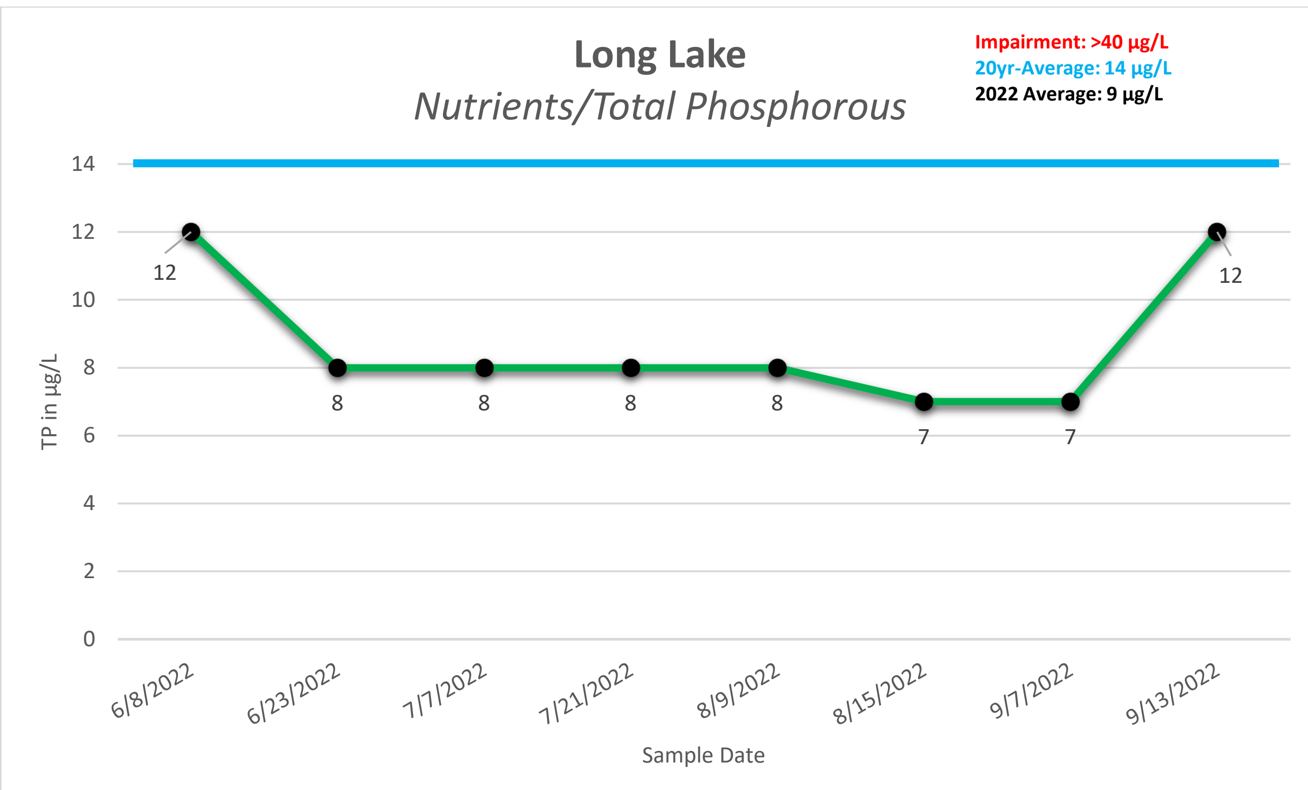


Figure 9.2. Long Lake 2022 total phosphorous

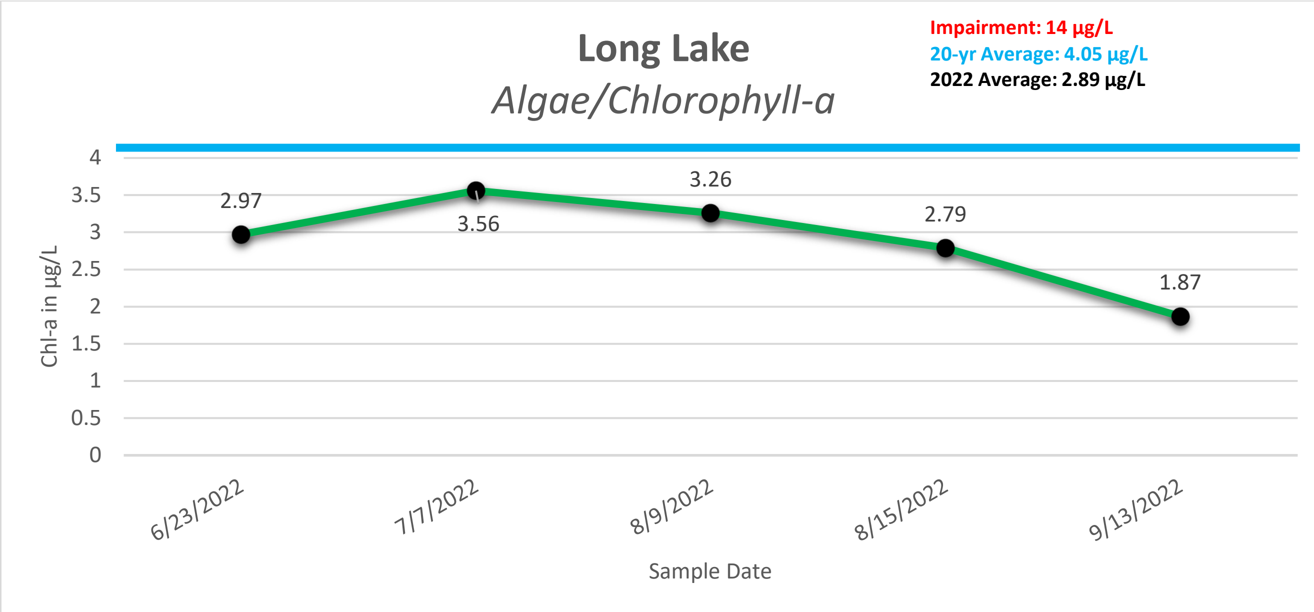


Figure 9.3. Long Lake 2022 chlorophyll-a

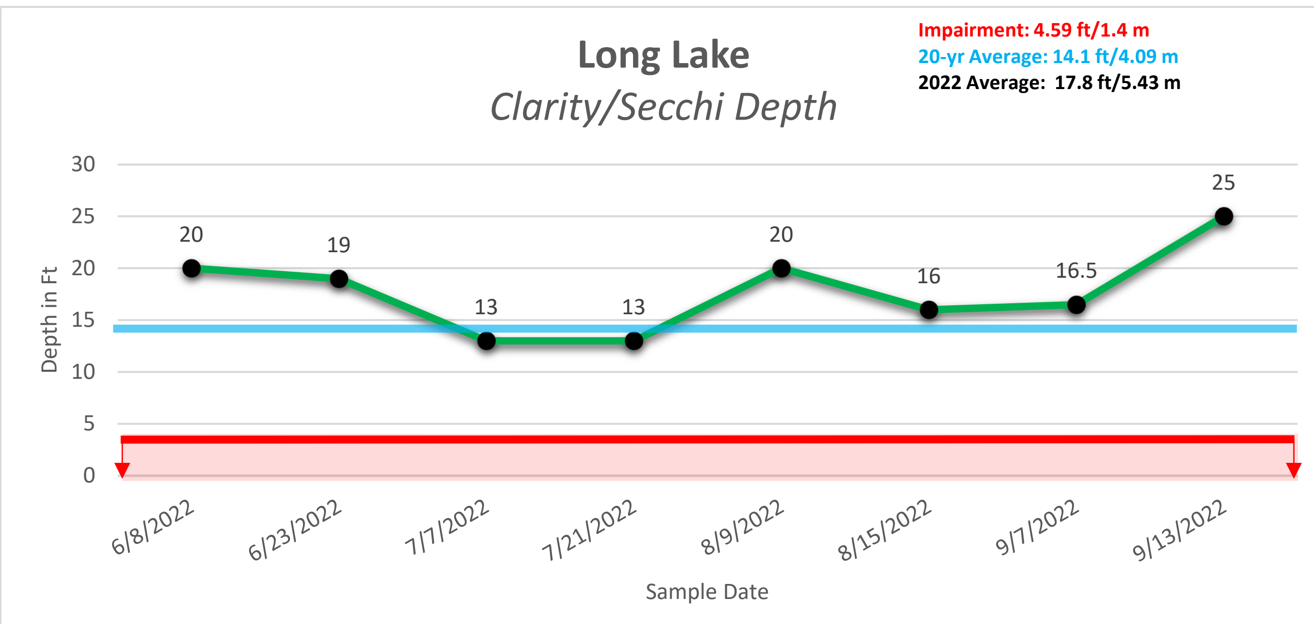


Figure 9.4 Long Lake 2022 secchi depth

10 Pearl/Loon Water Management Area

The Pearl/Loon WMA is about 5,400 acres on the Western edge of the District (Figure 9.1). All these lakes are relatively small and shallow waterbodies in the western edge of the District, and all depend primarily upon groundwater. Most land in this WMA is used for agricultural purposes. Water quality data has only been collected for Pearl and Loon Lakes. The District began to collect water quality data on Pearl Lake in 1998. Pearl exhibits relatively clear conditions, but phosphorus and chlorophyll-a levels are much higher than would be expected, given the lake's clarity. An MPCA Clean Water Partnership diagnostic study was completed on Pearl Lake in 2012 which noted large annual fluctuations in water quality and water level, concluding the primary sources of nutrients is lake sediments, agricultural runoff, and shoreline alteration. Curly-leaf pondweed has also spread throughout Pearl Lake since 2010 when it was discovered. Loon Lake was sampled 2006 to 2008 and demonstrated good water quality for a shallow lake. No data has been collected on any of the other smaller lakes.

