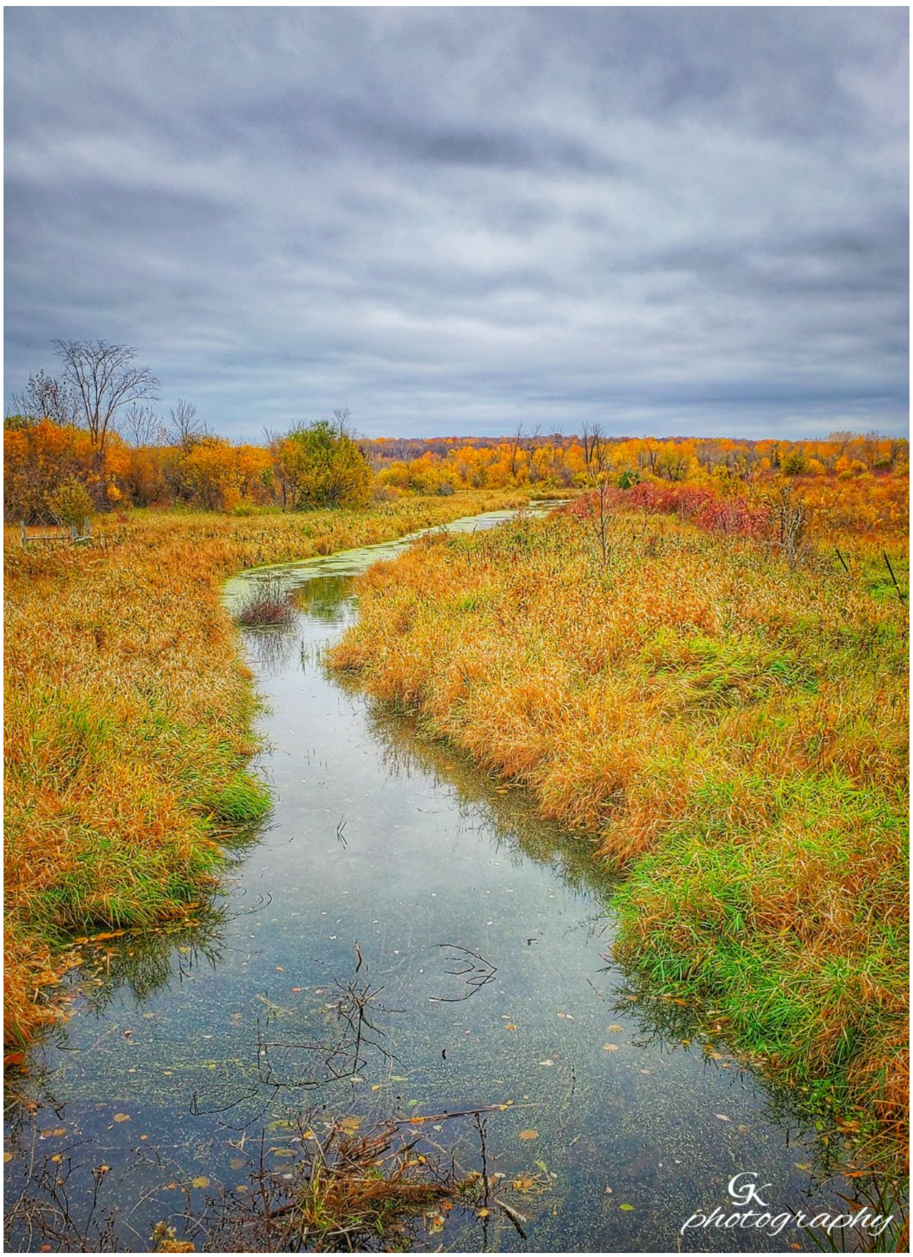
Pelican River watershed district

2021 Annual Monitoring Report

Gina Kemper
Water Resource Coordinator
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.



Headwaters of the Pelican River (Rice Lake Project)

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
µG/L ... 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

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 2021, District Staff conducted water quality sampling on 14 lakes and 17 locations on 5 different stream systems. Of the 14 lakes sampled, 3 lakes were sampled for the first time in 2021. An aquatic vegetation survey was performed on Sallie and Melissa lakes. Shoreline surveys were conducted on Big Floyd, Little Floyd, North Floyd, Reeves, and Abbey. Special study work included a Minnesota Department of Natural Resources streambank assessment on Campbell Creek from 230th Street to North Floyd Lake and E. coli sampling on the Pelican River between State Highway 34 and Detroit Lake outlet towards locating the bacteria source.

Water Quality in 2021 was above average on lakes across the District largely attributed to a lack of rainfall with little to no stormwater runoff entering into our water bodies. Drought conditions persisted from January– September with below average snowfall and precipitation.

Table 1.1. Lake water quality results from 2021 sampling efforts

Water Management Area	Lake	2021 Average			Historical Averages (2000-2020)			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	Big Detroit	15	3.85	17	25	8.26	10	<40	<14	>4.6
	Little Detroit	13	2.24	14	19	4.68	12	<40	<14	>4.6
Floyd/Campbell	Big Floyd	13	3.91	14	15	5.24	12	<40	<14	>4.6
	North Floyd	20	5.29	16	31	13.98	8	<40	<14	>4.6
	Little Floyd	16	4.58	12	24	8.91	9	<40	<14	>4.6
Long	Long	23	3.68	17	13	4.08	14	<40	<14	<4.6
Sallie/Melissa	Sallie	20	4.73	13	32	12.35	9	<40	<14	>4.6
	Melissa	15	4.83	16	20	6.69	11	<40	<14	>4.6
	St. Clair*	55	19.03	5	86	40.67	3	<60	<20	>3.3
	Muskrat	50	7.19	5	--	--	--	<60	<20	>3.3
Pearl/Loon	Pearl	18	3.14	10	29	9.10	10	<40	<14	>4.6
	Dart	64	20.87	1	58	19	5	<60	<20	>3.3
Small Lakes	Cottage	12	6.07	12	--	--	--	<60	<20	>3.3

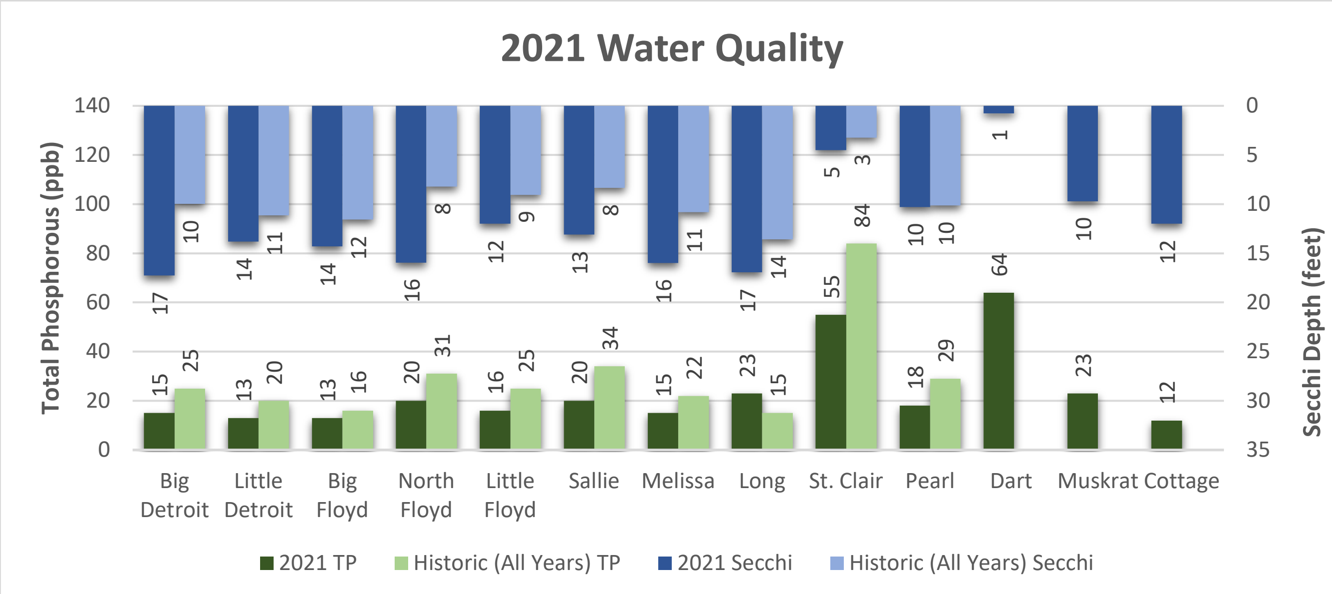


Figure 1.1. Lake water quality results from 2021 compared to historic averages.

Next year in 2022, 14 lakes and 17 stream sites will be sampled for water quality. Vegetation surveys will be conducted on Fox, Meadow, Mill Pond and Muskrat and shoreline surveys on Sallie, Melissa, and Lind

Table 1.2. 2022 Lake Monitoring Schedule

EQuIS ID	Lake Name	LWQMA	Monitoring	Water Quality Survey	Vegetation Survey	Shoreline Survey	Zooplankton/ Phytoplankton
03-0387-02-206	Big Floyd Lake	Floyd/Campbell	Major	X			X
03-0387-01-207	North Floyd Lake	Floyd/Campbell	Major	X			X
03-0386-00-201	Little Floyd Lake	Floyd/Campbell	Major	X			X
03-0381-00-204	Big Detroit Lake	Detroit/Rice	Major	X			X
03-0381-00-207	Little Detroit Lake	Detroit/Rice	Major	X			X
03-0383-00-201	Long Lake	Long	Major	X			X
03-0382-00-202	Saint Clair Lake	Sallie/Melissa	Major	X			
03-0359-00-201	Lake Sallie	Sallie/Melissa	Major	X		X	X
03-0475-00-202	Lake Melissa	Sallie/Melissa	Major	X		X	X
03-0366-00-201	Brandy Lake	Brandy/Wine	Minor	X			
--	Fish Lake		Minor	X			
--	Kennedy Lake		Minor	X			
--	Saint Patrick Lake		Minor	X			
03-0420-00-201	Sands Lake	Floyd/Campbell	Minor	X			
03-0358-00-201	Fox Lake	Fox/Munson	Minor		X		
03-0371-00-201	Meadow Lake	Small Lakes	Minor		X		
03-0377-00-201	Mill Pond	Sallie/Melissa	Minor		X		
03-0360-00-201	Muskrat Lake	Sallie/Melissa	Minor		X		
03-0376-00-201	Lind Lake	Small Lakes	Minor			X	

2 Background

The Pelican River Watershed District (PRWD) is one of 46 watershed districts established in Minnesota 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.

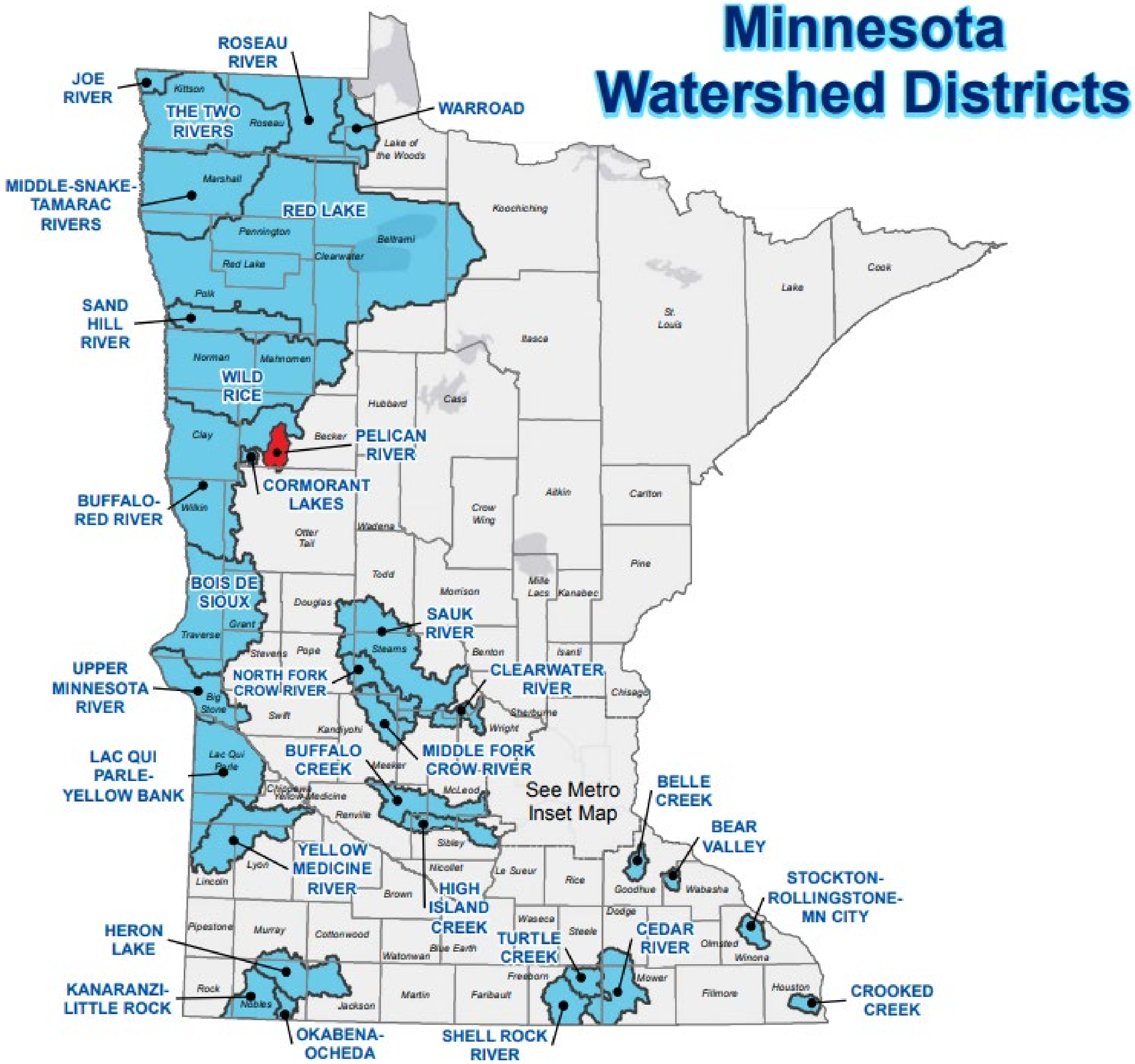


Figure 2.1. Minnesota watershed districts map

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. 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.

Overall, the year 2021 will be remembered for a number of extreme weather events from the two-week Arctic Cold Wave of February followed by a June heat wave and summer drought, the record number of air quality alerts (mostly due to smoke from wildfires in the west and in Canada) and ending the year with tornadoes in December located in parts of southern MN!

2021 will go down as the 5th warmest year in state history. On a statewide basis only one month was cooler than normal. February was 7 to 9°F below normal. In contrast June was 5°F warmer than normal, making it the 3rd warmest June in state history.

Precipitation was less than normal in 2021, but only the 31st driest year in state history. May, June, and July were all drier than normal, putting most of the state landscape into drought. Statewide average precipitation for 2021 was under 24 inches, marking the driest full year since 2006.

First Quarter 2021 – Winter Months: January – March

Average temperatures for the first quarter of 2021 were mostly above historical averages, except in February, where a cold snap had temperatures below zero for almost 12 consecutive days. This broke the 1995-96 previous historical record for Detroit Lakes of 7 consecutive days of below zero temperatures. The lowest recorded temperature was on February 13th with a low of -32.8°F, and the highest temperature during this period was on March 28th with 73.4°F. Fluctuations are not uncommon in the first quarter of the year.

First quarter started with below average precipitation, with total rainfall being 0.55", 1.98" less than historic average and snowfall being 12", 13.91" below average.

Second Quarter 2021 – Spring Months: April – June

Second quarter temperatures largely trended below the historical average for the first half of the quarter, with exceptions during the beginning of April and May. Average highs and lows for April were 52°F and 31.4°F, with the second quarter low being 15°F on April 1st. May average highs and lows were 68.8°F and 45.5°F. Starting mid-May, temperatures trended higher than average, and continued into June, with exceptions during the end of May and June, where average temperatures dipped below average for a few days. June average high was 83.3°F and average low was 59°F. June had the highest recorded temperature of the quarter with 96.8°F. 2021's June was also the second warmest on record, only behind 1933.

Second quarter rainfall started out promising, with 1.8" falling in April, but May and June trended well below average precipitation. May had only one storm event which was in spotty in areas ranging from 1" to 2", with 1.19" being recorded at the Detroit Lakes Wething Airport. June carried on the dry spell with 2.07" being recorded, 2.18" less than the monthly average of 4.25 inches.

Third Quarter 2021 – Summer Months: July – September

Third quarter temperatures in July and part of August trended closer to historical average temperatures, but then in the second half of the quarter the low temperatures started to dip down just below the historical average temps. The average highs and lows for July were 83°F and 63°F. The hottest day in July was on the 23rd with a reading of 93.2°F and the coolest day in July was on the 9th with a reading of 53.6°F. The average highs and lows for the month of August were 81°F and 62°F. The highest temperature recorded for August this year was also 93.2°F, which was on the 18th. The lowest temperature for August was on the 1st, 13th and 30th, with all three days having the same temperature of 51.8°F. In September the high was recorded at 86°F on the 28th and the lowest was recorded at 42.8°F on the 18th.

Precipitation greatly varied between July through September. In July, rainfall was well below the historical average totaling only 2.04 inches (1.85 inches below the average monthly rainfall of 3.89 inches). August trended closer to normal rainfall, with 3.06 inches, just above the historical rainfall average by 0.15 inches. September trended drier with a total of 2.12 inches, 0.57 inches below the monthly average of 2.69 inches. According to the Minnesota State Drought Index, this precipitation was still not enough to bring us out of a severe drought status.

Fourth Quarter 2021 – Fall Months: October – December

Fourth quarter high temperatures followed the historical average temperatures, but the lows were greatly above the historical average. For the month of October, the average high temperature for the year was 60°F which was 3 degrees warmer than the historical average of 57°F. The warmest day was on October 4th and 5th with both having the same temperature of 78.8°F. The average low for the month of October 43°F which was 6 degrees warmer than the historical average of 37°F; with the lowest temp for October 2021 being on the 21st with a temperature of 24.8°F. November the average highs of 38°F were slightly lower than the historical average high temps of 40°F by 2 degrees. The lows for November were 31°F which was 8 degrees warmer than the historical average of 23°F. The highest temperature for November was 58.6°F on the 6th and the lowest was 10.7°F on the 25th. The month of December the average highs were 24°F and the lows were 6°F. The historic average high and low were 23°F and 7°F so there wasn't much, but a 1-degree difference. The highest temperature for December was 50°F on the 1st and the lowest was -24°F on the 31st.

October finally brought some relief to the drought conditions, with a total of 5.84 inches of much needed rainfall which was well above the historical average of 2.41 inches. In November 0.76 inches of precipitation were recorded with the first snowfall of 0.99, inches, well below the historical average of 3.95 inches. During the month of December, we received 1.91 inches of precipitation and 25.45 inches of snow. This was well above the historical average for both precipitation (0.91 inches) and snow (13.29 inches).