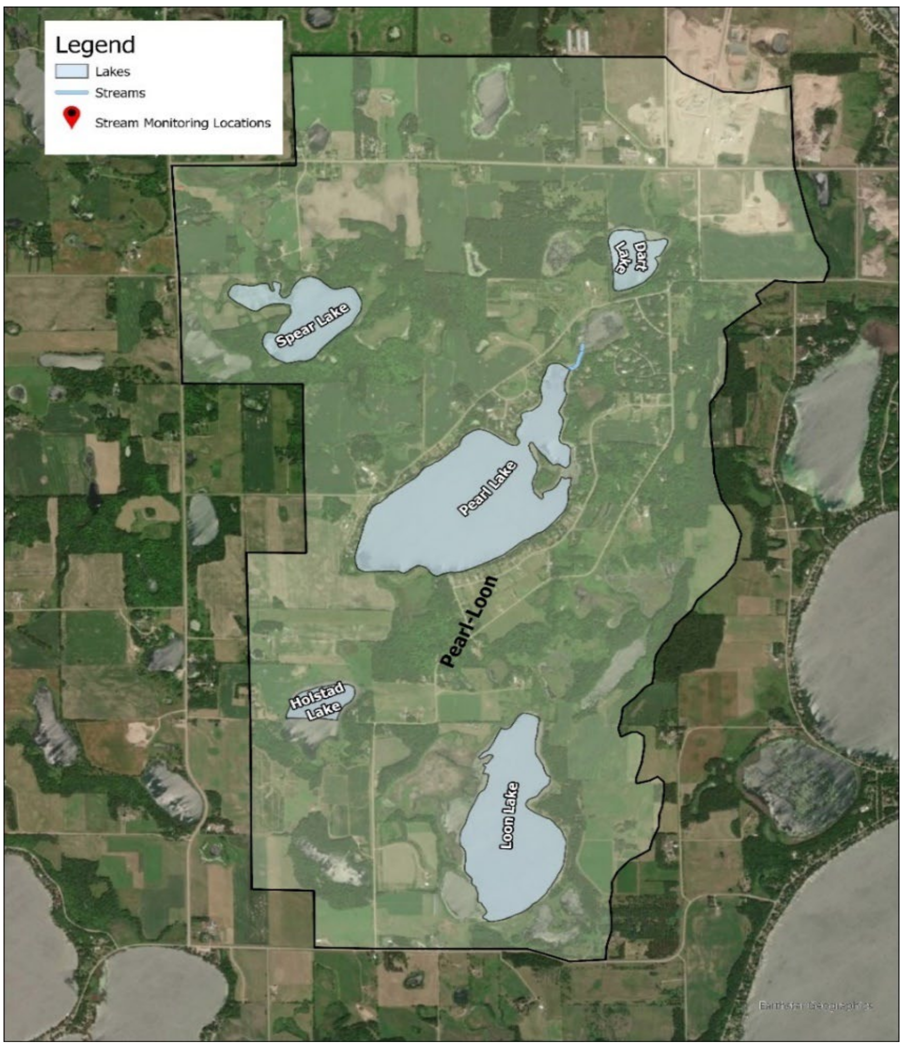


Figure 10.1. The Pearl/Loon Water Management Area.

10.1 Lakes

This WMA contains Pearl and Loon Lakes as well as several smaller lakes called Spear, Rider, Holstad, and Dart.

10.1.1 Pearl Lake

Pearl Lake is a 281-acre recreational development lake located along the western edge of the Pelican River Watershed District boundary. It has a littoral area (<15feet) accounting for 60% (168 acres) of its surface area. The drainage area of Pearl Lake includes several other small lakes and wetlands including Little Pearl, Dart, Bijou, and Holstad Lakes. Other than the lakes within its drainage area, Pearl is poorly connected to any downstream lake or other lakes within the watershed. Historically, Pearl Lake experiences large fluctuations in water levels, with a recorded range of 3.4 feet. A well-defined outlet was constructed in the southwest corner of the lake and maintains water levels at a more constant elevation.

The MN DNR maintains an asphalt public boat access ramp along the southern shoreline, allowing both public and private use of the lake. Curly leaf pondweed was first observed in a 0.20-acre area in 2010. A permit to chemically treat the plant was applied for but was denied by the MN DNR. By 2011, populations were widespread and now are found in all portions of the lake.

Residential development has substantially increased in the past 20 years. In 1983, there were only two riparian residences. By 2003, that number grew to 32, and by 2013, there were a total of 57 riparian residences. The remaining undeveloped riparian properties are not suitable for development due to wetlands and poor drainage.

Water quality exhibits large year-to-year fluctuations with a 10-year average of 28 μg/L phosphorus and clarity of 9.5 feet. A diagnostic study of Pearl Lake was completed in 2012, which determined that the primary source of in-lake phosphorus was from internal loading from nutrient rich sediments. The lake stratifies strongly between 4-6 meters and develops anoxia in the lower layer, further increasing release of phosphorus from lake bottom sediments into the lower water layer.

There is cultivated cropland on both the east and west sides of the lake that drain via private ditch to Pearl Lake. Study work from 2010 and 2011 show that during dry periods, there is very limited input from those sources to the lake, but during wet periods, a significant amount of sediment loads are observed. Due to the flashy nature of the monitoring locations, annual loads from those sources could not be determined.

10.1.2 Loon Lake

Loon Lake is a shallow 264-acre natural environment lake with little residential development. There are 2 single family homes on the west side of the lake, and one cattle pasture on the south shore. It is apparent the pasture extends to the shoreline and is potentially used as a water source which may be a significant source of nutrients. There is a prominent wetland fringe along the western and northern shoreline. Loon is a landlocked lake, meaning there is no surface water inlet or outlet, and is disconnected from all surface watercourses. Wild rice exists but is very sparse around much of the northern half of the lake. About 65% of the lake has an excellent cattail and bulrush fringe, mainly on the west shore. The deepest known point on the lake is 11’. Detroit Lakes MN DNR Fisheries had used the lake as a rearing pond for many years.

10.1.3 Spear Lake

Spear Lake is 71-acre natural environment lake on the Western boundary of the District. Not much is known about the lake due to its small size and lack of surface connection to other District waters. The shoreline is undeveloped except 1 parcel on the North end of the lake. The rest of the lake has a healthy natural buffer around the shoreline. No public accesses are present on the lake. The District will assess the health of the lake as part of the 2020-2030 Monitoring Plan.

10.1.4 Dart Lake

Dart Lake is a relatively small and shallow waterbody approximately 28.5 acres in size and a maximum depth of 5feet. It is located in a 3,534-acre sub-watershed 5miles Southwest of Detroit Lakes in the western edge of the Pelican River Watershed District and depends primarily on groundwater. Dart Lake was part of a diagnostic study conducted by the MPCA and PRWD in 2012.

11 Small Lakes Water Management Area

The Small Lakes WMA consists of about 11,000 acres in the southeastern corner of the District (Figure 11.1). This WMA extends into Ottertail County and contains numerous small lakes and wetland areas. Many of the lakes are connected by means of wetlands, and the overall drainage of the area is indistinct. Land use in this WMA can be roughly divided into the northwest half and the southeast half. The northwest half of the WMA contains significant agricultural areas, as well as most of the lakes and wetlands in the WMA. The southeast half of the WMA is mostly forested with steep slopes. Less than 2 percent of the WMA is covered by impervious surface. The shorelines of the lakes in this WMA are sparsely settled but have recently seen more development interest, Johnson and Reeves Lakes in particular. Water quality data has been collected for Abbey, Meadow, Johnson, Reeves, Lind, and Glawe. Lind drains into Melissa Lake in the Sallie-Melissa WMA, making it the last lake in the WMA.