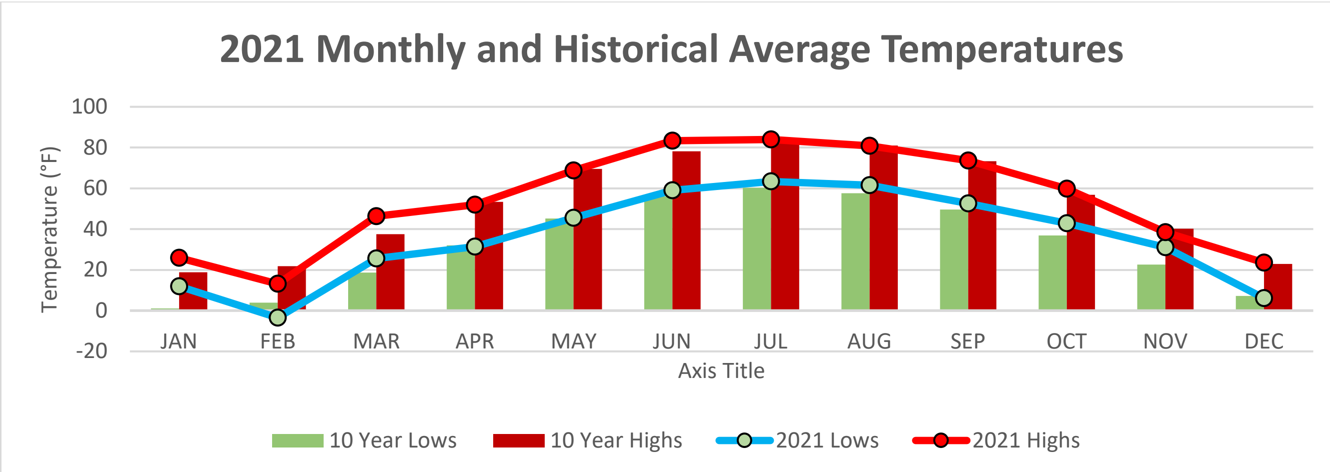


Figure 3.1. Monthly high and low temperatures from 2021

Table 3.1. Rainfall events in Detroit Lakes >0.5" April-October 2021.

Date	Inches	Date	Inches	Date	Inches
4/7/2021	1.06	7/24/2021	1.36	10/10/2021	2.43
4/8/2021	0.59	8/20/2021	1.12	10/13/2021	0.96
5/20/2021	1.19	8/26/2021	0.56	10/14/2021	0.76
6/8/2021	0.54	8/29/2021	0.51	10/27/2021	0.83
6/11/2021	0.75	9/2/2021	1.12	10/28/2021	0.51

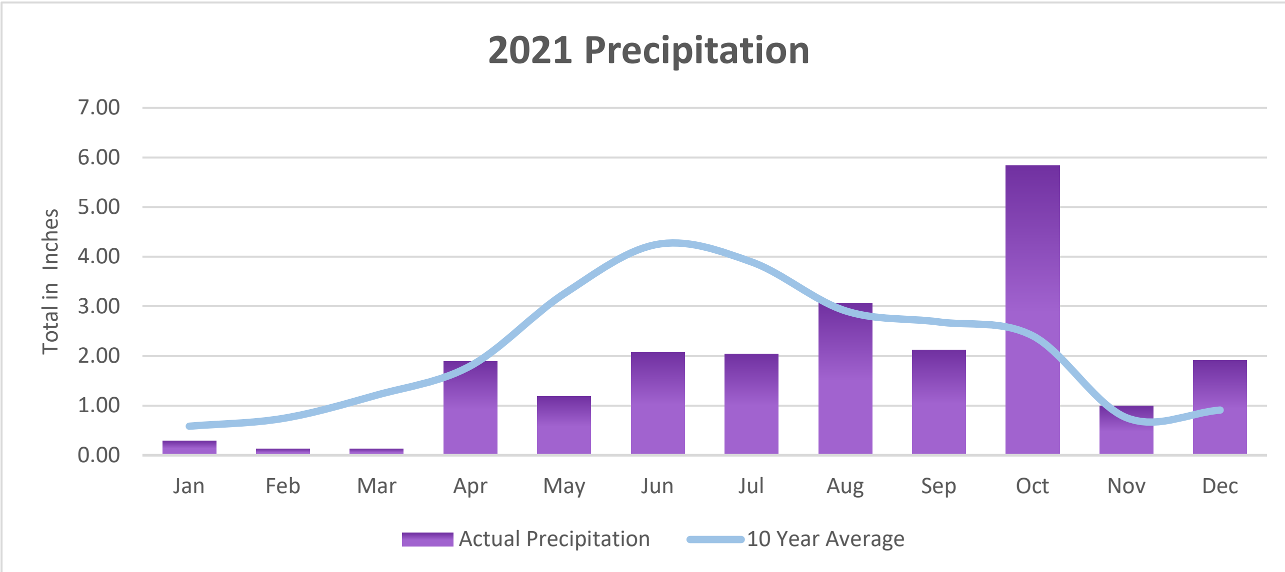


Figure 3.2. Monthly precipitation from 2021

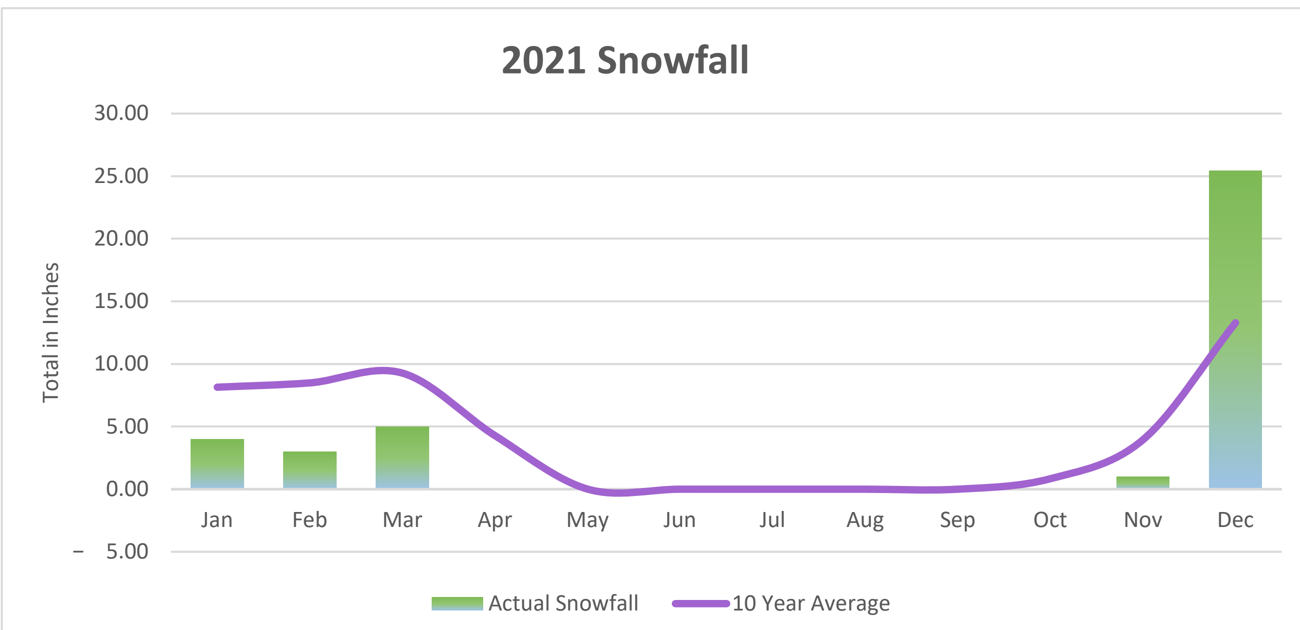


Figure 3.3. Monthly Snowfall from 2021

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 below chart is from the MPCA 2020 Draft 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.

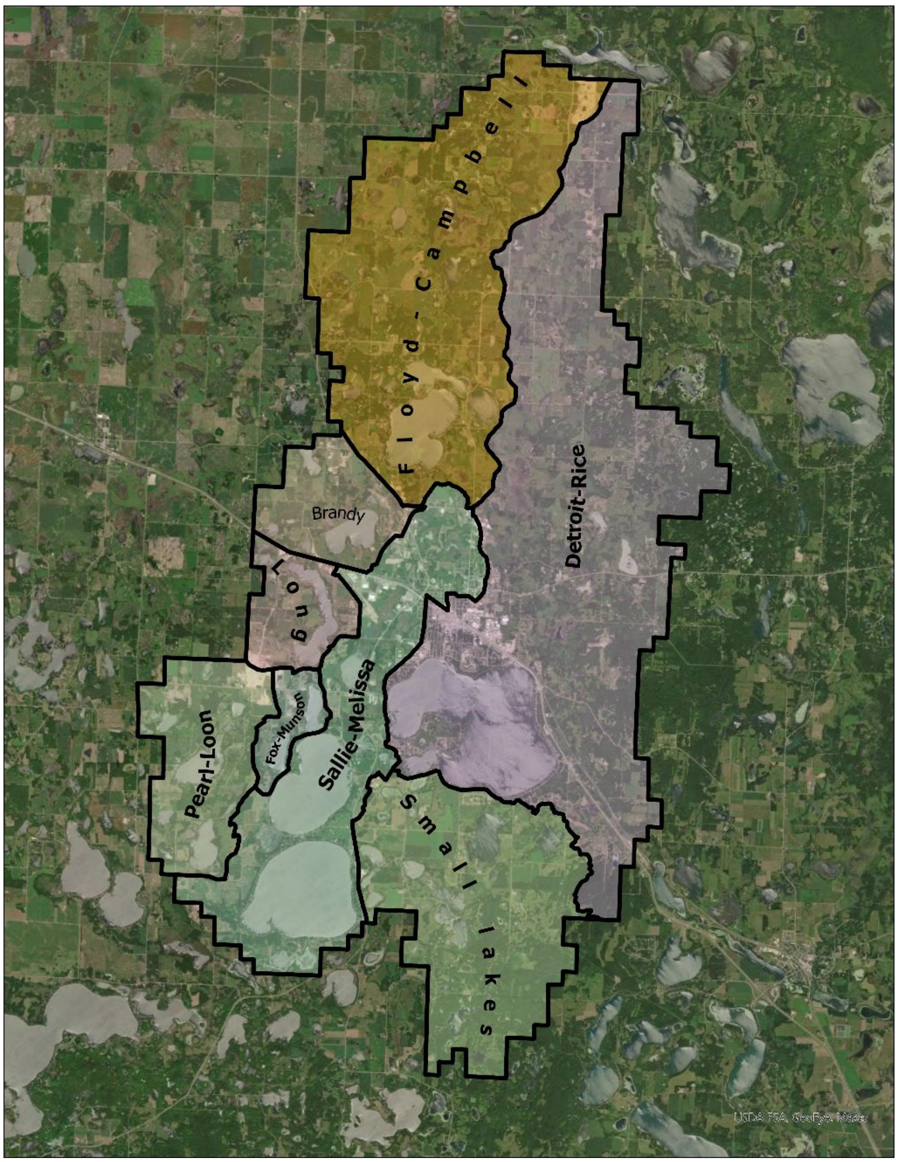
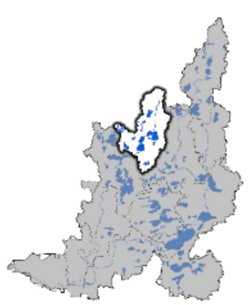
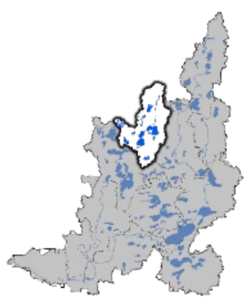
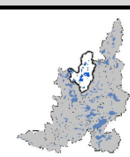
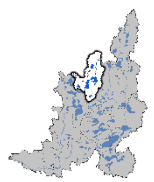


Figure 4.1. Water Management Areas.

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** 	**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)
		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)

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** 	**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.

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)

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	**WQ Goal** (overall load to reduce)	**Strategy type**	**Best Management Practice (BMP) Scenario**	
							BMPs/Actions	**Interim 10-yr Milestone**
Sediment	**Upper Pelican River 902010307** 	**Campbell Creek** (-543)	Becker County, PRWD	91.2 µg/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 µg/L)

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. 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. 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.

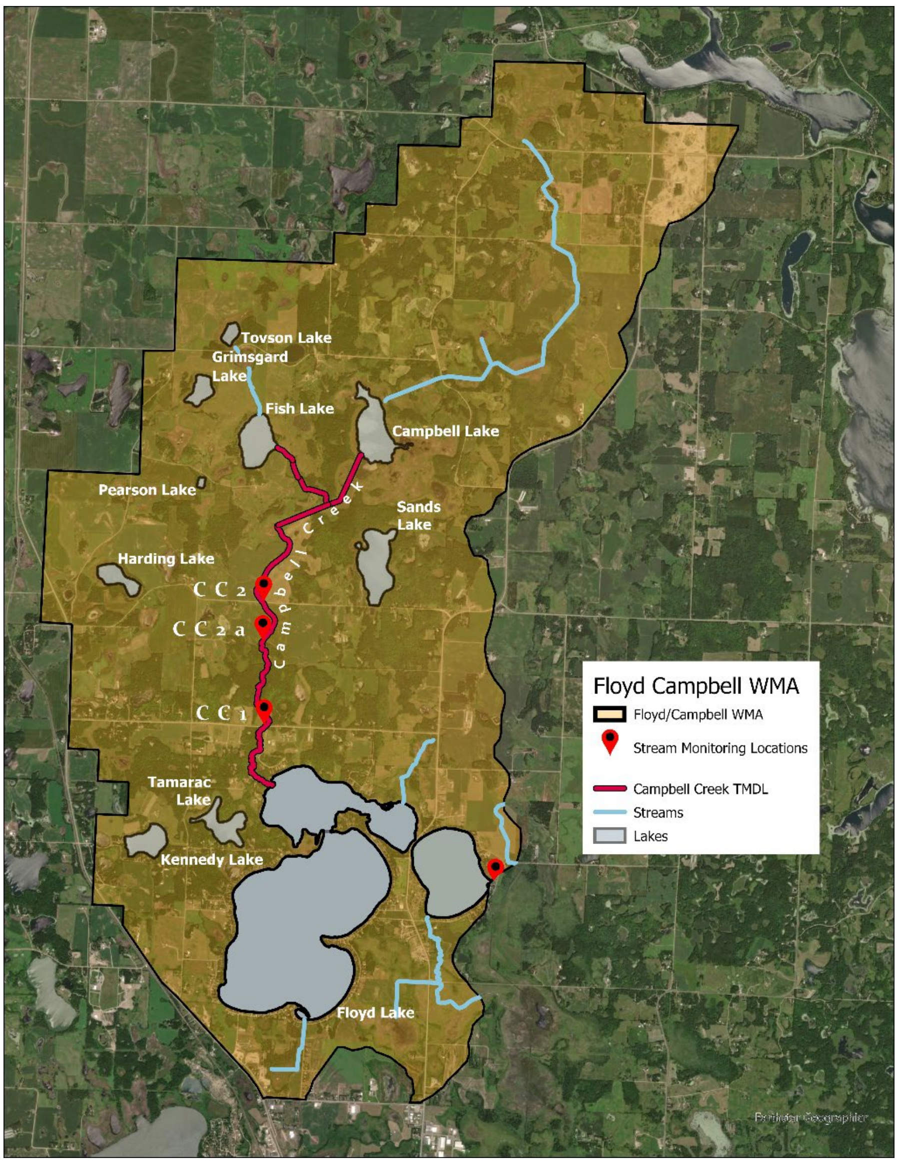


Figure 5.1. The Floyd/Campbell WMA.

5.1 Lakes

Lakes monitored by the District in the 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. In 2021, the District performed a water quality survey, shoreline survey, and zooplankton survey on the Floyd Chain of Lakes. In 2022, the District will perform a water quality survey on the Floyd Chain of Lakes, Sands Lake, Fish Lake, and Kennedy 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. 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 µg/L 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 µg/L 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 20µg/L to 34µg/L and are highly responsive to storm-events and heavy rainfall patterns. The 10-year (2008-2017) average is 25 µg/L 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 2020 to track trends in relation to climate change. For 2020, there were 219 days without ice cover on Floyd Lake, and 164 days of ice cover in the winter of 2019-2020. The number of ice cover days is a slight decrease from the 10-year average of 222, but an increase from the historic average of 215 days. The number of ice cover days from the winter of 2019-2020 was increased from the historic average of 149 days and the 10-year average of 143 days.

5.1.1.1 Water Quality/Quantity – Big Floyd

Water Quantity – Floyd Chain of Lakes

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 (1354.1 NVGD 29) on the outlet of Little Floyd Lake. Due to severe summer drought conditions water levels were below the OHWL and the dam at Little Floyd outlet was not flowing come mid-August.

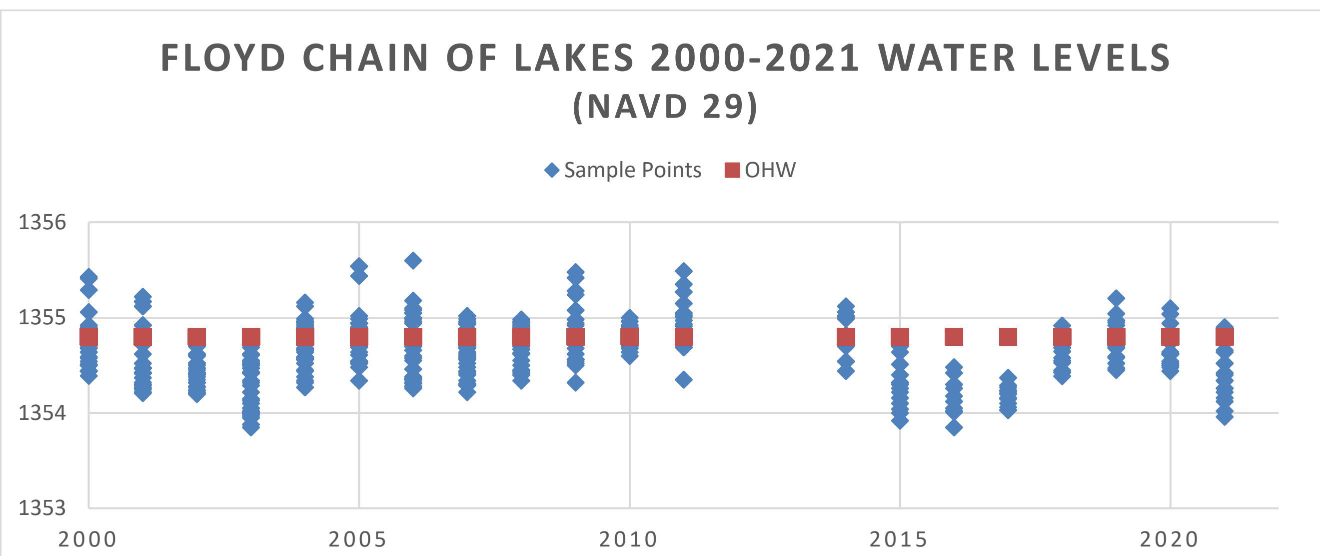


Figure 5.2. Floyd chain of lakes water levels from 2000-2021.

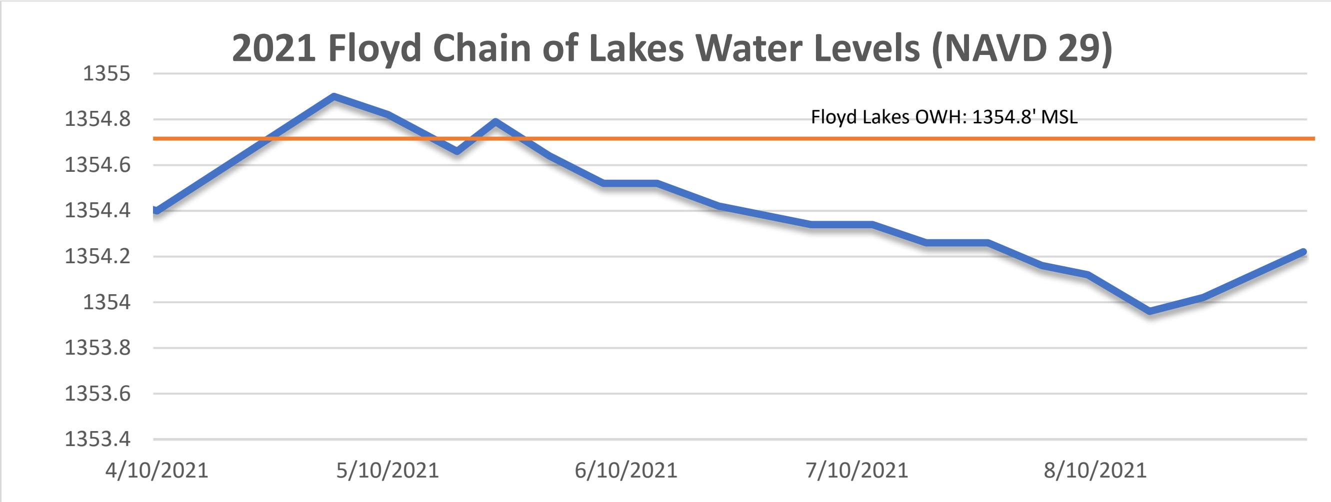


Figure 5.3. Floyd chain of lakes water levels 2021.

Water Quality - Big Floyd Lake

In 2021, Big Floyd's average Total Phosphorus (TP) was 13 µg/L, slightly better than the 20-year average of 15 µg/L. However, CHL-A (algae) was significantly lower at 3.91 µg/L (20-year - 9.47 µg/L) and water clarity (secchi depths) averaged 14.3 feet, almost 3 feet better than the 20-year average of 11.7 feet. The drought weather conditions had a positive water clarity impact due to the lack of nutrients entering the lake from rainfall events. Even after the mid-August water "turnover" event, water quality remained very good, with no algae blooms observed in late August and September.

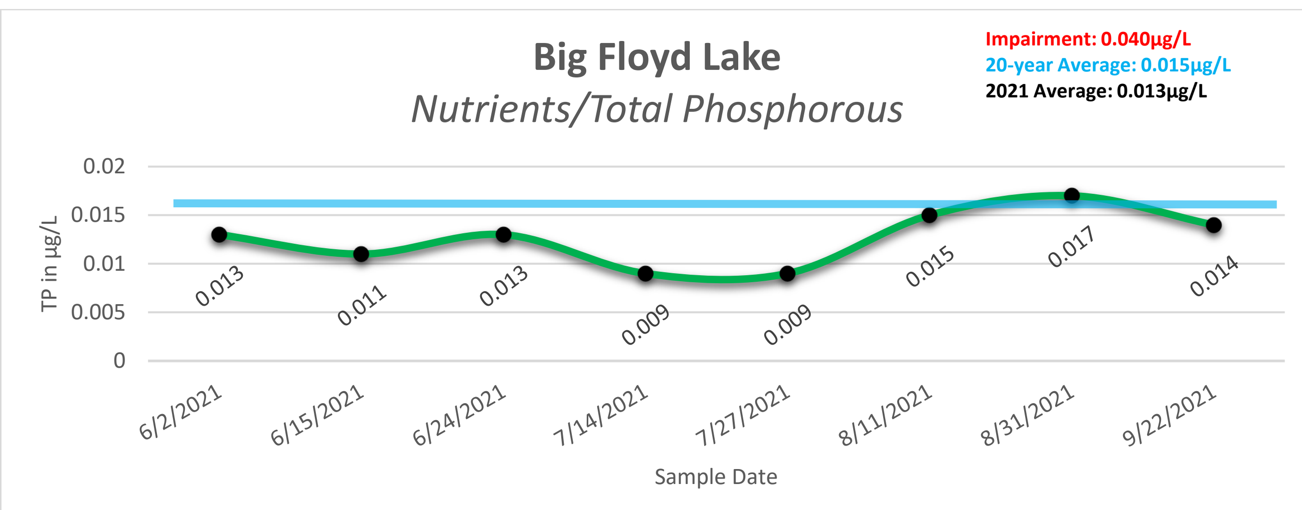


Figure 5.4. Big Floyd Lake 2021 total phosphorous.

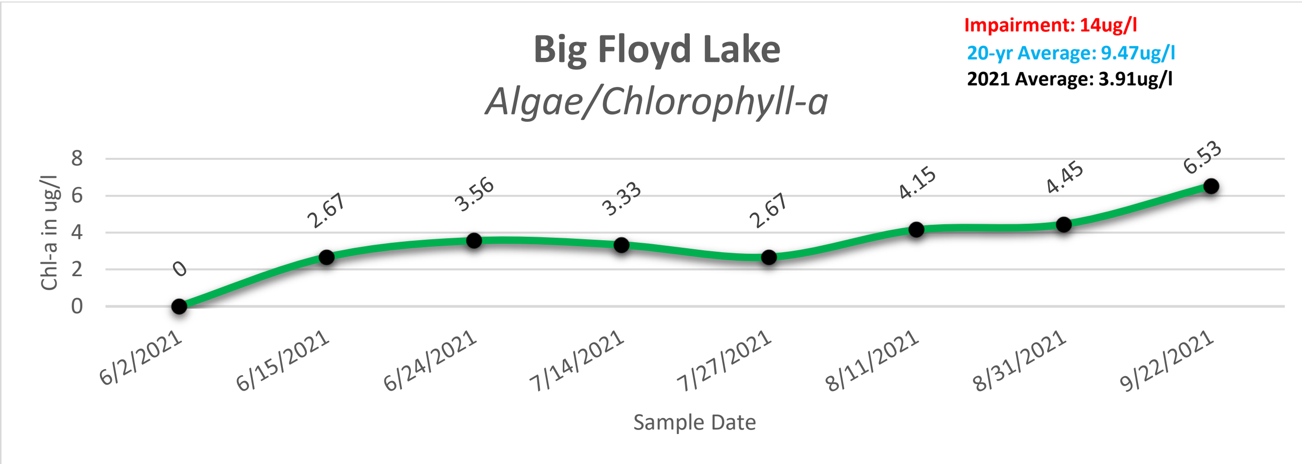


Figure 5.5. Big Floyd Lake 2021 chlorophyll-a.

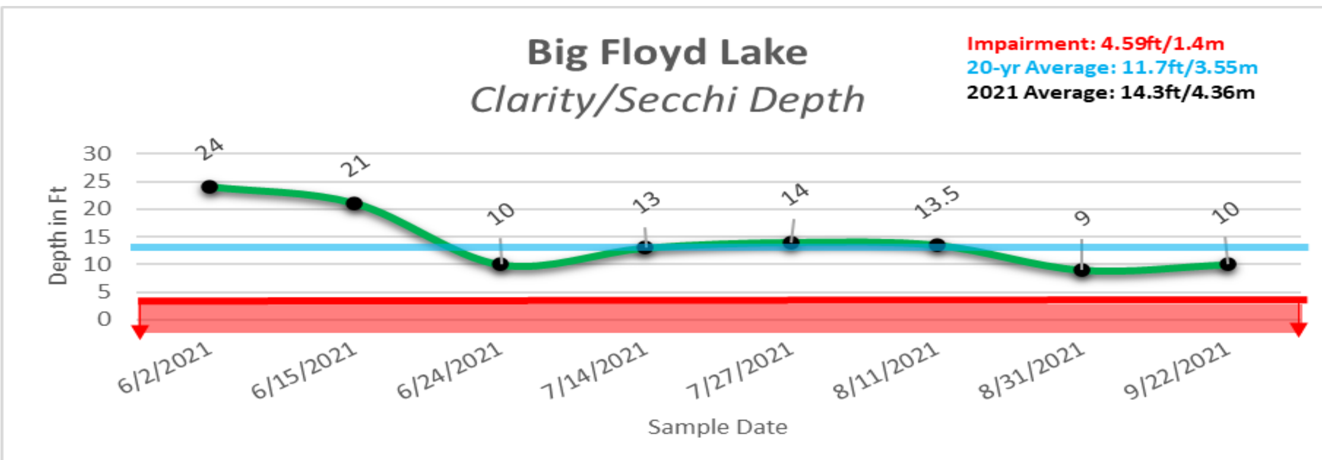


Figure 5.6. Big Floyd Lake 2021 secchi depth.

5.1.1.2 Ecological Integrity – Big Floyd

Shoreline Survey* – Big Floyd Lake, *304 Parcels

Shoreline Alteration: Big Floyd Lake's shoreline is 1% natural, 1% minimally altered, 9% moderately altered, and 89% greatly altered. 131 parcels have riprap along the shoreline as follows: 99 of the parcels have riprap 100% along the shoreline; 11 parcels have 75% - 99% rip-rap along the shoreline; 12 parcels cover 50% -75% of shoreline with riprap; 3 parcels with 25% - 49% shoreline in rip-rap; and 6 parcels have less than 25% of shoreline in rip-rap. Sand blankets are on a total of 162 parcels: 140 parcels have a sand blanket along the entire length of shoreline; with the remaining 23 parcels covering 75% or less of their shoreline with sand blankets. There are 81 parcels with retaining walls; 63 parcels have >75% of the shoreline with the remaining 18 parcels less than 50% of the shoreline area.

Table 5.1. Shoreline alteration grading scale

Natural	Natural vegetation for all of shoreline and shore-impact zone; No Modifications have been made to the shoreline except a small walkway (~4ft) and/or a dock.
Minimally Altered	Naturally vegetated for 80% of shoreline and shore-impact zone; Some modifications maybe made, a small strip of vegetation may be cleared; Only natural sand blanket and rip-rap present
Moderately Altered	20%-50% of shoreline altered from natural state; No retaining walls present; Modifications to Shore-impact zone are present, but limited to less than 50% of shoreline; property retains some trees or shrubs in shore-impact zone
Greatly Altered	More than 50% of shoreline is altered; Retaining walls or concrete patio may be present in Shore-impact Zone; Turf grass all the way to shoreline/riprap/sand blanket; upland may be clear cut

Waterfront Equipment: Since the last survey in 2016, the number of docks and rafts have remained constant. The number of covered boat lifts increased from 154 (2009), 186 (2016) to 241 in 2021 which corresponded with the decrease in non-covered lifts. Personal Watercraft decreased from 94 (2009) to 55 in 2021. Other motorized boats (pontoons, waterski, fishing) remained relatively unchanged from 244 (2016) to 253 in 2021. There is an increase in non-motorized watercraft (kayaks, paddleboats) from 98 (2009) to 150 in 2021. on-motorized boats increased, while there was a decrease in the other boatlifts and PWCs. (Figure 7.5).

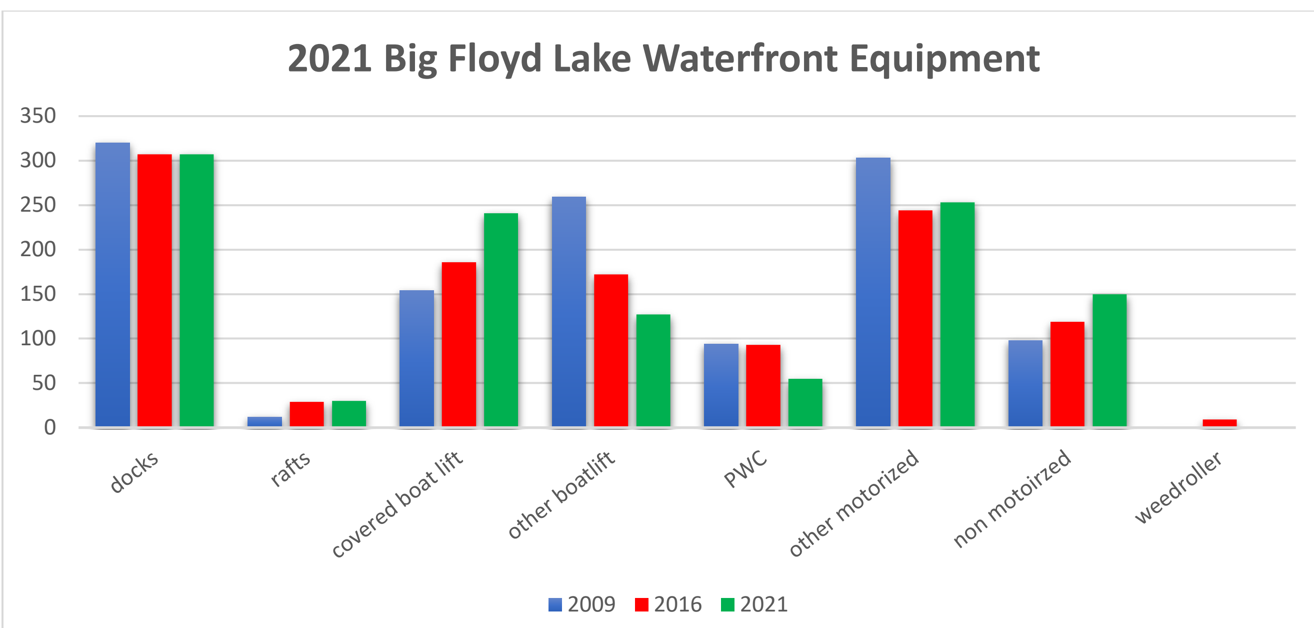


Figure 5.7. Waterfront equipment on Big Floyd Lake

Waterfront Structures*:* Since 2009 the number of boathouses has decreased from 16 (2009) to 10 in 2021, however there is a marked increase in storage sheds from 8 (2009) to 30 in 2021. Decks have also greatly increased from 11 (2009) to 31 in 2021 and patio areas increased from 1 (2009) to 18 in 2021.

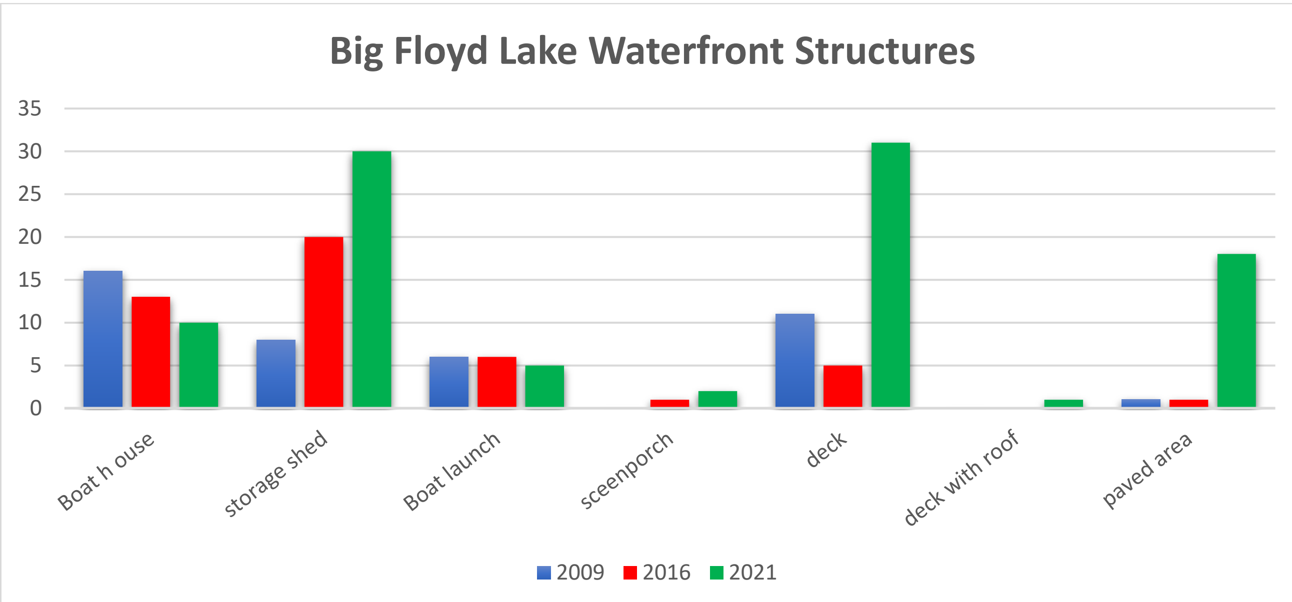


Figure 5.8. Waterfront structures on Big Floyd.

5.1.1.3 Water Quality/Quantity – North Floyd

Water Quality - North Floyd Lake

North Floyd Lake also had better than average water quality in 2021. The average TP was 20 µg/L, well below the 20-year average of 31 µg/L. Most TP results were well below 20 µg/L throughout the summer, but after the mid-August water "turnover" event, the TP readings increased to 22µg/L on August 31 up to 47µg/L on September 22nd. CHL-A (algae) levels were also low at 5.29 µg/L, less than one-half the 20-year average of 13.26 µg/L. The highest CHL-a measurement was also after the fall water turnover event with CHL-A reading at 15.1 µg/L on September 22. Water clarity readings were also better than average with secchi reading depths averaging 15.9 feet, almost 7-feet better than the 20-year average of 8.60 feet, with the worst water clarity reading occurring in September at 9-feet. These readings show the direct correlation of the negative impact Campbell Creek has on North Floyd's water quality with the lack of rainfall (summer drought conditions) preventing the normal nutrient loading discharges from Campbell Creek.

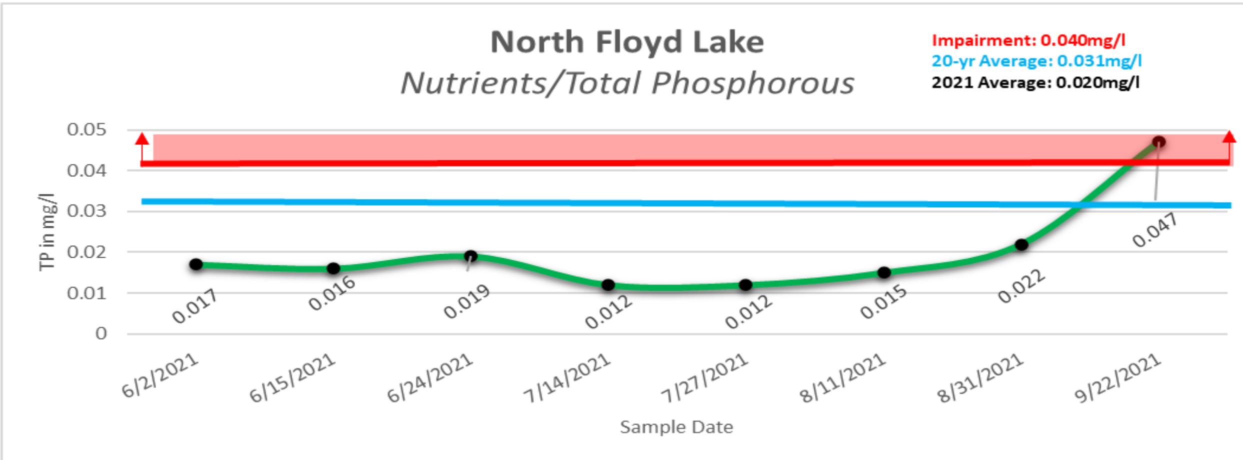


Figure 5.9. North Floyd Lake 2021 total phosphorous.