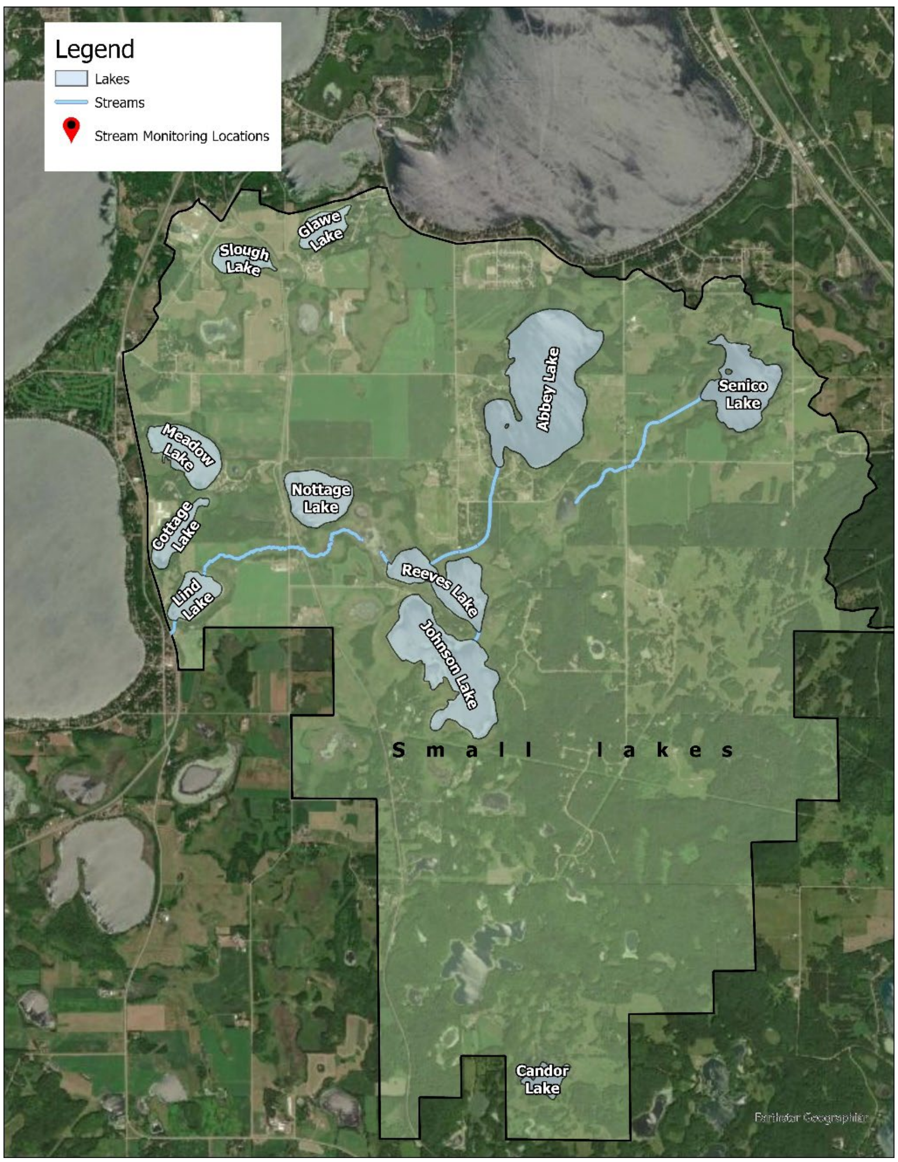


Figure 11.1 The Small Lakes Water Management Area.

11.1 Lakes

There are multiple lakes in the Small Lakes WMA, hence the name. The District monitors 6 of the 11 in the 10-year monitoring plan. In 2022, the District conducted a vegetation survey on Meadow Lake and a shoreline survey on Lind Lakes. In 2023, the District will conduct water quality sampling on Lind Lake.

11.1.1 Glawe Lake

Glawe is a small natural environment lake totaling about 40 acres and reaching a depth of 20 feet. It is separated from Curfman Lake by a 250-foot-wide land bridge along its northern shoreline. Water quality on Lake Glawe has remained stable and the lake is classified as mesotrophic. Development around the lake has increased in recent years with the construction of the Golden Bay Shores development along the NE shoreline. Stormwater from the development is treated via stormwater ponds on the north side of the lake prior to discharge to Glawe. A new single family residential development is also under construction on the east side of the lake. Shoreline vegetation removal from residential home construction should be minimized to avoid negative impacts to these small, sensitive lakes.

In addition to the residential development, there is a commercial campground located along the southern shoreline. The majority of the campground sites are outside of the drainage area but do allow lake access for clients for non-motorized lake use. Currently there is no watercraft access and there is no motorized boat use.

11.1.2 Meadow Lake

Meadow is a 71-acre natural environment lake located approximately 4.5-miles SW of the City of Detroit Lakes. Despite its relatively small size, the lake is quite deep, reaching a maximum depth of 72 feet. Meadow has no surface water inlet and is recharged primarily by groundwater interaction and some surface water runoff. There is no true outlet to the lake, however, there is a culvert below HWY 59 that connects Meadow to a wetland and another culvert below CSAH 17 that connects the wetland to Lake Melissa.

Attempts were made by the MN DNR between 1987 through 2009 to regularly stock Rainbow (*Oncorhynchus mykiss)* and Brown Trout (*Salmo trutta*) with limited success. The MN DNR began stocking walleye in 2010, however, further study found that the lake best supports largemouth bass (*Micropterus salmoides*), bluegill, (*Lepomis spp.* crappie (*Pomoxis nigromaculatus*), and northern pike (*Esox Lucius)* population, so stocking efforts ceased. There is a small trout population remaining.

There are three residential homes on the western shoreline and a campground located on the Southeast portion. There is some agricultural (row crop) activity to the North of the lake that is separated from the lake by a forested buffer, 150-300 feet wide. Emergent vegetation is present along most of the shoreline except for about 1000 feet near the campground, which may have been removed for the installation of a sand beach and docking area. There is moderate macrophyte growth in the littoral area of the lake (<15 ft). Lake depths begin to drop sharply about 150-250’ offshore, where plant growth becomes much more limited.

11.1.2.1 Ecological Integrity

Vegetation Survey – Meadow Lake

The first vegetation point-intercept survey of Meadow Lake (EQuIS# 03-0358-00-201 conducted by the PRWD occurred on August 10th, 2022. Plants were rooted to a maximum depth (95%) of 15.1 feet, with depths ranging from 0 – 72 feet. However, since 86 acres is considered the littoral zone (< 15 feet deep and where aquatic plants are likely to be found) it was very rare to find any rooted plants deeper than 15 feet. 84% of the points had submersed native vegetation (Table 11.1) with a mean submersed native taxa per point of 2.6. Meadow Lake has up to 4 submersed native taxa.

*Table 11.1 - Point-intercept Metrics**.** Summary of PRWD point-intercepts Meadow Lake, Becker County (EQuIS# 03-0371-00-201). Shaded values were calculated from littoral depth range (0-15 feet).*

Metric	**August 2022**
Surveyor	PRWD
Total # Points Sampled	45
Max depth of growth	15
Depth Range of Rooted Veg (ft.)	0.0 – 15.0
Max Depth of Growth (95%) (ft.)	15
# Of Vegetated Points in Max Depth Range	45
# Points in Littoral (0-15 feet)	45
% Points w/ Submersed Native Taxa	84
Mean Submersed Native Taxa/ Point	2.6
# Submersed Native Taxa	4
# Submersed Non-Native Taxa	0
% Points w/ Submersed Non- native Taxa	0

Based on the 2022 point-intercept survey, the native plant community within the littoral area in Meadow Lake was primarily dominated by Common Stonewort (*Chara Contraria*) 80%, Coontail (*Ceratophyllum demersum*) 7%, Sago Pondweed (*Stuckenia pectinate*) 5%, and White-stem Pondweed (*Potamogeton praelongus)* 2%. These aquatic plants are central to a healthy fish population, offering shelter and providing food and habitat to wildlife. Meadow Lake also has the following floating leaf and emergents: Bulrush (*Schoenoplectus* sp.) 27%, Cattail (*Typha sp.*) 20%, Water Lilies (*Nymphaeaceae spp.) 32%.* These emergent plants are especially good at preventing shoreline erosion, habitat and providing food sources for waterfowl. Plants also absorb nutrients and reduce algae, thereby improving water quality.

Meadow Lake has an average of four species per sampling site. Figure 11.2 displays the spatial distribution and species richness (# of species per sample point) of all native species from the 2022 point-intercept survey.