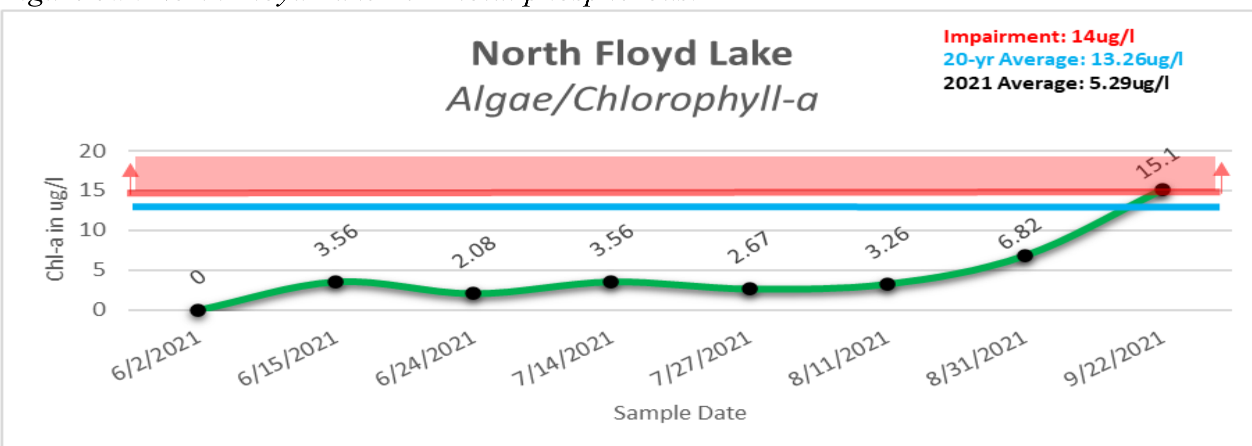


Figure 5.10. North Floyd Lake 2021 chlorophyll-a.

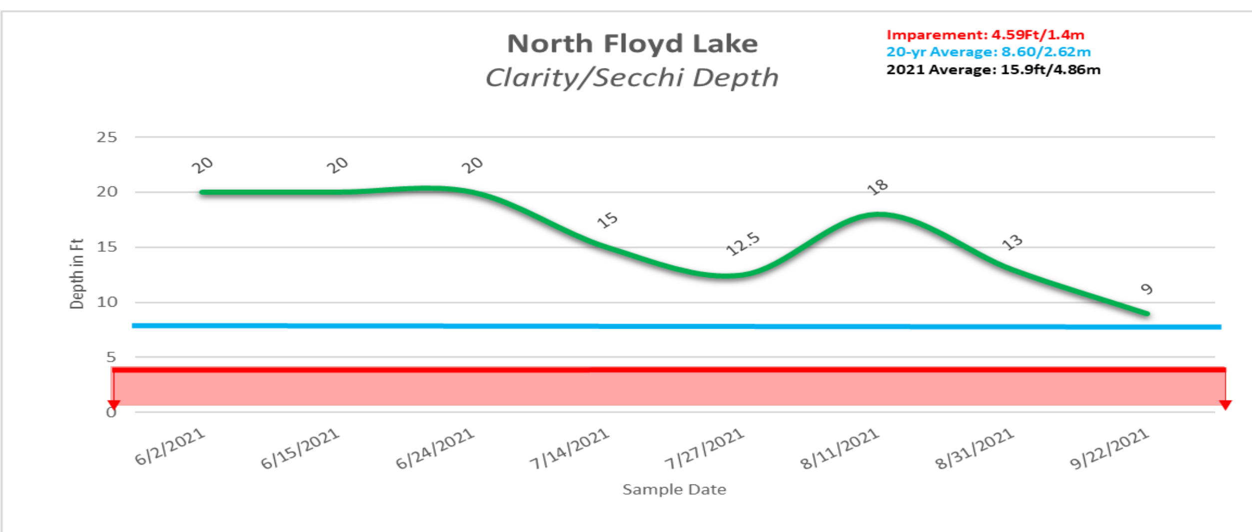


Figure 5.11. North Floyd Lake 2021 secchi depth.

5.1.1.4 Ecological Integrity – North Floyd

Shoreline Survey – North Floyd Lake, 58 Parcels

Shoreline Alteration*:* North Floyd Lake's shoreline is 40% natural, 23 parcels (2021) down from 51 parcels (2016). 24% minimally altered, 14 parcels (2021) up from 8 parcels (2016). 17% moderately altered, 10 parcels (2021) up from 4 parcels (2016). 19% greatly altered, 11 parcels (2021) up from 4 parcels (2016). 14 parcels have riprap along the shoreline as follows: 5 of the parcels have riprap 100% along the shoreline; 1 parcel has 75% - 99% rip-rap along the shoreline; 2 parcels cover 50% -75% of shoreline with riprap; 1 parcel with 25% - 49% shoreline in rip-rap; and 5 parcels have less than 25% of shoreline in rip-rap. Sand blankets are on a total of 5 parcels: 1 parcel has a sand blanket along the entire length of shoreline; with the remaining 4 parcels covering 75% or less of their shoreline with sand blankets. There are 4 parcels with retaining walls; all 4 are less than 50% of the shoreline area.

Table 5.2. Shoreline alteration grading scale.

Natural	Natural vegetation for all of shoreline and shore-impact zone; No Modifications have been made to the shoreline except a small walkway (~4ft) and/or a dock.
Minimally Altered	Naturally vegetated for 80% of shoreline and shore-impact zone; Some modifications maybe made, a small strip of vegetation may be cleared; Only natural sand blanket and rip-rap present
Moderately Altered	20%-50% of shoreline altered from natural state; No retaining walls present; Modifications to Shore-impact zone are present, but limited to less than 50% of shoreline; property retains some trees or shrubs in shore-impact zone
Greatly Altered	More than 50% of shoreline is altered; Retaining walls or concrete patio may be present in Shore-impact Zone; Turf grass all the way to shoreline/riprap/sand blanket; upland may be clear cut

Waterfront Equipment*:* Since the last survey in 2016, there was little change in the number of docks, covered boat lifts, other motorized boats (pontoons, waterski, fishing) and not motorized (kayaks, paddleboats). Interestingly, the number of rafts, uncovered boat lifts, PWC, and weed rollers decreased since the 2016 survey.

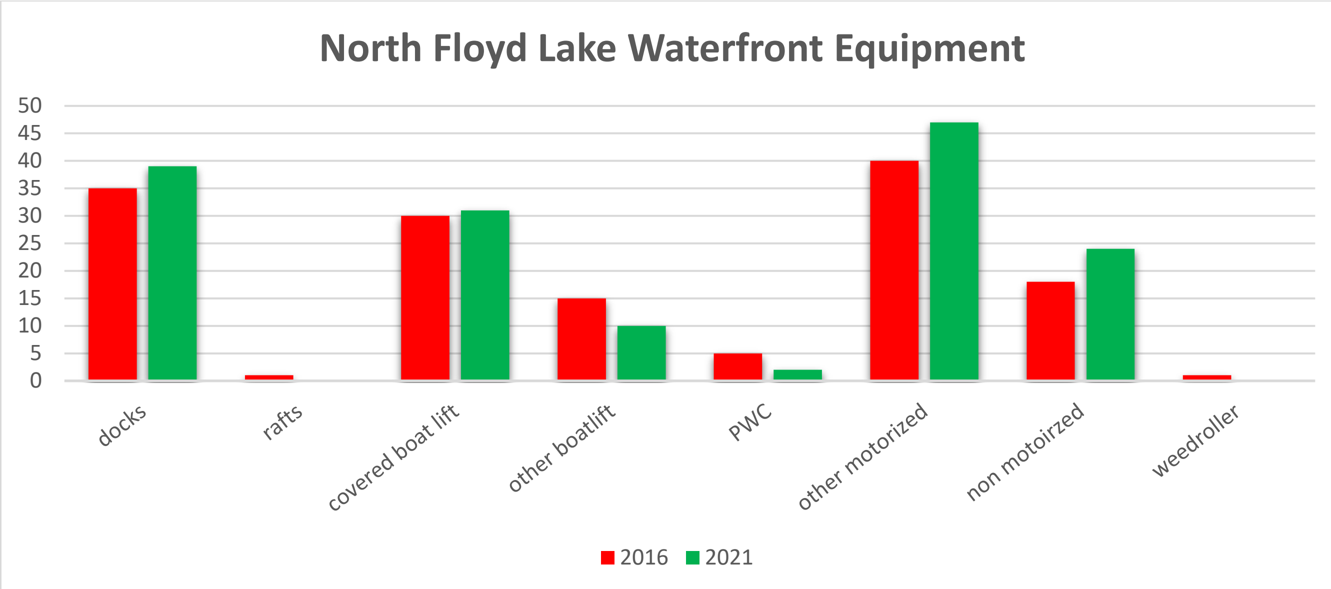


Figure 5.12. Waterfront equipment on North Floyd Lake.

Waterfront Structures*:* The number of waterfront structures remained constant between the surveys (2 sheds and one deck).

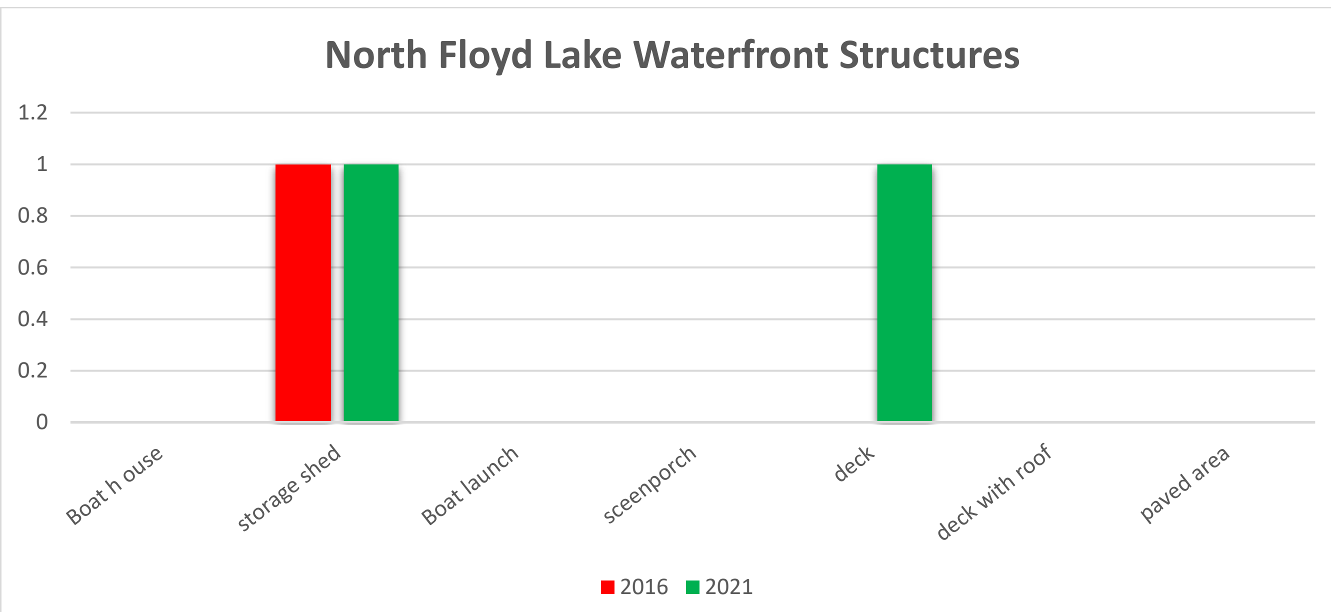


Figure 5.13. Waterfront structures on North Floyd Lake.

5.1.1.5 Water Quality/Quantity – Little Floyd

Water Quality - Little Floyd Lake

Little Floyd Lake experienced an above average" water quality year. average TP 16 µg/L, a marked improvement over the 20-year average of 23 µg/L. The highest TP reading was in September after the North Floyd fall water turnover event. At 21 µg/L. CHL-A at 4.58 µg/L, almost one-half the 20-year average of 8.58 µg/L; water clarity reading (secchi) averaged 15.9 feet, 7.3 ft better than the 9.2 feet 20-year average.

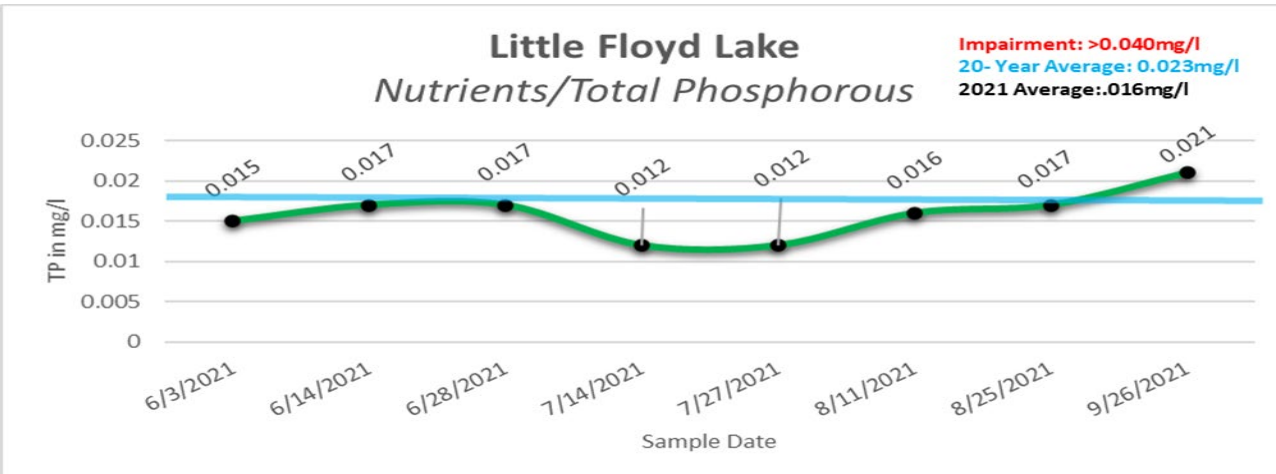


Figure 5.14. Little Floyd Lake 2021 total phosphorous.

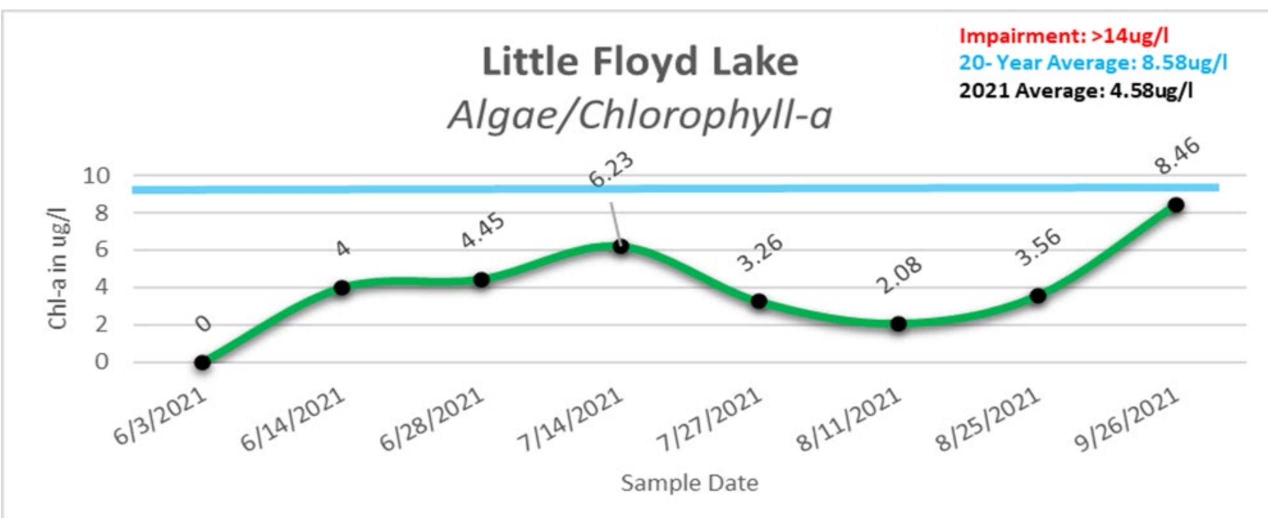


Figure 5.15. Little Floyd Lake 2021 chlorophyll-a.

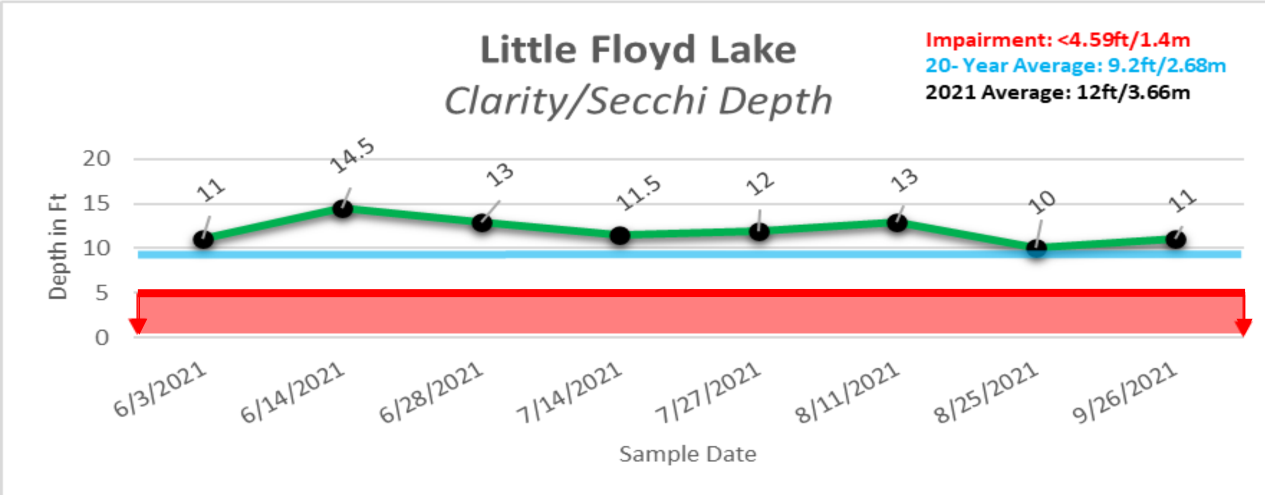


Figure 5.16. Little Floyd Lake 2021 secchi depth.