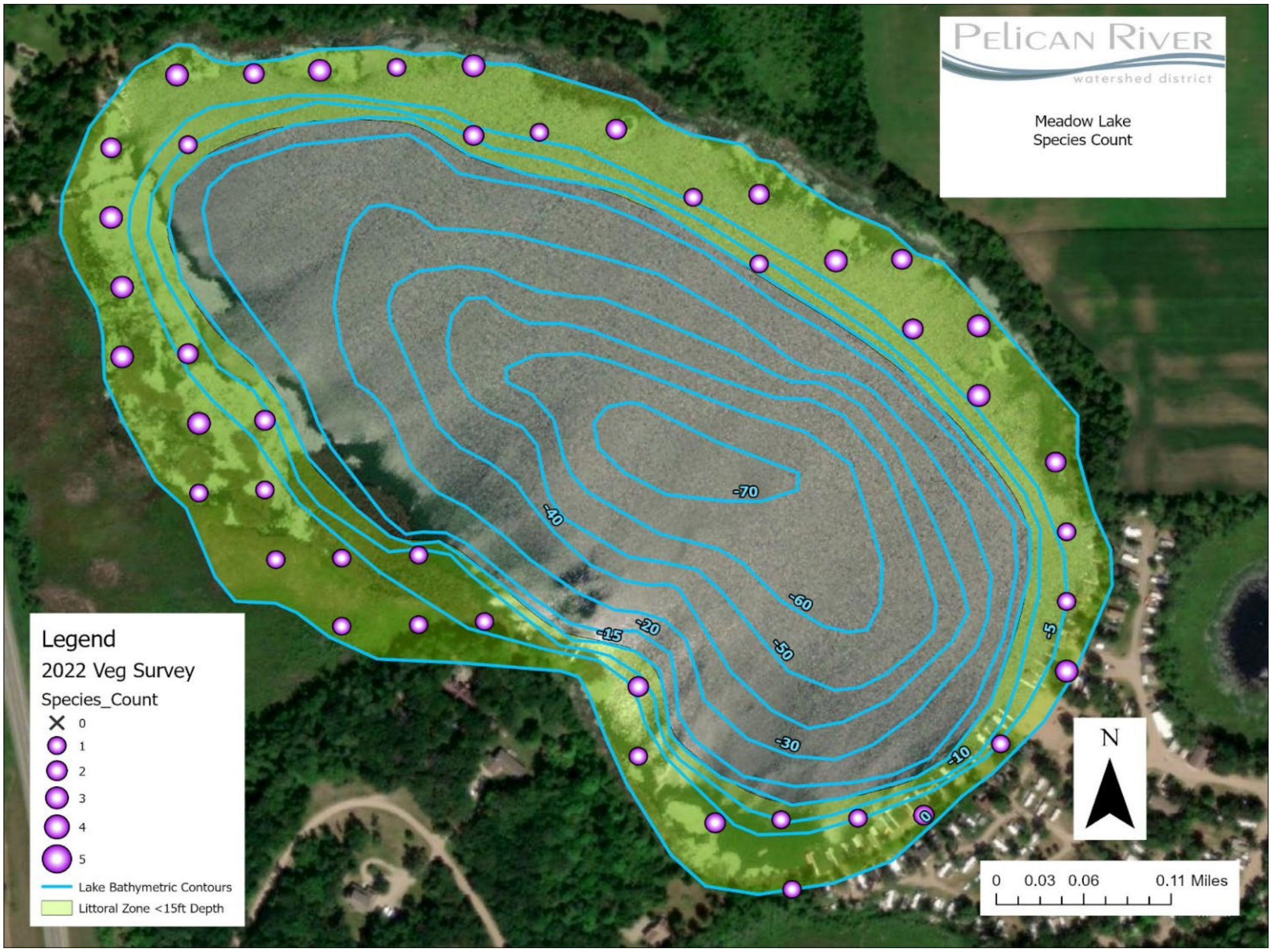


Figure 11.2 Species Richness Distribution. Number of species at each site from the 2022 point-intercept survey in Meadow Lake, Becker County (EQuIS# 03-0371-00-201). Densities ranged from 0 to 5 at each point, with a 5 indicating the richness in species presence and 0 indicating no species.

Table 11.2 Results from 2022 Meadow Lake vegetation survey.

Meadow Lake 2022 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	2.33	3	7%
Chara Contraria	Common Stonewort	3.03	35	80%
Schoenoplectus spp.	Bulrush	2.17	12	27%
Nymphaeaceae spp.	Water Lilies	2.50	14	32%
Typha latifolia & angustifolia	Cattail	2.89	9	20%
Potamogeton praelongus	White-stem Pondweed	2.00	1	2%
Stuckenia pectinata	Sago Pondweed	1.00	2	5%
Empty Points	-	-	0	0%
Total Points	-	-	44	100%

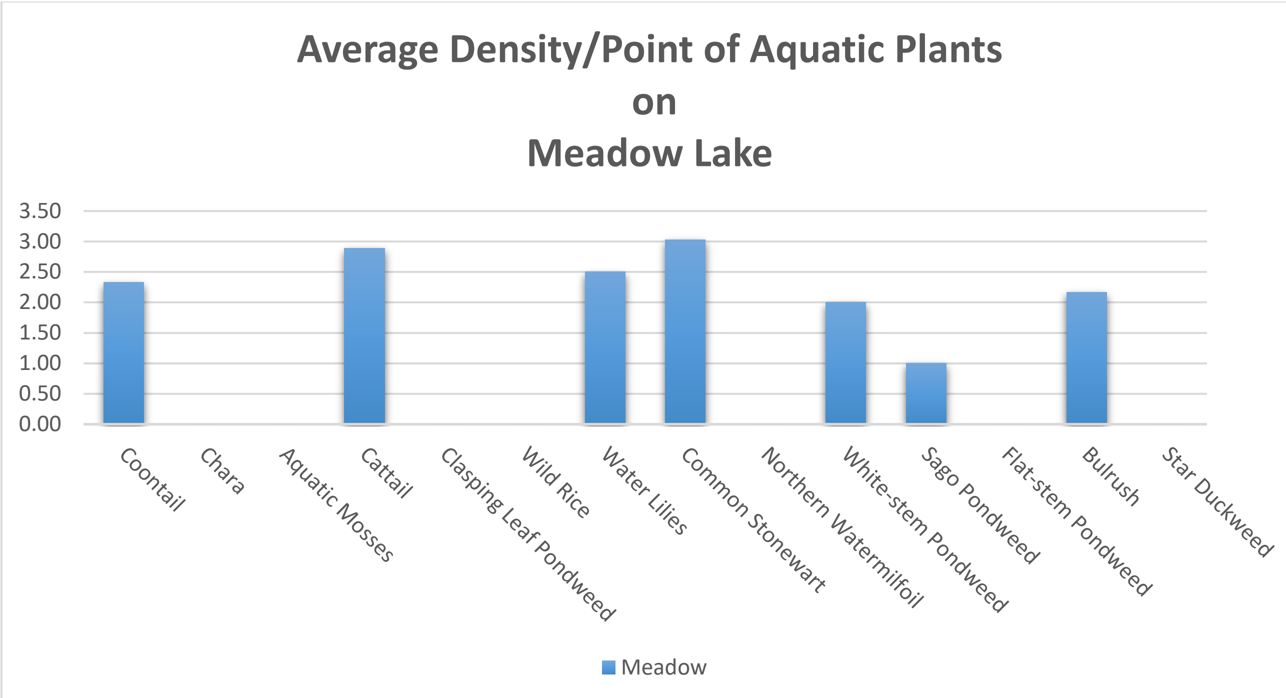


Figure 11.3 2022 Meadow Lake density of aquatic plants.