5.1.1.6 Ecological Integrity – Little Floyd

Zooplankton Survey – Floyd Chain of Lakes

District Staff have been involved in a cooperative project with the MN DNR and Concordia College in Moorhead to examine the effect of zebra mussels on the microscopic communities of zooplankton that form the base of the food web. Zebra mussels filter large amounts of water and strip the water column of resources. Through this study, District Staff collect monthly zooplankton samples and preserve them for later analysis. Analysis of these samples requires specialized identification knowledge. Staff from MN DNR and Concordia College will analyze the samples and report to the District once multiple years of population data has been collected. This project is on-going. In 2021 Samples were collected and sent into the MN DNR, however due to staffing issues they have not been analyzed to date (2022).

Shoreline Survey – Little Floyd Lake, 89 Parcels

Shoreline Alteration: Little Floyd Lake's shoreline is 2% natural, 2 parcels (2021) down from 12 parcels (2016). 2% minimally altered, 2 parcels (2021) down from 18 parcels (2016). 18% moderately altered, 16 parcels (2021) down from 18 parcels (2016). 78% greatly altered, 69 parcels (2021) up from 37 parcels (2016). 33 parcels have riprap along the shoreline as follows: 22 of the parcels have riprap 100% along the shoreline; 4 parcels have 75% - 99% rip-rap along the shoreline; 4 parcels cover 50% - 75% of shoreline with riprap; 2 parcels with 25% - 49% shoreline in riprap; and 1 parcel has less than 25% of shoreline in riprap. Sand blankets are on a total of 12 parcels: 1 parcel has 100%, a sand blanket along the entire length of shoreline; 2 parcels have 75% -99% of sand blanket along the shoreline; 2 parcels with 50%-74% of sand blanket along the shoreline; with the remaining 7 parcels covering 50% or less of their shoreline with sand blankets. There are 13 parcels with retaining walls; 8 parcels have retaining walls along 100% of the shoreline with the remaining 5 parcels covering 75% or less of the shoreline area.

Table 5.1. Shoreline alteration grading scale

Natural	Natural vegetation for all of shoreline and shore-impact zone; No Modifications have been made to the shoreline except a small walkway (~4ft) and/or a dock.
Minimally Altered	Naturally vegetated for 80% of shoreline and shore-impact zone; Some modifications maybe made, a small strip of vegetation may be cleared; Only natural sand blanket and rip-rap present
Moderately Altered	20%-50% of shoreline altered from natural state; No retaining walls present; Modifications to Shore-impact zone are present, but limited to less than 50% of shoreline; property retains some trees or shrubs in shore-impact zone
Greatly Altered	More than 50% of shoreline is altered; Retaining walls or concrete patio may be present in Shore-impact Zone; Turf grass all the way to shoreline/riprap/sand blanket; upland may be clear cut

Waterfront Equipment: Since the last survey in 2016, there was little change in the number of docks, covered boat lifts, other motorized boats (pontoons, waterski, fishing) and not motorized (kayaks, paddleboats), and other waterfront equipment.

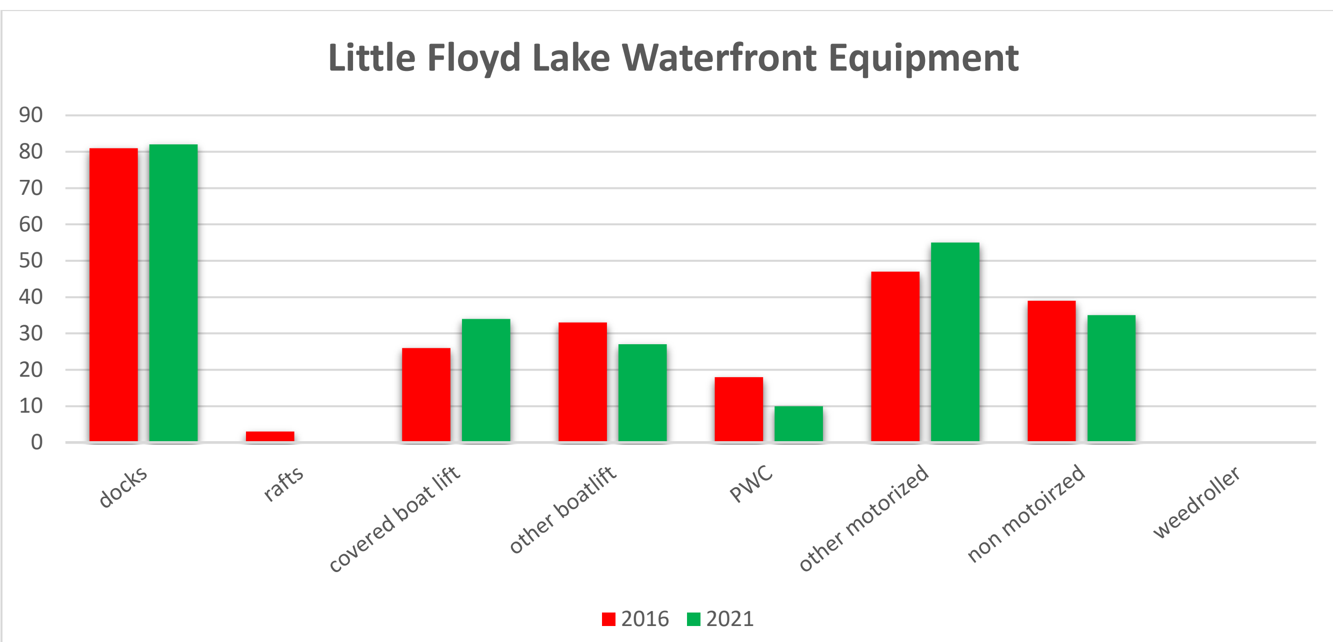


Figure 5.17. Waterfront equipment on Little Floyd Lake

Waterfront Structures: The number of waterfront structures increased between the surveys with 4 more sheds, 6 more decks, and 1 boat launch.

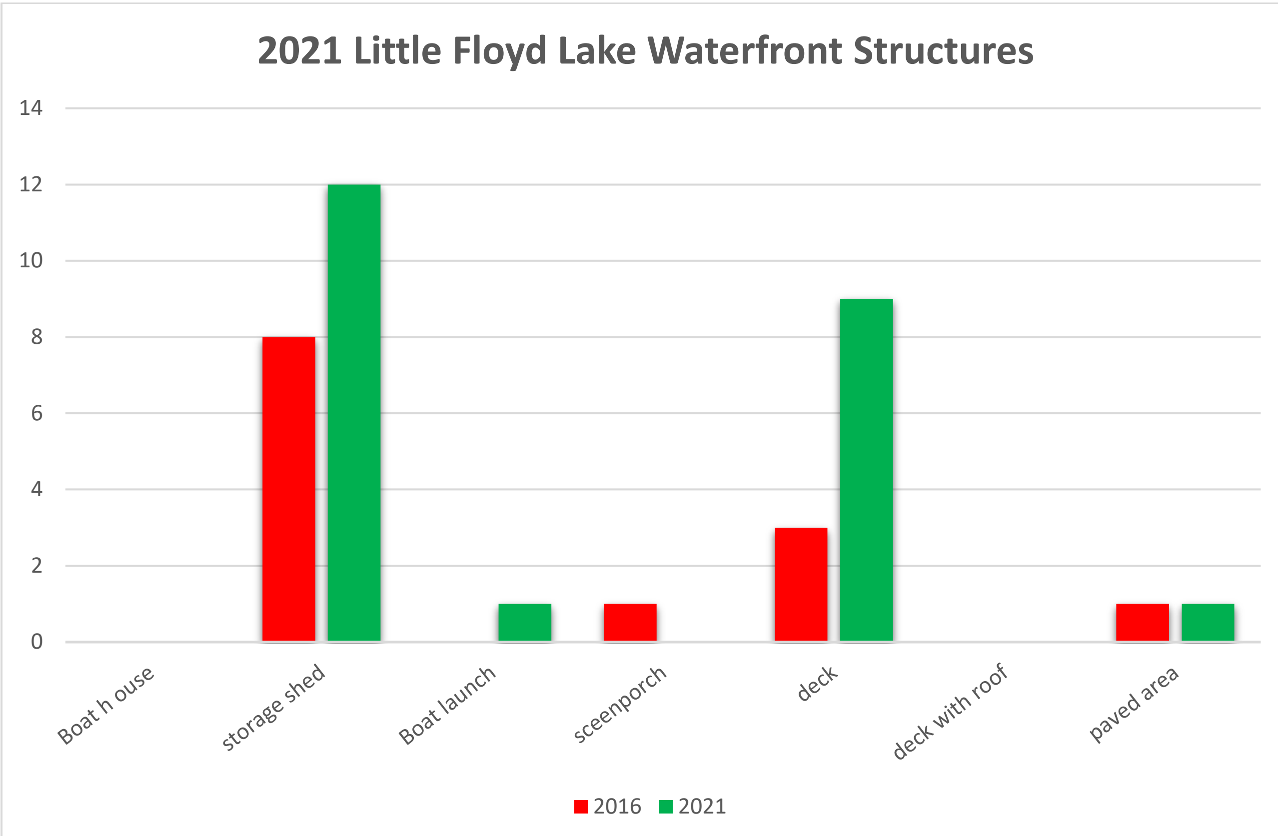


Figure 5.18. Little Floyd Lake waterfront structures.

5.1.2 Sands Lake

Sands Lake is small (104 acres) natural environment lake to the North of the Floyd Chain of Lakes (Figure 5.15). Sands is a shallow lake, with a maximum depth of 11 feet and a natural wetland fringe around the edge. The lake is land locked, with no significant surface inlets or outlets. Water quality in Sands Lake is marginal, with a 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.

No water quality data was collected in 2021. Data will be collected in 2022 and 2027. A Shoreline Survey is scheduled for 2025.

5.1 Streams/Ditches

5.1.1 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)
In 2021, Campbell Creek experienced one of its best years of water quality, due to the extended drought conditions from July through September. Since there was no stormwater runoff to carry sediment downstream North Floyd Lake had water quality benefits as well. By mid-July there was no stream flow and the last sample taken was on July 12th at CC1, and on August 20th at CC2 after a rainfall event. Even with a few minor rainfall events in July and August, Campbell Creek remained dry with no flow. The average concentrations at CC2 (April – mid-August) was 261 µg/L TP and 148 mg/L TSS. The average concentrations (April – mid-July) at CC1 was 118 µg/L TP and 57.4 mg/L TSS.

Water Quantity – Campbell Creek (Ditch 11/12)
Because of the major drought conditions (July – September) there was little to no water flow in the creek for most of the summer. Due to no stream flow, flow measurements could not be taken, and the District was not able to calculate water quantity for nutrient loading.

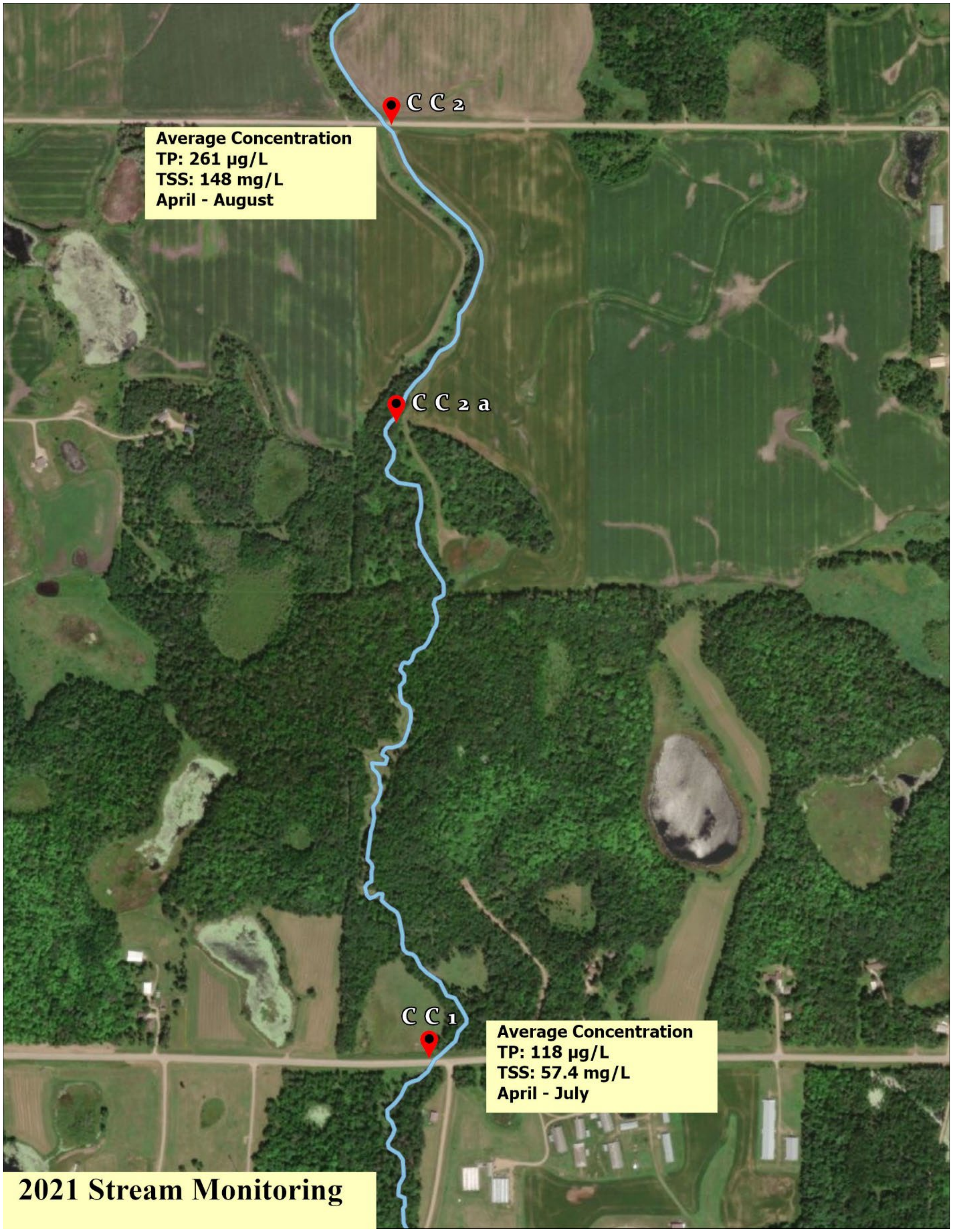


Figure 5.19. Pollutant loading on Campbell Creek.

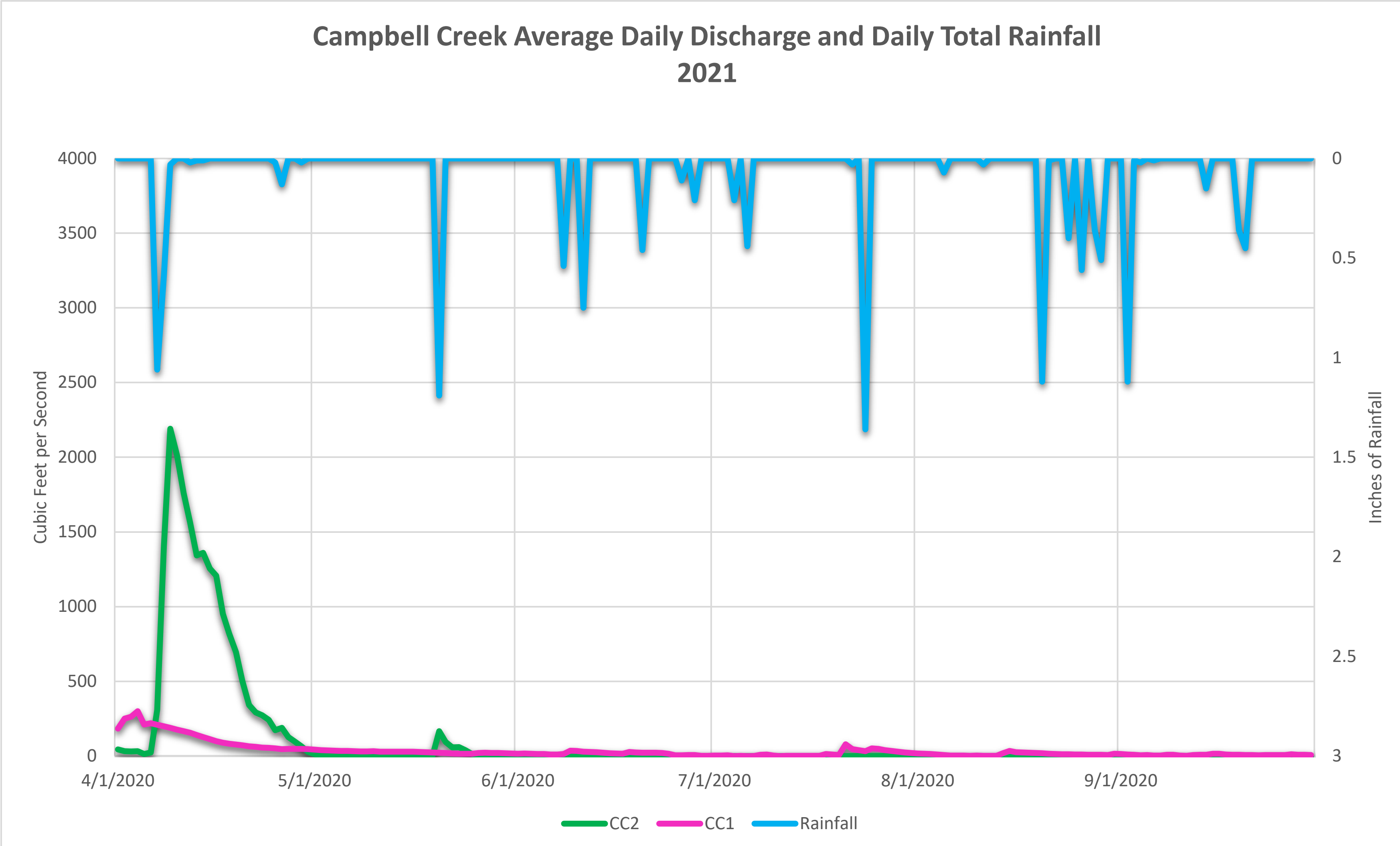


Figure 5.20. 2021 Average daily flows in Campbell Creek and Daily Total Rainfall. Data from Campbell Creek at 230th St (CC2) and CSAH 149 (CC1).

5.2.1.2 Ecological Integrity

In 2021 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. 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 5.21. Example of bank erosion on Campbell Creek. North of CSAH 149.

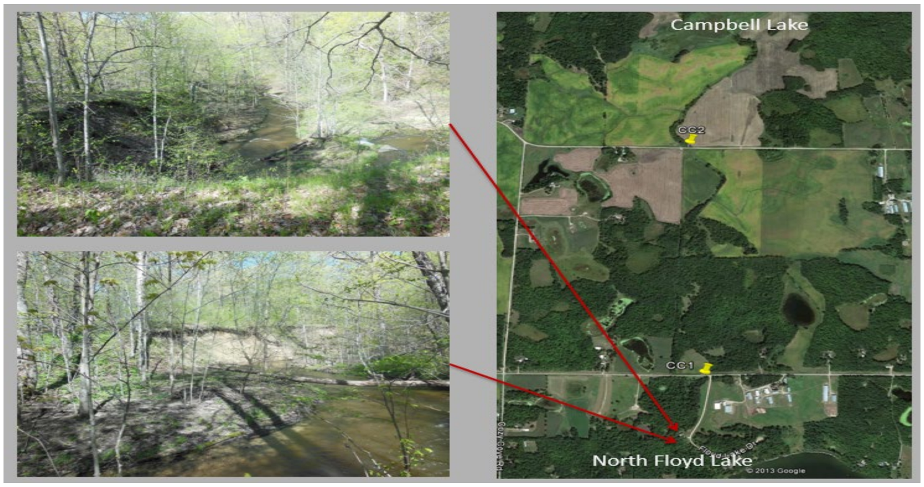


Figure 5.22 Targeted areas of stream channel erosion

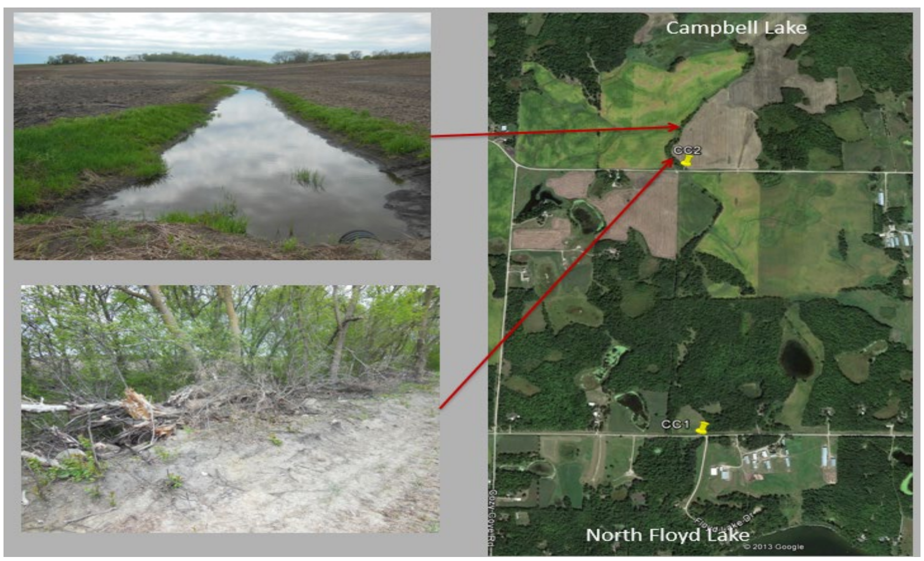


Figure 5.23 Targeted areas of stream channel erosion

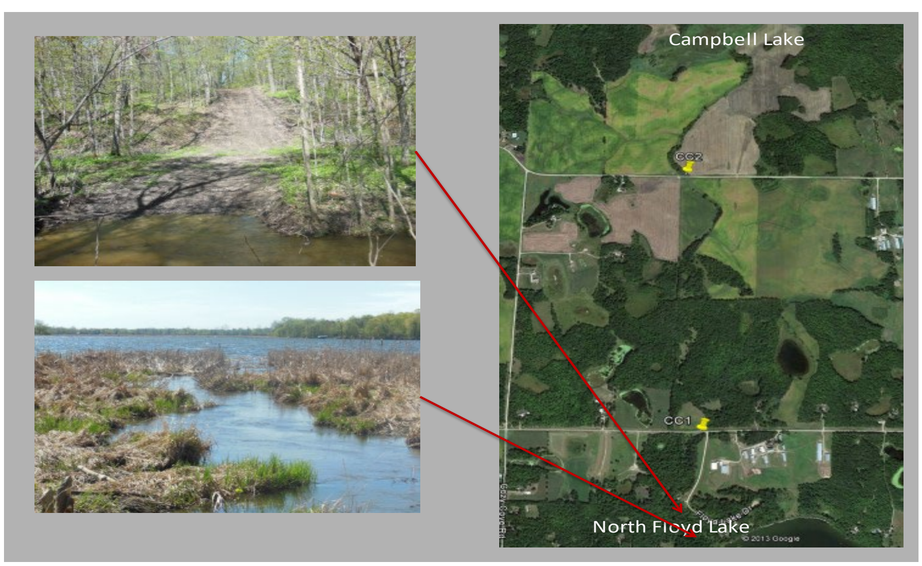


Figure 5.24 Targeted areas of stream channel erosion

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.

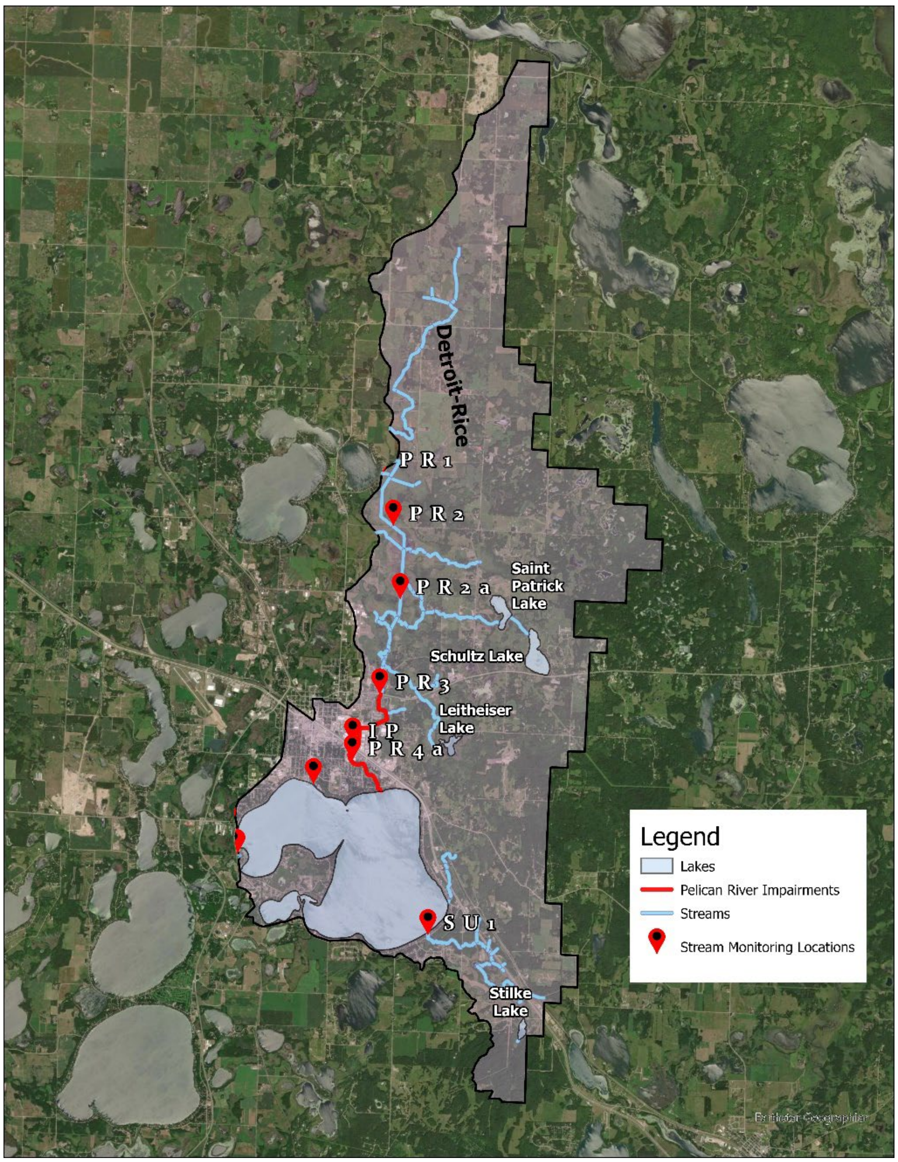


Figure 6.1. Detroit/Rice Water Management Area.

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 2021, the only water quality sampling in the WMA was on Detroit Lake (Big & Little). In 2022, the District will sample water quality on Detroit Lake and St. Patrick. Detroit Lake received chemical treatments for Flowering rush (*Butomus umbellatus)* and Curly-leaf pondweed (*Potamogeton crispus)* in 2021.

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.

AIS have a large effect on lake health and in turn, lakeshore property value. 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 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 Thursday, November 25, 2021. That date is about 5 days later than the average of 110 years for which record have been kept, but about 3 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 last year on November 11. We had December ice-on in 2001, 2004, 2009, 2016, 2017. Area residents enjoyed 206 days of open water in 2020, about 8 days less than the all-year average and 19 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
The Lakes do share a common outlet and OHW. The water level for Detroit Lake is measured at the outlet under County HWY 6/West Lake Drive. For 2021, water levels remained high for most of the beginning of the year (Figure 6.3). Towards the end of the year Detroit Lake dropped below its OHW and stayed there for the remainder of the season (Figure 6.2). The last reading the District took was on October 25th, at an elevation of 1333.65' MSL. The decreased rainfall events, causing a state-wide drought are to blame for the low water levels.

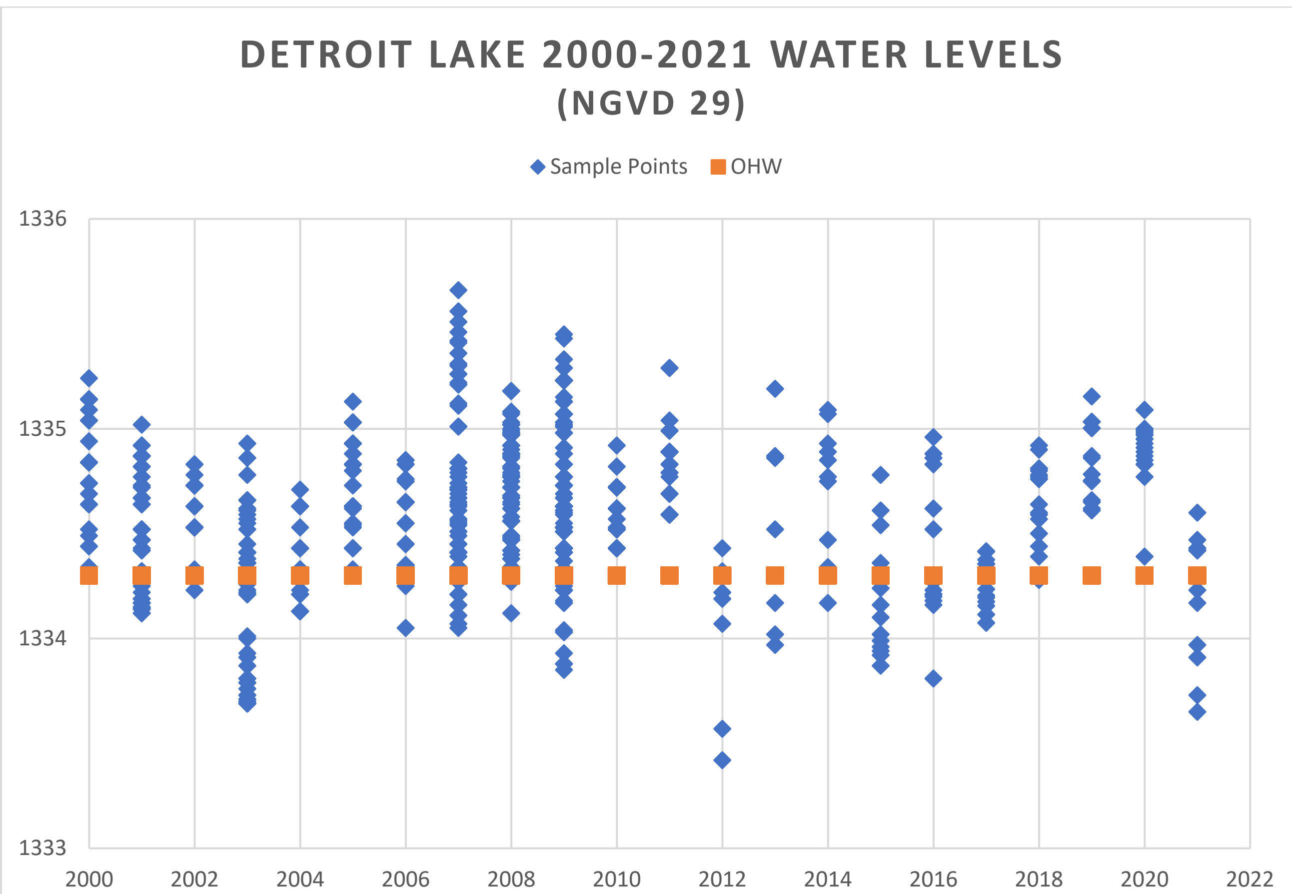


Figure 6.2. Detroit Lake Water Levels from 2000-2021.

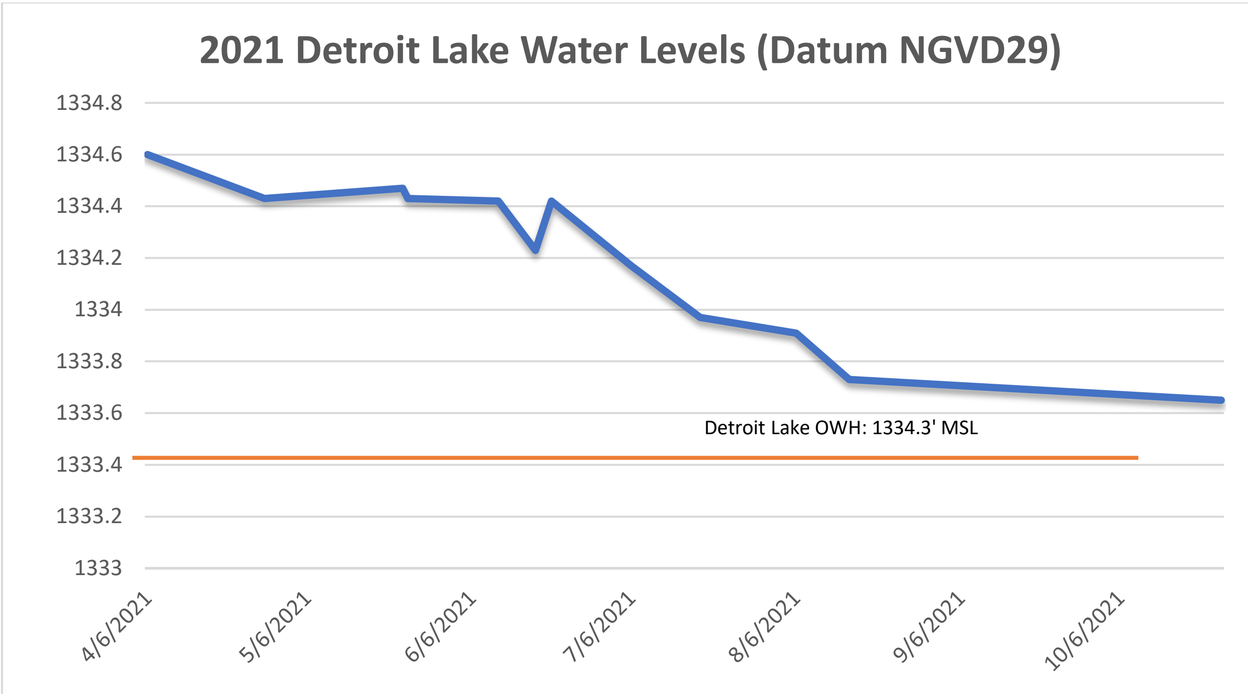


Figure 6.3. Detroit Lake Water Levels in 2021.

Water Quality – Big Detroit Lake

Big Detroit Lake had "better than average" water quality in 2021. The average TP was 15 µg/L, which was an improvement from 20- year average of 24 µg/L. On July 27th TP dropped dramatically down to 12 µg/L. CHL-a average was 3.85 µg/L, which was down from the 20-year average of 7.86µg/L. and water clarity (secchi depths) averaged at 17.25 feet, which was an improvement of almost 8 feet from the 20-year average (10.6 feet).

All samples came in just below their respective annual averages indicating improved water quality. This may be attributed to improved stormwater management as a result of Distict Rules enacted in 2003. Another important influence on water quality comes from the presence of zebra mussels. Detroit Lake has been infested with zebra mussels since 2016 and has been showing drastically increased water quality each year since. Zebra mussels increase secchi depth and decrease the CHL-a by filtering the water column. We did however see our water quality decrease towards the later part of the year and this could be attributed to the lack of rainfall event and the higher then normal temperatures causing the lake to warm, plants to grow more and algea blooms to form or the lake "turn over" in late August.

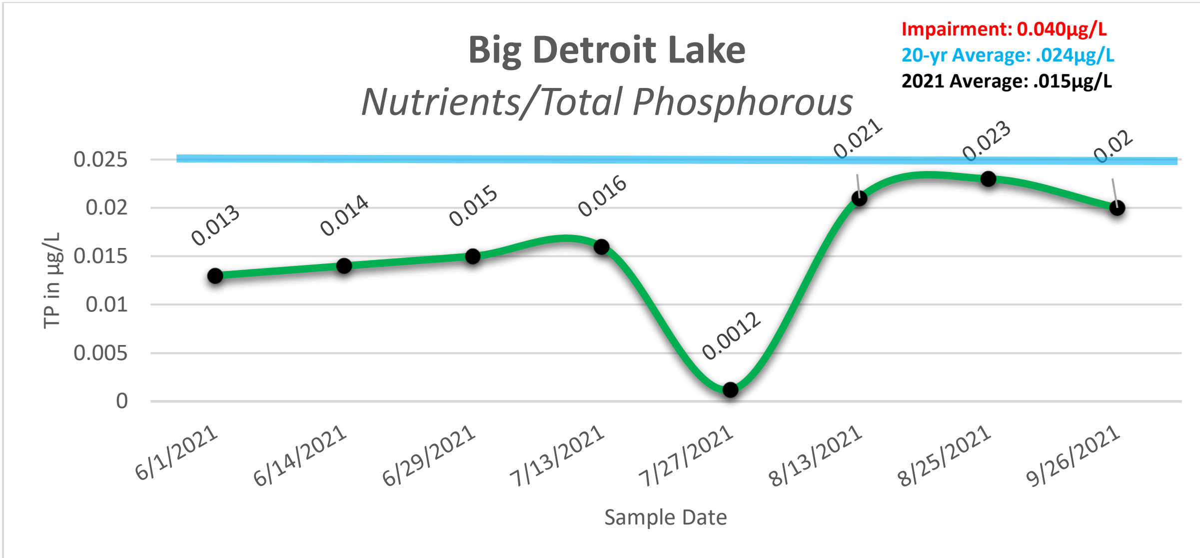


Figure 6.4. Big Detroit Lake 2021 total phosphorous.