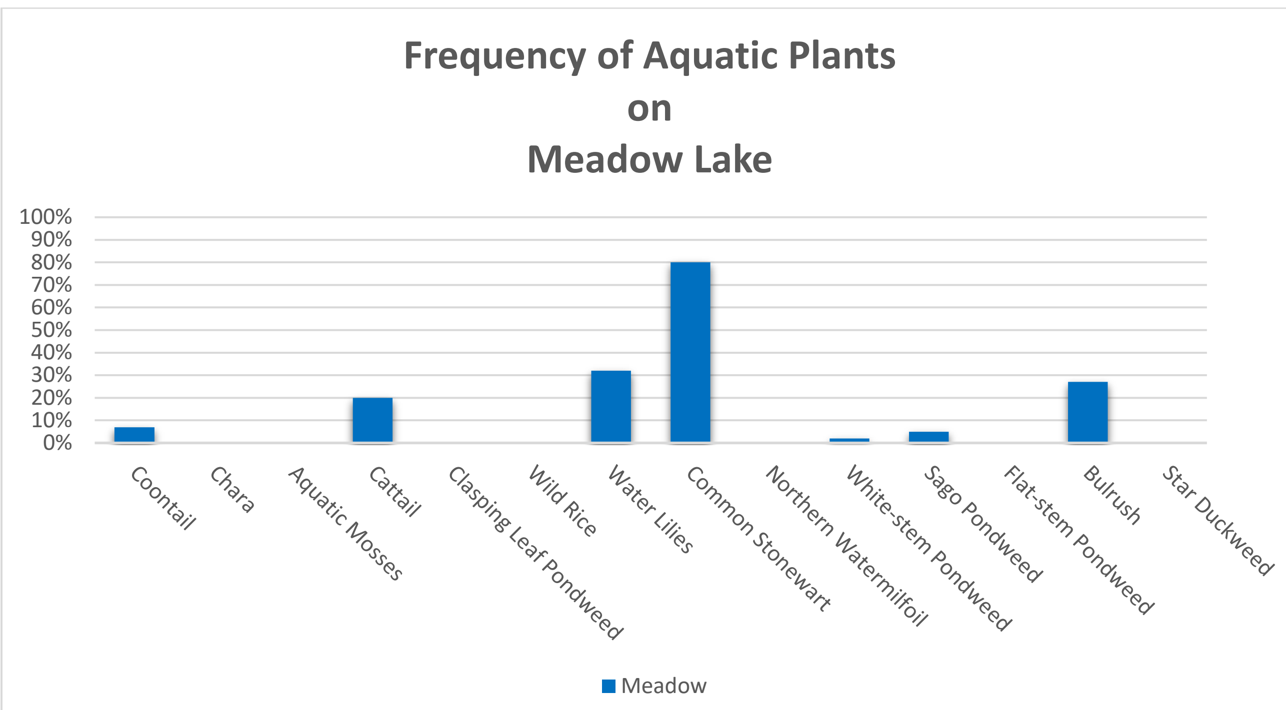


Figure 11.4 2022 Meadow Lake frequency of aquatic plants.

11.1.3 Johnson Lake

Johnson Lake is a moderately developed, natural environment lake located south of the City of Detroit Lakes. Johnson lake is connected to Reeves Lake via a small natural channel on the Northeast shore of the lake. A prominent wetland fringe surrounds the lake, uprooted portions of wetland vegetation often detach and move around the lakes by wind and water currents. The channel between the two lakes sometimes becomes blocked by floating bogs, making watercraft passage between the two impossible. Johnson lake lies to the south of Reeves, totaling 219.6 acres in size and reaching a depth of 30 feet.

The primary source of surface water input to the lake is stormwater runoff from the large drainage area of 4,576 acres. Johnson Lake outlets to Reeves Lake to the North. Groundwater interactions also play a role in the water budget.

Residential development is located on the peninsula which extends between the two lakes from the west. There is also a small campground located on that peninsula, which contains the only boat access to the lake (private access). Due to the extensive wetland fringe on the lake, only a few locations allow lake access from riparian properties. In some locations where the wetland fringe is not as prominent, access to the lake has been obtained by removing portions of the wetland vegetation.

11.1.4 Cottage Lake

Cottage Lake is a small 30-acre, shallow land-locked, hardwater lake. 29 of its acres are considered in the littoral area and the maximum depth is 18 feet. The land surrounding the lake is mostly wooded and is used for pasture. Shoreline soils consist largely of sand. It is within a 3,509-acres sub-watershed.

11.1.5 Reeves Lake

Reeves Lake is a 146.6-acre, natural environment lake with a max depth of 43 feet. The lake sits north and south relative to Johnson Lake and is connected via a natural channel on its east side. Johnson and Reeves have similar littoral areas that are 63% and 61% of the lake surface area, respectively.

Water quality has remained stable over the last 20-year period with average clarity of 10 ft on Reeves Lake. Total phosphorus levels are also stable on the lake, averaging 26 µg/L and 27 µg/L. Reeves lake is considered mesotrophic with moderately clear water. The lake does stratify in the summer months, developing an anoxic layer below 4-5 meters (13-16 feet).

The primary source of surface water input to the lake is stormwater runoff from the large drainage area of 4,576 acres. There is a small amount of water that travels via wetland stream from Abbey Lake to the north into Reeves. Reeves also outlets via a wetland stream to Nottage Lake.

11.1.6 Abbey Lake

Abbey Lake is a 269-acre shallow, natural environment lake with a maximum depth of 7 feet and is listed as a priority shallow lake with the MN DNR. The entire lake is considered littoral with significant macrophyte growth throughout the lake. Abbey is considered mildly eutrophic with significant late season algal blooms and supports only warm fisheries. The lake's watershed has no surface water inlets and drains out of the wetland on the south shore of the lake and into Reeves Lake. The contributing watershed has a total area of 772 acres. There is heavy residential development on the southwest portion of the lake with limited development elsewhere.

11.1.7 Lind Lake

Lind and Nottage Lakes are both small natural environment lakes located in the drainage area between Johnson/Reeves Lake and Lake Melissa.

Lind Lake is located in the southern portion of the drainage area. Water flows into the north side of the lake via a wetland stream from Reeves Lake. A small stream exits the lake to the south and flows to Lake Melissa. Lind is deep for its size, reaching a depth of 51 feet in the northern portion of the lake. There are currently four single family residential homes along the western shoreline and one commercial business on the south shore. Heavy agricultural use is present, including cattle grazing within 150 feet of the lake, and using the input stream as a water source.

In 2015, water quality monitoring began in Lind to obtain baseline data and investigate nutrient loads to Melissa. The proximity of cattle to the lake and stream raised concerns about nutrients loads. Results from monitoring showed in-lake mean summer nutrient levels at 42 μg/L, putting the lake in the mildly eutrophic category. Interestingly, phosphorus levels were at their highest in the spring and declined in the summer. Water clarity also increased in the summer as the lake stratified. Anoxia developed below 3 meters in June and remained throughout the year. Internal phosphorus loading is a major factor with bottom orthophosphate concentration approaching 1300 pounds per minute in September. Monitoring of nutrient load from Lind to Melissa was minimal due to low stream flow.

11.1.7.1 Ecological Integrity

Shoreline Survey – Lind Lake, 8 Parcels

Photos were taken of all 8 parcels during mid-July of 2022.

12 Munson/Fox Water Management Area

The Munson-Fox WMA contains about 1,350 acres (Figure 12.1). The only lakes in this WMA are Munson and Fox Lakes. Both are small lakes, at 129 and 138 acres, respectively, but both are also elongated, giving them good amounts of shoreline. Both lakes are fed by groundwater and have adjacent wetlands and some shoreline runoff, but neither has a significant inlet stream. Both lakes have small outlets. Munson and Fox lakes have relatively small watersheds. Land within these watersheds is a little more than 25 percent forested, 23 percent water, 50 percent cultivated, grassland or pastureland, and less than 2 percent impervious surface. Some major gravel mining operations are found in the area.