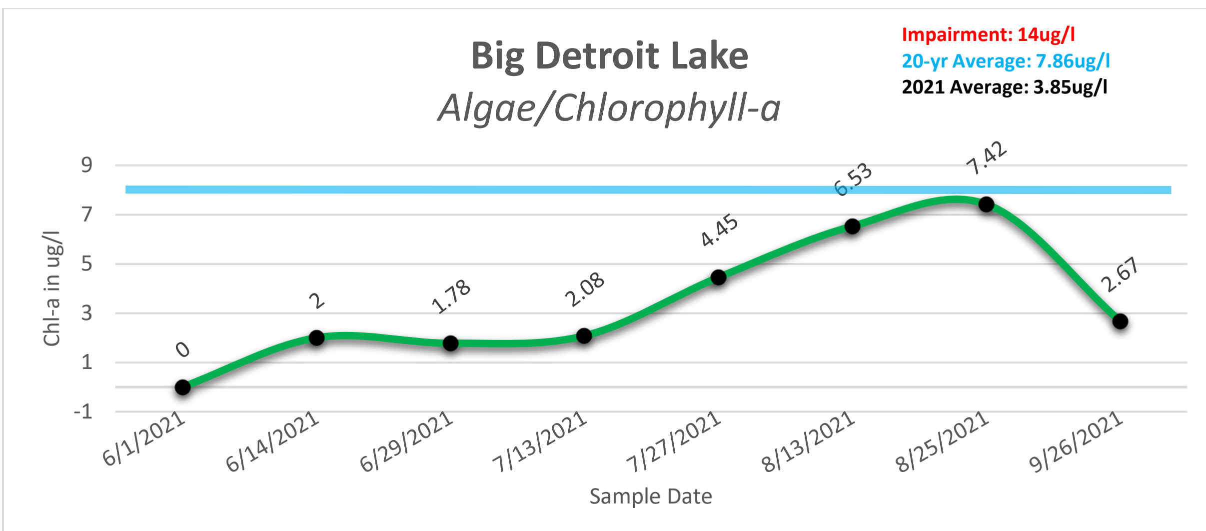


Figure 6.5. Big Detroit Lake 2021 chlorophyll-a.

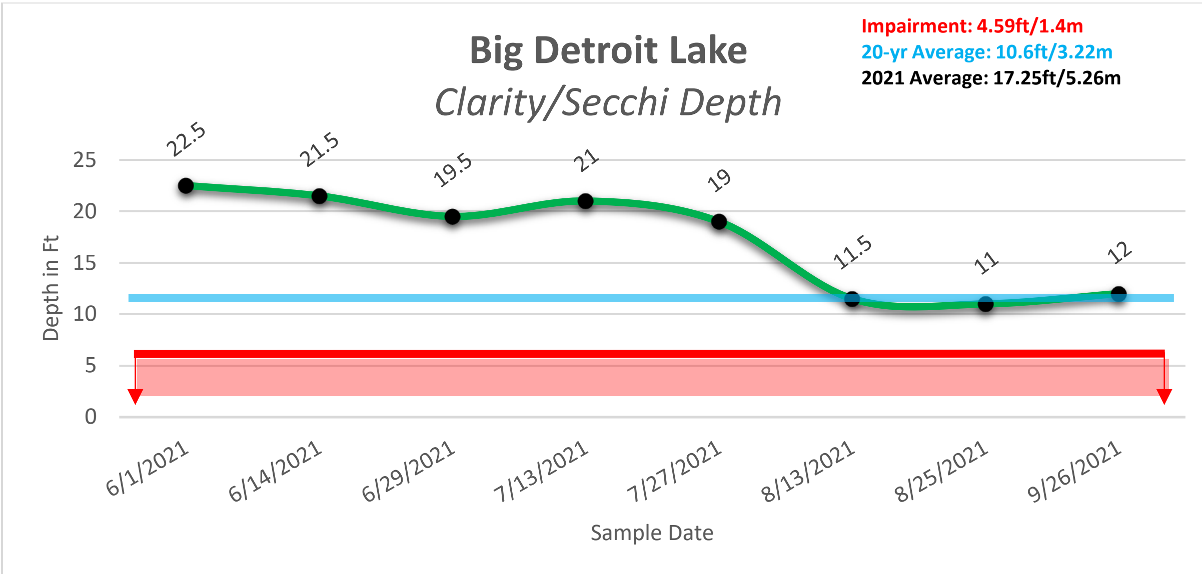


Figure 6.6. Big Detroit Lake 2021 secchi depth.

Water Quality – Little Detroit Lake.

Lake also experienced a "better than average" water quality year. The average TP (Figure 6.7), CHL-A (Figure 6.8), and secchi depths (Figure 6.9) of 13 µg/L, 2.24µg/L, and 13.8' were all improved from their respective 20-year averages of 19 µg/L, 4.45µg/L, and 11.6'. TP readings spiked just above the historical average of 19 µg/L once during the summer (9/26/21), CHL-A readings remained below the 20-year average for the duration of the summer, Secchi stayed above the 20-year average of 11.6' except for on 8/25/21 it dipped down to 10'.

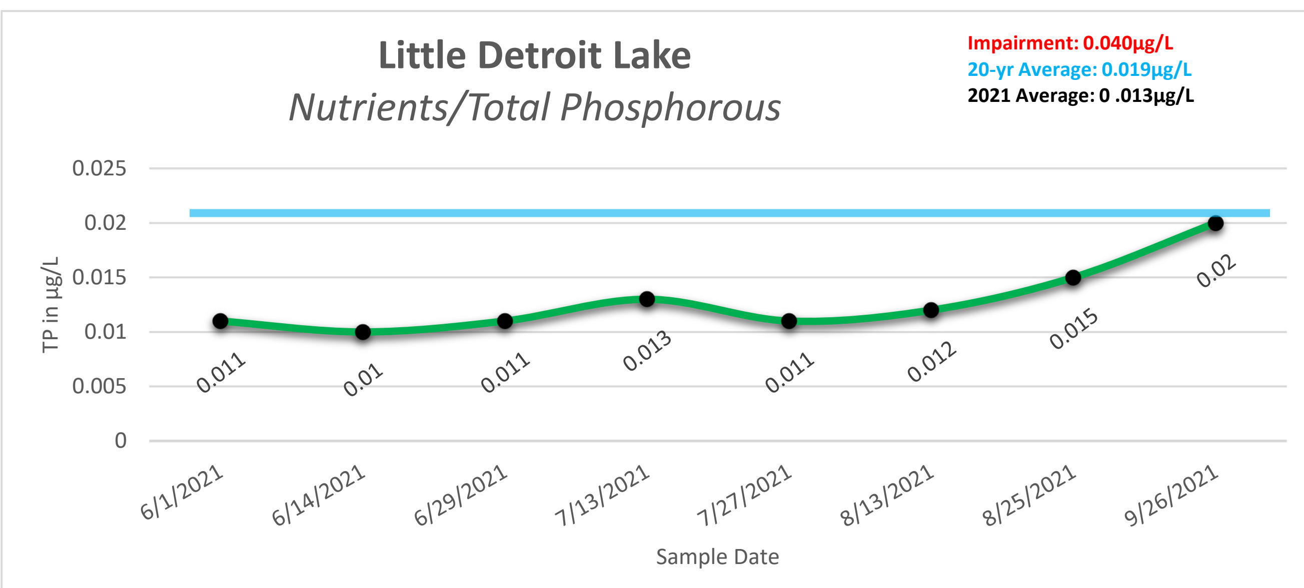


Figure 6.7. Little Detroit Lake 2021 total phosphorous

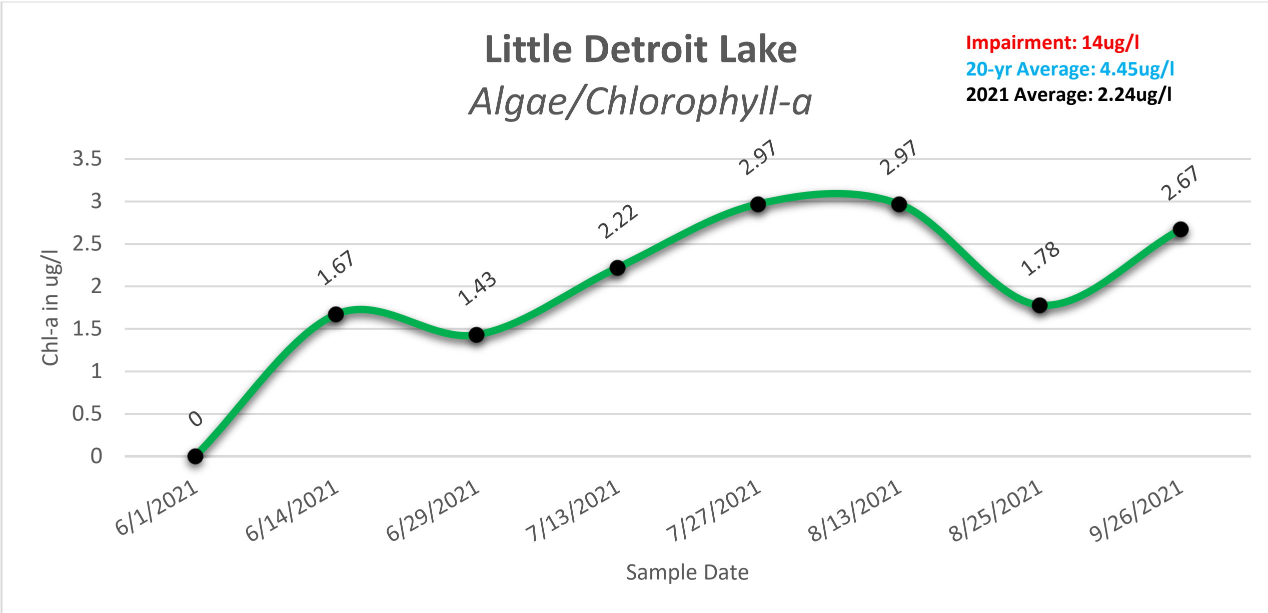


Figure 6.8. Little Detroit Lake 2021 chlorophyll-a.

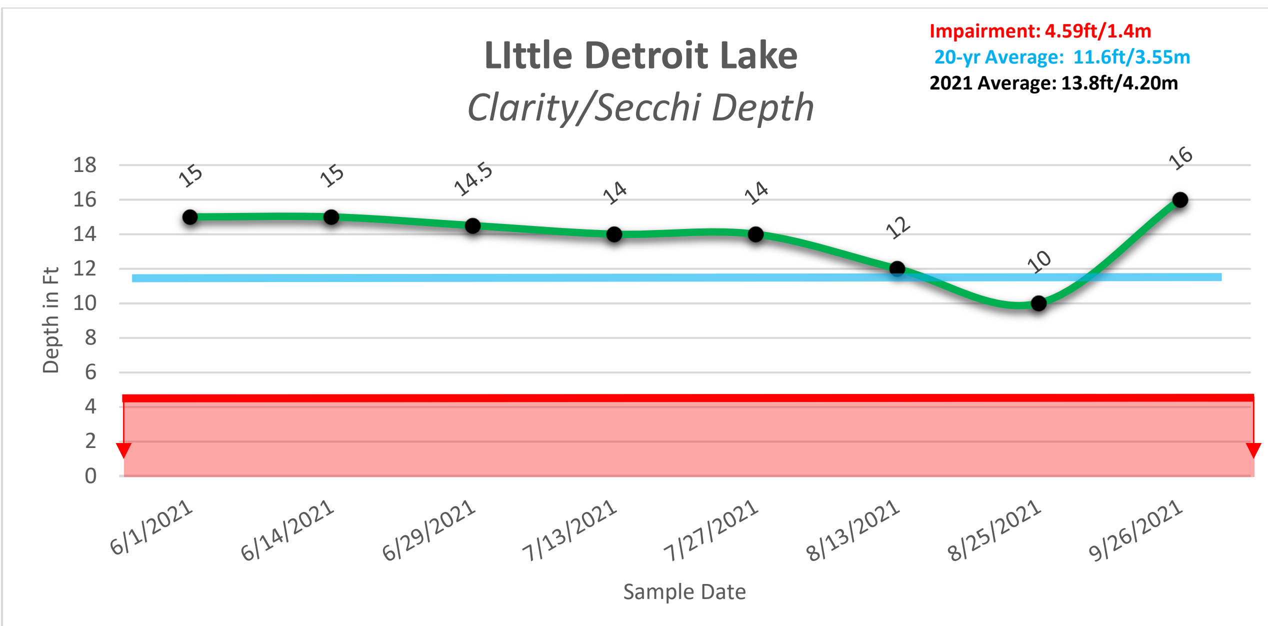


Figure 6.9. Little Detroit Lake 2021 secchi depth.

6.1.1.2 Ecological Integrity

Aquatic Invasive Species Control

Detroit Lake was treated with chemical for flowering rush and curly-leaf pondweed in 2021. A total of 16.1 acres of curly-leaf pondweed and 49.35 acres of flowering rush were treated (Figure 6.10). The 49.35 acres of flowering rush were treated twice, once on June 28th and once on August 9th. These treatments are greatly reduced from historic treatments (maximum of 172.7 acres of flowering rush in

2013, and a 37.53% reduction of curly-leaf pondweed from 2020) signaling the effectiveness of the District's chemical AIS treatments. The District will continue to monitor and treat AIS on Detroit Lake in the coming years.

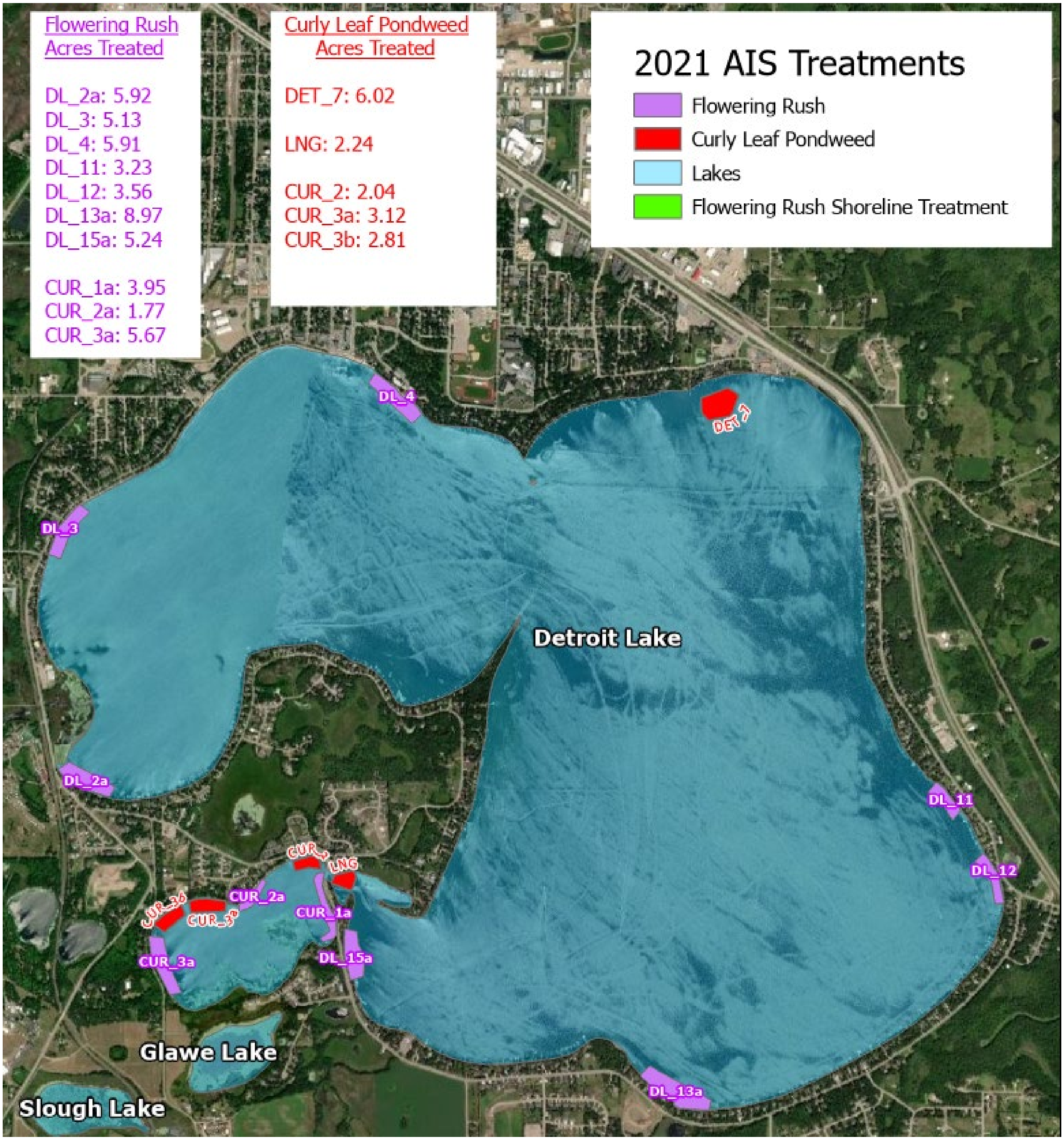


Figure 6.10. Aquatic invasive species treatments on Detroit Lake in 2021.

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 planning a restoration project to limit loading from the Rice Lake Wetland.

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 an average water quality year in 2021 (Figure 6.11). Concentrations at Site PR1 (outlet of Little Floyd Lake) was 16 µg/L TP and 4 µg/L OP; Site PR2A was 45 µg/L TP and 14 µg/L OP; Site PR3 (HWY 34/PR) was 51 µg/L TP, and 42 µg/L OP; and PR4a was 75 µg/L TP and 14 µg/L OP. Staff noted the presence of beaver dams between the PR2A and PR3 Upper structure of the Rice Lake wetland restoration project went on-line in fall of 2021.

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 2022 and beyond.