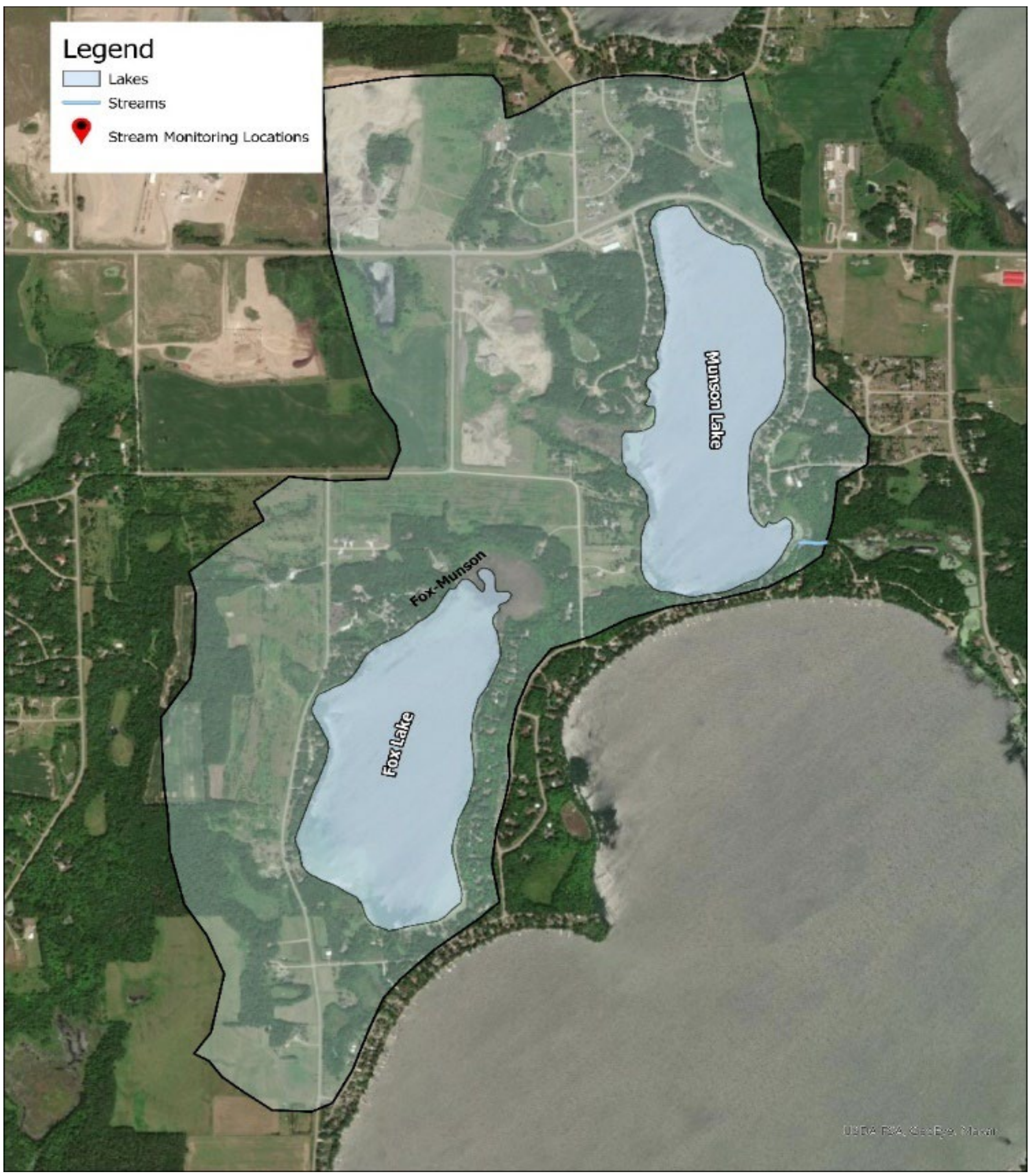


Figure 12.1 – The Munson/Fox Water Management Area.

12.1 Lakes

There are 2 lakes in the Munson/Fox WMA, Munson Lake, and Fox Lake. The District monitors water quality, shoreline development, and aquatic vegetation on these two lakes in accordance with the 2020-2030 Water Monitoring Plan.

12.1.1. Munson Lake

Munson lake is recreational development lake with a heavily developed shoreline, located just southeast of the City of Detroit Lakes, between Long Lake and Lake Sallie. Munson Lake has a littoral area of approximately 48 acres (36% of lake surface area). There are no surface water inlets, and the lake receives water primarily from stormwater runoff and groundwater interaction. Water flows from the lake on the southeast corner through a series of historic MN DNR fisheries rearing ponds to Lake Sallie. A MN DNR public access constructed of gravel is located near the outlet.

The shoreline topography is predominantly steep slopes with bluffs draining toward the lake. During early development of these areas, wood retaining walls were used to alter the slope topography to allow building construction closer to the lake. In many locations, the wood walls have begun to fail and need to be removed and the slope stabilized with vegetation. In some cases, when removal is not feasible, the walls must be properly replaced. The shoreline survey conducted in 2017, revealed 23 parcels containing retaining walls.

Munson is classified as a mesotrophic lake with good water quality that supports a healthy fishery and allows many types of recreational uses. Munson is dimictic, mixing in the spring and in the fall, remaining well mixed in the upper 5-6 meters (16.5-19.5 feet). Water quality on Munson has been stable for the last 10 years with the exception of total phosphorus level, which showed a 20% improvement from the previous ten-year period (1998-2007). Water clarity averages are nearly 11 feet with total phosphorus levels of 18 μg/L.

Because of Munson's elongated shape, it has a higher shoreline length to lake area ratio. This allows more residential development and increases developmental pressure than a lake similar to its size with a round shape. Developmental pressure was apparent during a survey of shoreline alteration where 52% of the parcels were found to be greatly or moderately altered. Only 24% of the parcels were in a natural condition.

Two gravel mining operations are located in the western portion of the drainage area.

12.1.2 Fox Lake

Fox lake is a small, heavily developed lake totaling 143 acres and reaching a depth of 24 feet. Approximately 60% (86 acres) of the lake is considered littoral and less than 15 feet. There is no surface water inlet, and the lake receives water primarily from stormwater runoff and groundwater interactions. There is one outlet to the lake which flows south through a wetland to Lake Sallie.

The majority of residential lake development occurred between the 1960s and 1990 where the number of homes more than doubled from 24 to 55. The MN DNR owns a 3 acres tract of land that contains approximately 1300 feet of shoreline on the north side of the lake that remains protected.

Prior to 2004, a 40-acre parcel just north of the lake was used for ag purposes with turkey manure being applied to the land periodically. The lake showed signs of degradation with nuisance algal bloom and poor water clarity. The turkey manure application ceased in 2004. The lake responded with drastic and immediate increases in water clarity and reductions of in-lake phosphorus levels.

12.1.2.1 Ecological Integrity

Vegetation Survey – Fox Lake

The first vegetation point-intercept survey of Fox Lake (EQuIS# 03-0358-00-201) conducted by the PRWD occurred on August 11th, 2022. Plants were rooted to a maximum depth (95%) of 15.1 feet, with depths ranging from 0 – 24 feet. However, since 86 acres is considered the littoral zone (< 15 feet deep and where aquatic plants are likely to be found) it was very rare to find any rooted plants deeper than 15 feet. 69% of the points had submersed native vegetation (Table 12.1) with a mean submersed native taxa per point of 2.1. Fox Lake has up to 4 submersed native taxa (Table 12.2).

Table 12.1 - Point-intercept Metrics. Summary of PRWD point-intercepts Fox Lake, Becker County (EQuIS# 03-0358-00-201). Shaded values were calculated from littoral depth range (0-15 feet).

Metric	August 2022
Surveyor	PRWD
Total # Points Sampled	153
Max depth of growth	15
Depth Range of Rooted Veg (ft.)	0.0 – 15.0
Max Depth of Growth (95%) (ft.)	15
# of Vegetated Points in Max Depth Range	132
# Points in Littoral (0-15 feet)	153
% Points w/ Submersed Native Taxa	69
Mean Submersed Native Taxa/ Point	2.1
# Submersed Native Taxa	4
# Submersed Non-Native Taxa	0
% Points w/ Submersed Non- native Taxa	0

Based on the 2022 point-intercept survey, the native plant community within the littoral area in Fox Lake was primarily dominated by Chara (*Chara sp*.) 65%, Coontail (*Ceratophyllum demersum*) 17%, Sago Pondweed (*Stuckenia pectinate*) 7%, and Clasping-leaf Pondweed (*Potamogeton richardsonii)*. These aquatic plants are central to a healthy fish population, offering shelter and providing food and habitat to wildlife. Fox Lake also has the following emergents: Cattail (*Typha sp.*) 17%, Bulrush (*Schoenoplectus* sp.) 9% and Wild Rice (*Zizania palustris).* These emergent plants are especially good at preventing shoreline erosion, habitat and providing food sources for waterfowl. Plants also absorb nutrients and reduce algae, thereby improving water quality.

Fox Lake has an average of three species per sampling site. Figure 2 displays the spatial distribution and species richness (# of species per sample point) of all native species from the 2022 point-intercept survey.

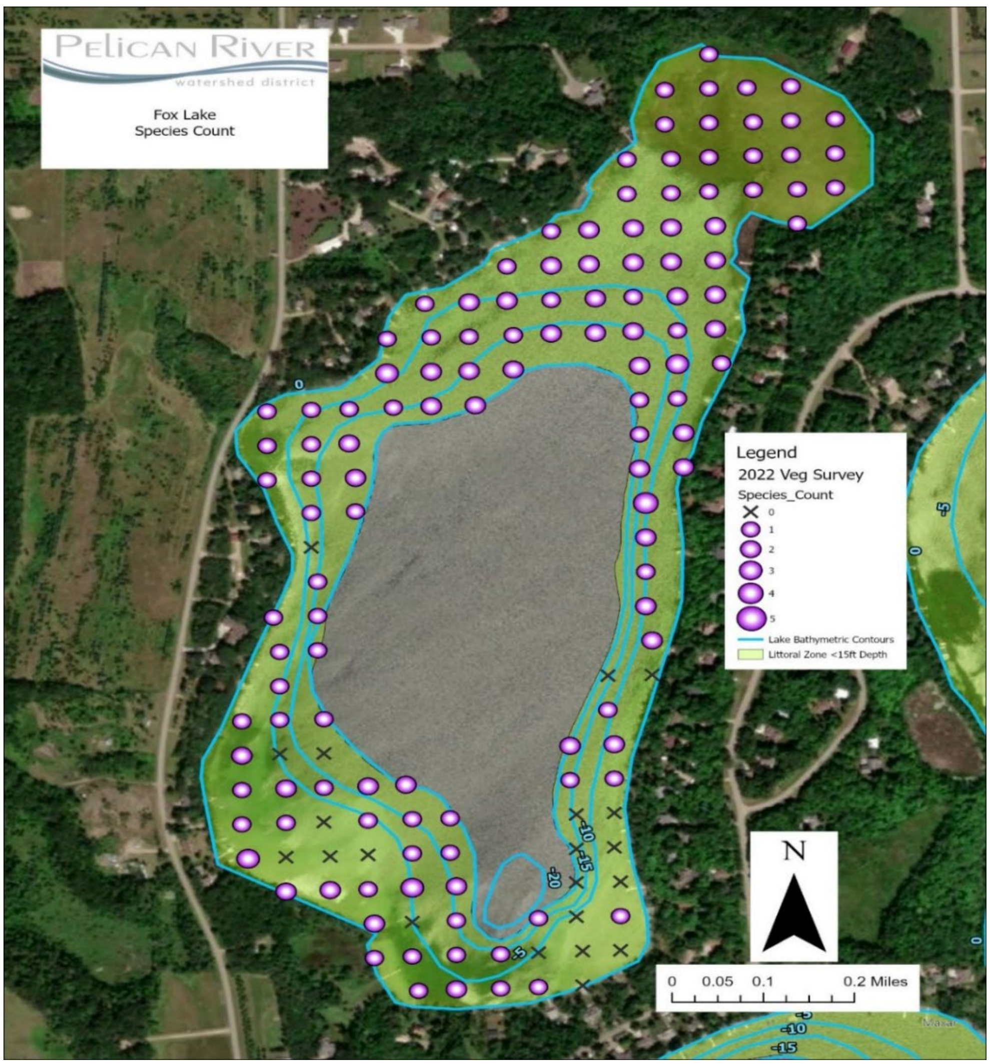


Figure 12.2 – Species Richness Distribution. Number of species at each site from the 2022 point-intercept survey in Fox Lake, Becker County (EQuIS# 03-0358-00-201). Densities ranged from 0 to 5 at each point, with a 5 indicating the richness in species presence and 0 indicating no species.

Table 12.2 *Results from 2022 Fox Lake vegetation survey.*

Fox Lake 2022 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	1.46	26	17%
Chara spp./Nitella spp.	Chara	2.61	100	65%
Typha latifolia & angustifolia	Cattail	3.00	26	17%
Schoenoplectus spp.	Bulrush	1.36	14	9%
Zizania palustris	Wild Rice	1.75	4	3%
Potamogeton perfoliatus	Clasping Leaf Pondweed	2.00	2	1%
Stuckenia pectinata	Sago Pondweed	2.18	11	7%
Empty Points	-	-	21	14%
Total Points	-	-	153	100%

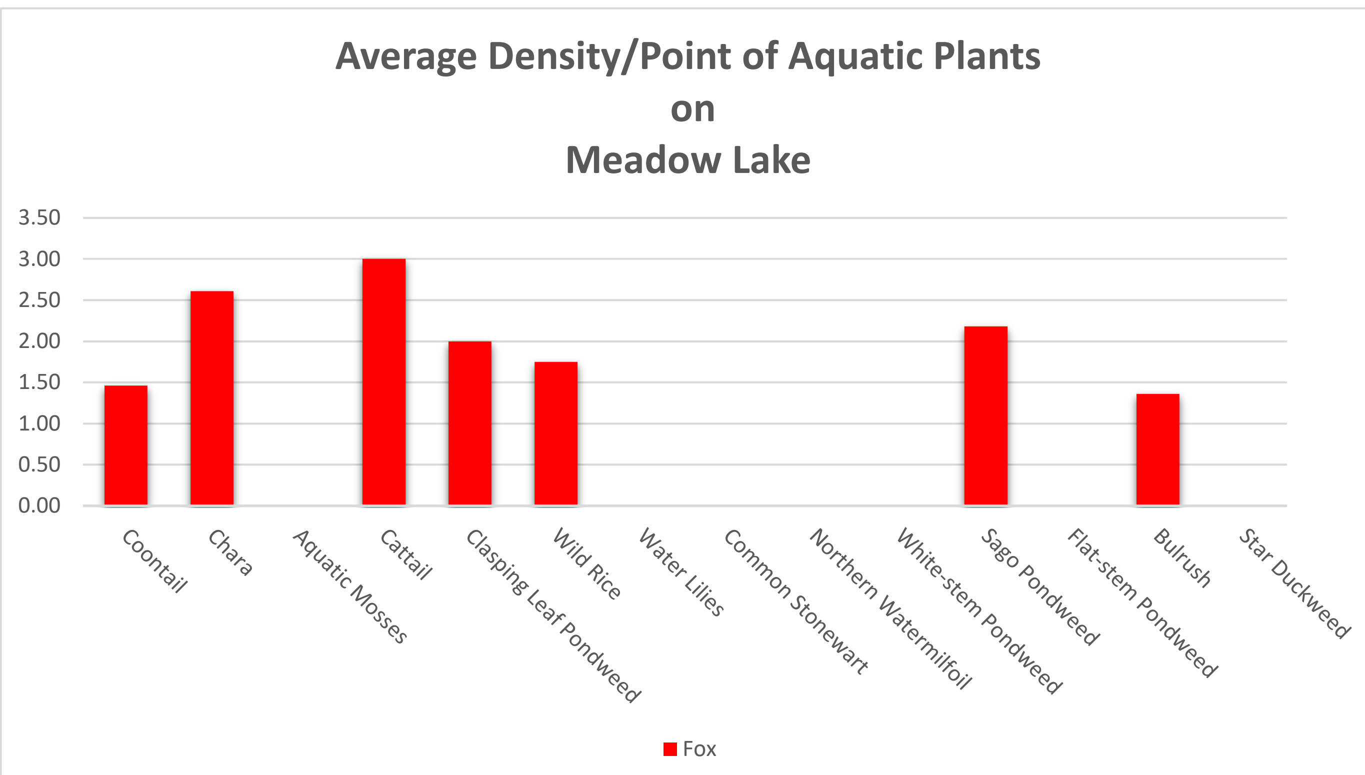


Figure 12.3 2022 Fox Lake density of aquatic plants.

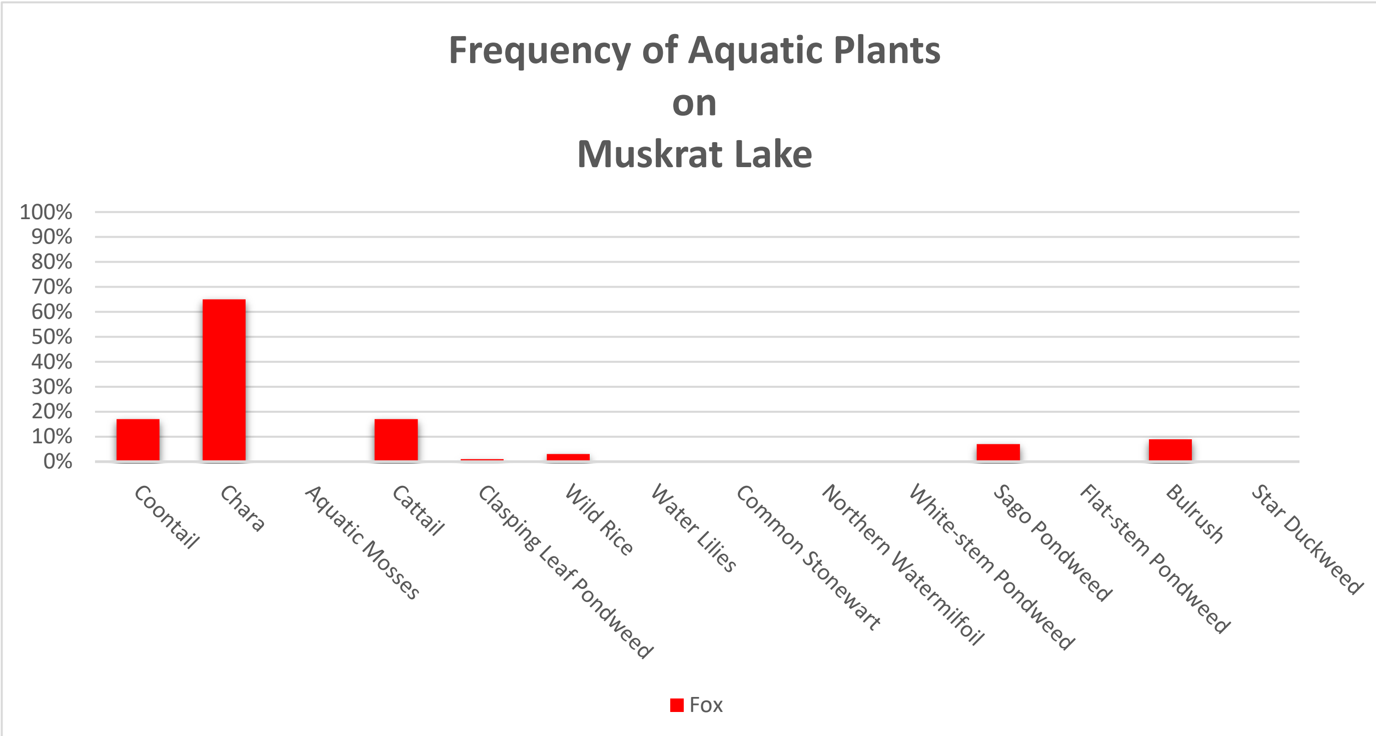
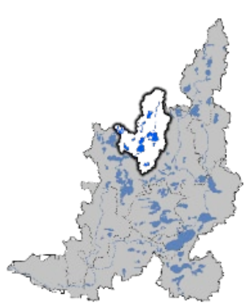
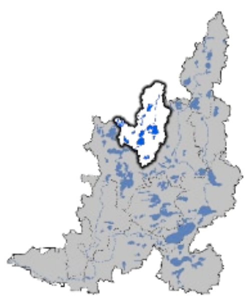


Figure 12.4 2022 Fox Lake density of aquatic plants.

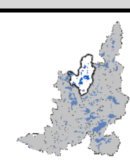
13.1 Appendices

Appendix A

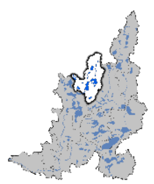
Parameter	Waterbody and location			Water quality					Strategies to achieve final water quality goal		
Pollutant/ Stressor	Aggregated HUC-12 Sub-watershed	Waterbody (ID)	Location & County	Current WQ conditions conc. µg/L load lbs/yr	Trend	P Load Focus (HSPF)	Risks and Qualities	WQ Goal (load to reduce)	Strategy type	Best Management Practice (BMP) Scenario: BMPs/Actions	Best Management Practice (BMP) Scenario: Interim 10-yr Milestone
Phosphorus	**Upper Pelican River 902010307-01** 	**Floyd** (03-0387-00)	Becker, PRWD	19 µg/L 1,137 lbs/yr	→	Tributary	High Bio Sig. and Highest P Sensitivity	Protect	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Continue Campbell Creek and Rice Lake restoration projects. Maintain current forests and lakeshore buffers, protection, lakeshore infiltration practices and agricultural BMPs. Fix noncompliant septic systems.
		Little Floyd (03-0386-00)	Becker, PRWD	25 µg/L 1,257 lbs/yr	→	Nearshore	Outstanding Bio Sig	Protect			
		Big Detroit (03-0381-00)	Becker, PRWD	24 µg/L 4,069 lbs/yr	↓	Tributary	Highest P Sensitivity	679 lbs/yr	Lakeshore protection Infiltration on developed properties Urban stormwater management	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Install retention areas. See strategies for Phosphorus in Table 22	5% reduction (203 lbs/yr)
		Little Detroit (03-0381-00)	Becker, PRWD	load included with Big Detroit	↑	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties Urban stormwater management	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Install retention areas. See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices, and urban stormwater practices.
		Curfman (03-0363-00)	Becker, PRWD	23 µg/L 89 lbs/yr	→	Not included in HSPF model	-	Protect			
		St. Clair (03-0382-00)	Becker, PRWD	68 µg/L 1,190 lbs/yr	↓	Tributary	-	286 lbs/yr	Infiltration on developed properties Urban stormwater management Point source reduction. Lake Internal load management	Install infiltration practices such as rain gardens. Install retention areas. Wastewater treatment plant upgrades in Detroit Lakes Alum treatment See strategies for Phosphorus in Table 22	5% reduction (60 lbs/yr)
		Muskrat (03-0360-00)	Becker, PRWD	35 µg/L 3,175 lbs/yr	→	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. See strategies for Phosphorus in Table 22	Maintain lakeshore buffers and increase lakeshore infiltration practices and agricultural BMPs. Fix non-compliant septic systems.
		Sallie (03-0359-00)	Becker, PRWD	40 µg/L 7,118 lbs/yr	→	Nearshore	**Eutrophication stressor in Lake IBI Report**	1,069 lbs/yr	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (356 lbs/yr)
		Melissa (03-0475-00)	Becker, PRWD	23 µg/L 5,626 lbs/yr	↑	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain lakeshore buffers and increase lakeshore infiltration practices and agricultural BMPs. Fix non-compliant septic systems.
		Abbey (03-0366-00)	Becker, PRWD	47 µg/L 97 lbs/yr	↓	Not included in HSPF model	-	16/lbs/yr	Forest protection Lakeshore protection Infiltration on developed properties Improve upland/field surface runoff	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (5 lbs/yr)

Parameter	Waterbody and location			Water quality					Strategies to achieve final water quality goal		
										Best Management Practice (BMP) Scenario	
Pollutant/ Stressor	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**Location & County**	**Current WQ conditions** conc. µg/L load lbs/yr	**Trend**	**P Load Focus (HSPF)**	**Risks and Qualities**	**WQ Goal** (load to reduce)	**Strategy type**	**BMPs/Actions**	**Interim 10-yr Milestone**
Phosphorus	**Upper Pelican River 902010307-01** 	**Wine** (03-0398-00)	Becker, PRWD	100 µg/L 72 lbs/yr	→	Nearshore	-	30 lbs/yr	Infiltration on developed properties Improve upland/field surface runoff	Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (4 lbs/yr)
		Brandy (03-0400-00)	Becker, PRWD	NA	↑	Not included in HSPF model	-	Protect	Forest protection Lakeshore protection Infiltration on developed properties Improve upland/field surface runoff	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices and agricultural BMPs.
		Long (03-0383-00)	Becker, PRWD	15 µg/L 183 lbs/yr	↑	Tributary	Highest P Sensitivity	Protect	Forest protection Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff.	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices and agricultural BMPs. Fix noncompliant septic systems.
		Fox (03-0358-00)	Becker, PRWD	15 µg/L 32 lbs/yr	↑	Not included in HSPF model	Highest P Sensitivity	Protect			
		Munson (03-0357-00)	Becker, PRWD	20 µg/L 58 lbs/yr	↑	Not included in HSPF model	Highest P Sensitivity	Protect			
		Pearl (03-0486-00)	Becker, PRWD	29 µg/L 316 lbs/yr	→	Not included in HSPF model	-	Protect			
		Campbell Creek (-543) **Pelican River** (-771, -772)	Becker County, PRWD	"Nearly" Impairment Risk	-	-	-	Enhance	Infiltration on developed properties Urban stormwater management Improve upland/field surface runoff	Install infiltration practices such as rain gardens. Install retention areas. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Model implementation scenario for P reduction in PTMApp.

Appendix B

Parameter	Waterbody and location			Water quality		Strategies to achieve final water quality goal		
							Location & County	
Pollutant/ Stressor	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**Location & County**	**Pollutant/ Stressor**	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**BMPs/Actions**	**Interim 10-yr Milestone** (% to reduce)
Bacteria	**Upper Pelican River 0902010307-01** 	**Pelican River** (-772)	Becker, PRWD	241.0 org/100mL	48%	Sanitation (failing SSTS and WWTPS)	Investigate sources in the City of Detroit Lakes See strategies for Bacteria in Table 22.	7% (16.9 org/100 mL)

Appendix C

Parameter	Waterbody and location			Water quality		Strategies to achieve final water quality goal		
							Best Management Practice (BMP) Scenario	
Pollutant/ Stressor	Aggregated HUC-12 Sub-watershed	Waterbody (ID)	Location & County	Current WQ conditions conc. mg/L	WQ Goal (overall load to reduce)	Strategy type	BMPs/Actions	Interim 10-yr Milestone
Sediment	**Upper Pelican River 902010307** 	**Campbell Creek** (-543)	Becker County, PRWD	91.2 mg/L	67%	In stream erosion Bank erosion Surface runoff Surface runoff, Open tile intakes	Use surface sediment controls to prevent sediment mobilization and transport including conservation tillage, cover crops, removing open tile intakes, or strategic implementation of sediment reducing BMPs. Increase runoff filtration or detention in cultivated fields to trap/settle eroded sediment (e.g., grassed waterways or water and sediment control basins). Manage pastures to prevent overgrazing and direct stream access by livestock. Maintain riparian vegetation (native vegetation). Implement streambank stabilization/buffer enhancements - in areas to provide the most benefit to threatened, high value property. Incorporate the principles of natural channel design. See strategies for Sediment in Table 25. See strategies for Hydrology in Table 25.	4% Reduction (3.6 mg/L)