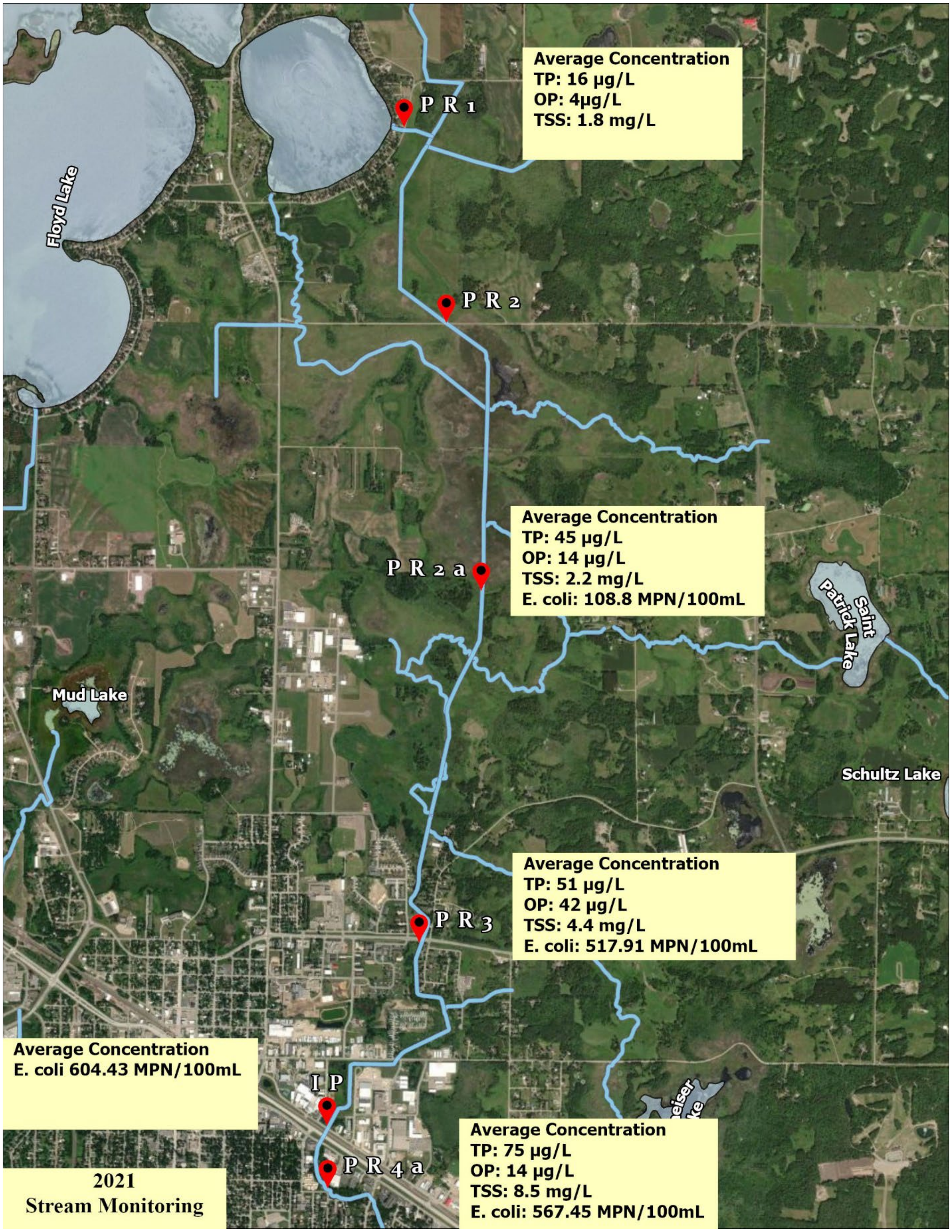


Figure 6.11. Pelican River sampling in the Detroit/Rice WMA.

The impairments on the Pelican River are directly related to low DO in river. The District purchased an automated DO sampler in 2019 and deployed it in Pelican River North of HWY 10 (Figure 6.12). Extreme daily fluctuations in DO were observed, with some readings bottoming out at 0.54 µg/L on August 24th. For reference, Walleye (*Sander vitreus)* prefer concentrations above 5.0 µg/L, can survive down to 2.0 µg/L, and anything below 1.0 µg/L is deadly. Every type of aquatic life form has different tolerances to DO concentrations, which is why IBI scores can be used to judge the health of a stream. The low IBI scores assigned to the Pelican River shows it is not hospitable for very many species of aquatic life. Drivers of this low DO can vary, but the District suspects high *E. coli* loads, and the altered hydrology of the Rice Lake Wetland as factors.

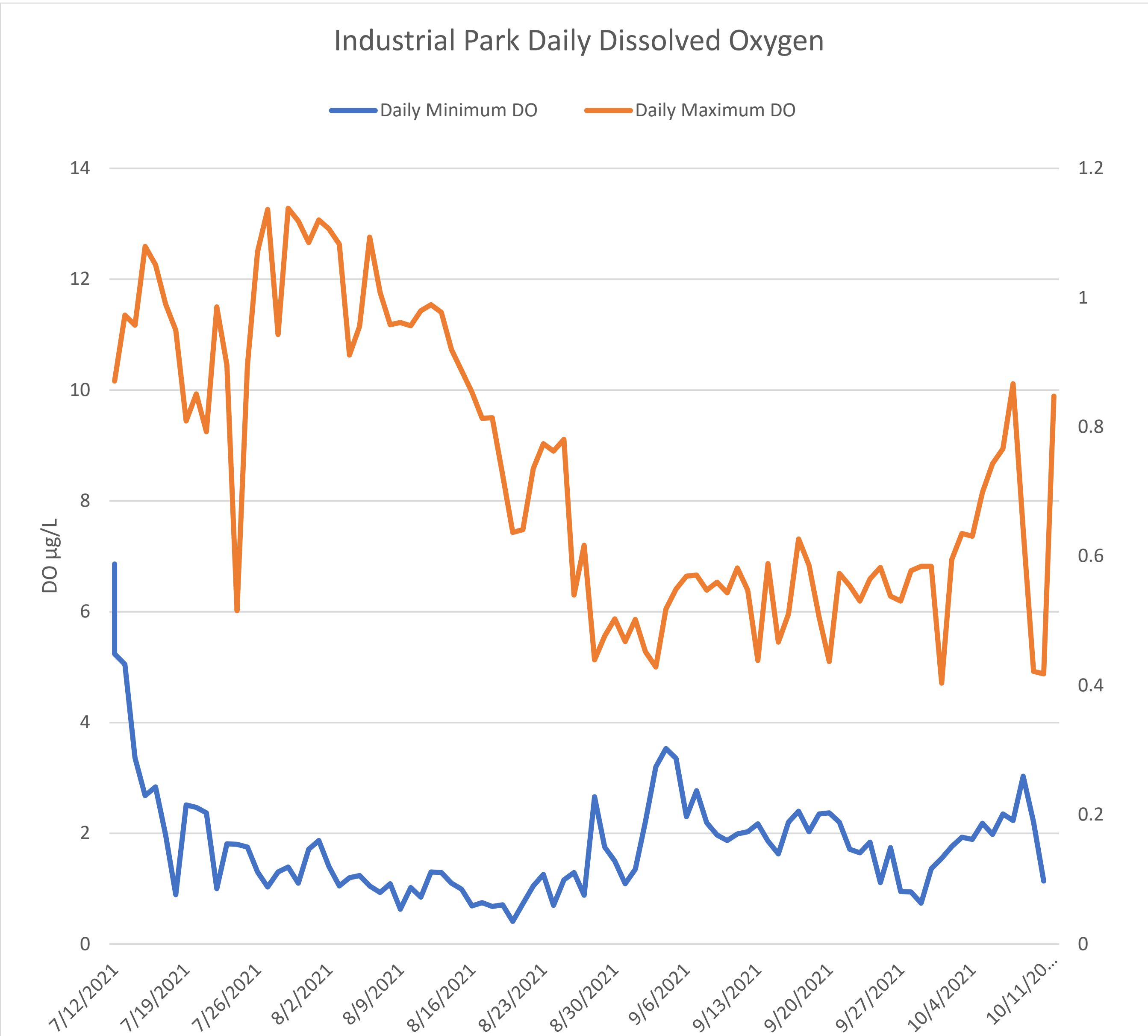


Figure 6.12. Dissolved oxygen fluctuations in the Pelican River. Readings taken in the Industrial Park North of Minnesota Highway 10.

In 2021, the District routinely sampled *E. coli* concentrations at 3 locations (PR2a, PR3, and PR4a; Figure 6.11) and after storm events at 1 location (IP). Samples ranged from 2 MPN/100ml at PR2a on 7/26/21 to topping the lab's readings at >2,419.6 MPN/100ml at PR4a on 8/20/21. This data supports the MPCA listed impairment for *E. coli* loads (average >126 MPN/100ml or >10% of sample above 1260 MPN/100ml).

The high *E. coli* loads in the Pelican River is a perplexing problem. The District is still unsure what is contributing to these loads. Previous studies of the City of Detroit Lake sanitary sewer system have not found any leaks into the Pelican River. *E. coli* source testing performed in 2018 has been inconclusive as to the source of the *E. coli* as well. The District has been incrementally testing the Pelican River to see if there is an area where concentrations spike, but results have been inconclusive. Staff sampled stormwater ponds in the Industrial Park area North of HWY 10 adjacent to the Pelican River and found some spikes in concentrations (up to 1046.2 MPN/100ml on 7/6/21). We will continue our investigation in 2022 to try to narrow the source.

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).

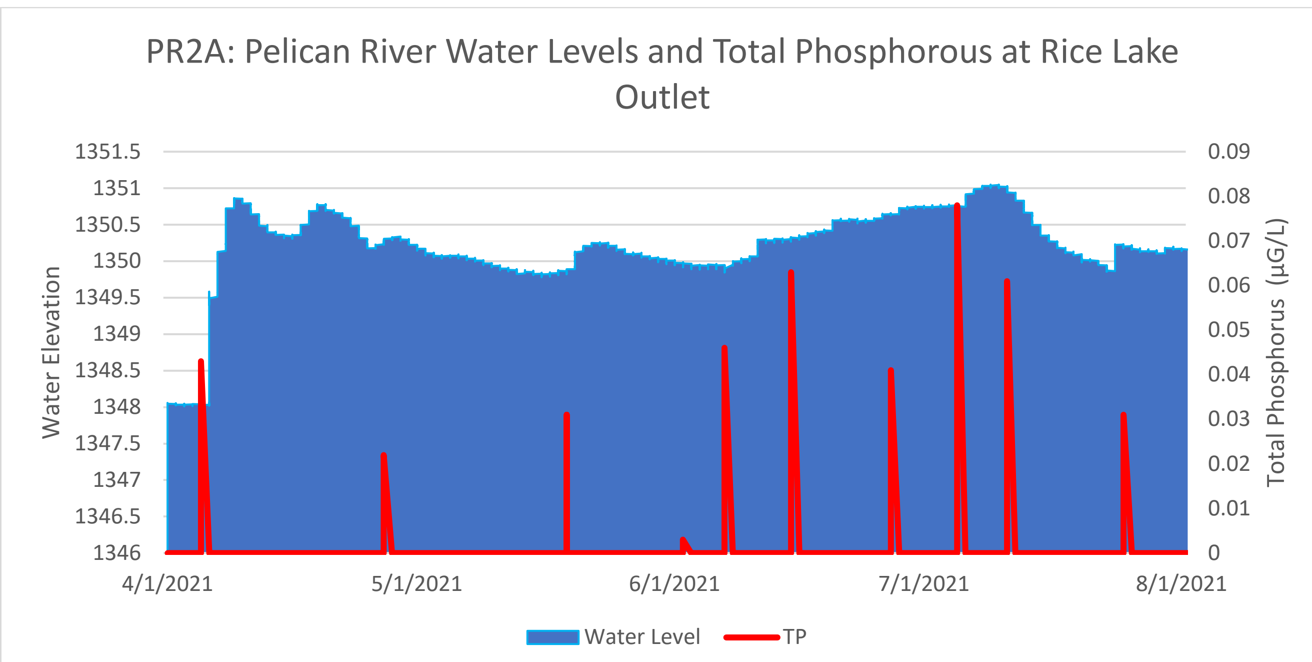


Figure 6.13. 2021 Water Level and total phosphorous at Rice Lake Outlet.

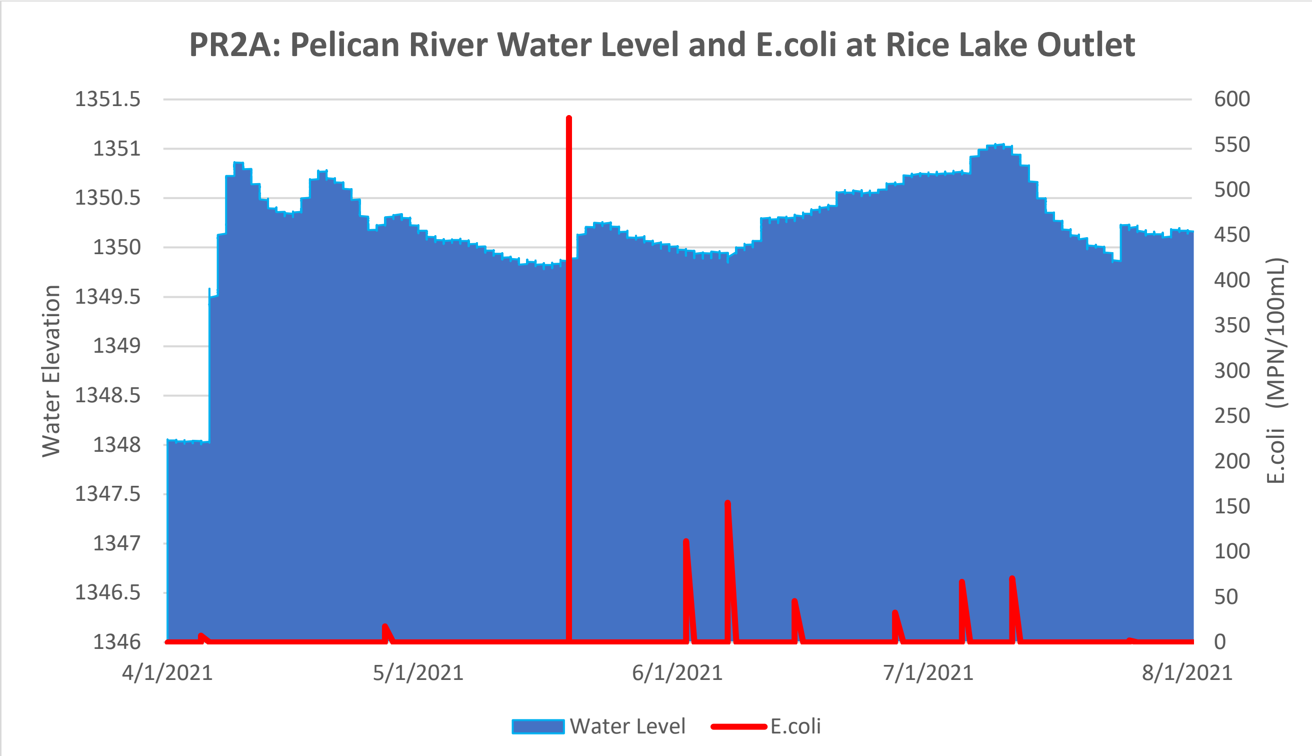


Figure 6.14. 2021 Water levels and E. coli at Rice Lake Outlet.

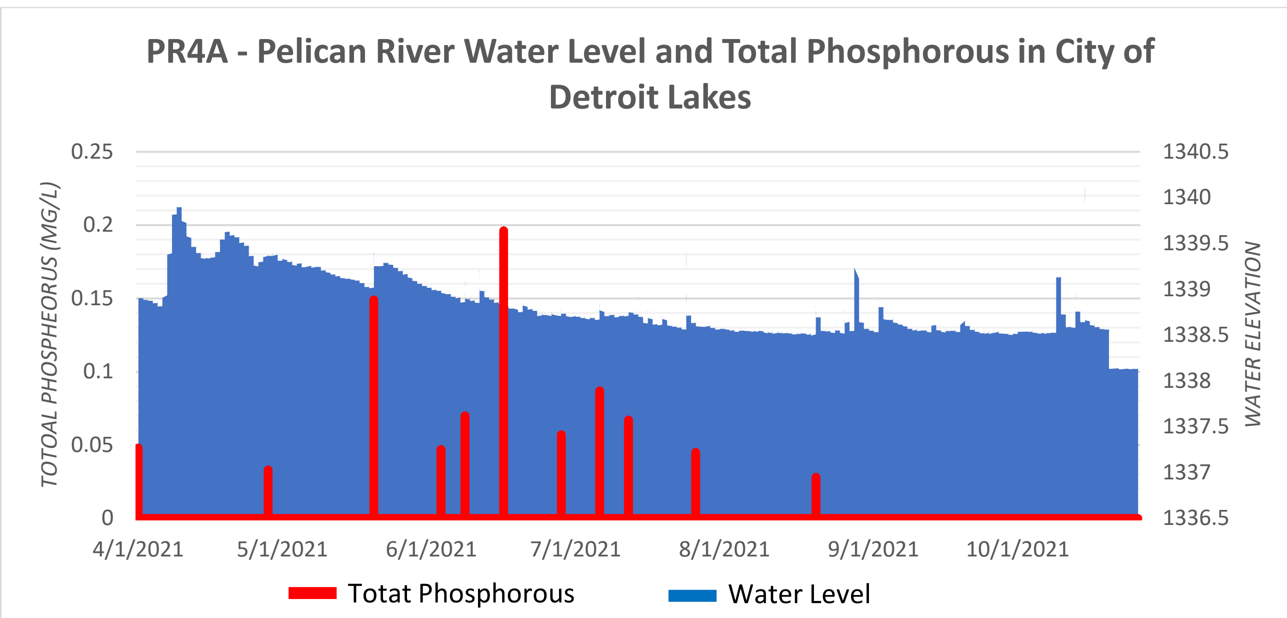


Figure 6.15. 2021 Water levels and total phosphorous in City of Detroit Lakes. Samples taken at location PR4a, near Jackson Ave. Storage units.

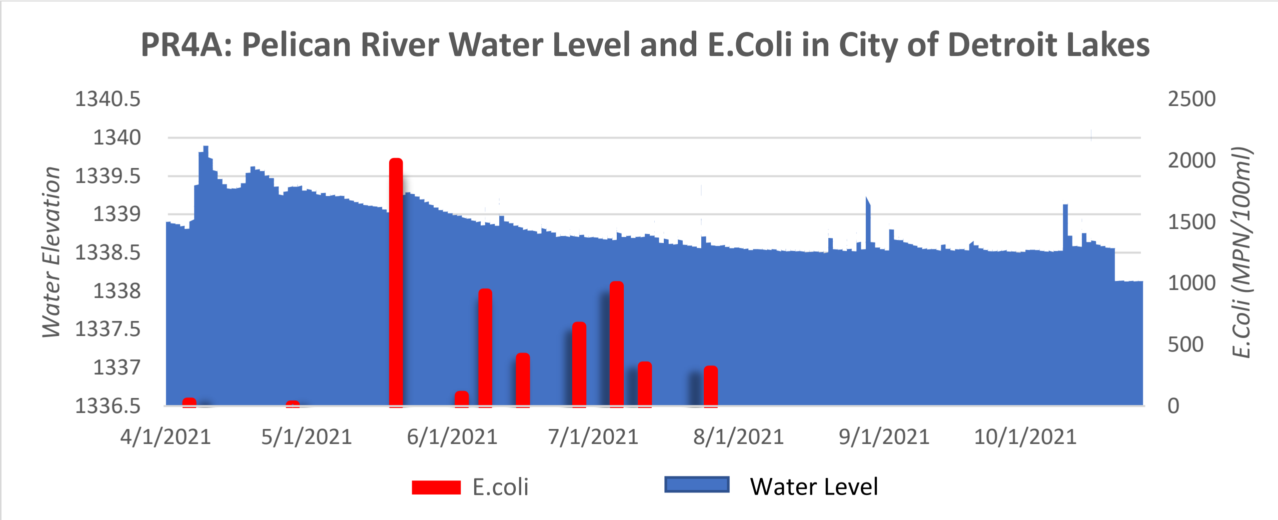


Figure 6.16. 2021 Water levels and *E. coli* in City of Detroit Lakes. Samples taken at location PR4a, near Jackson Ave. storage units. Sample on 5/20/21 reached 1986.3 MPN/100ml.

6.2.2 Sucker Creek

Sucker Creek is a natural creek that flows into the Southeast shore of Big Detroit Lake. Sucker Creek is protected by the Sucker Creek Nature Preserve, a protection area aimed to preserve the natural state of Sucker Creek and educate people about the benefits of natural systems. Sucker Creek is the District's only designated trout stream. Because if its unique natural state, the District monitors water quality at one point on the creek

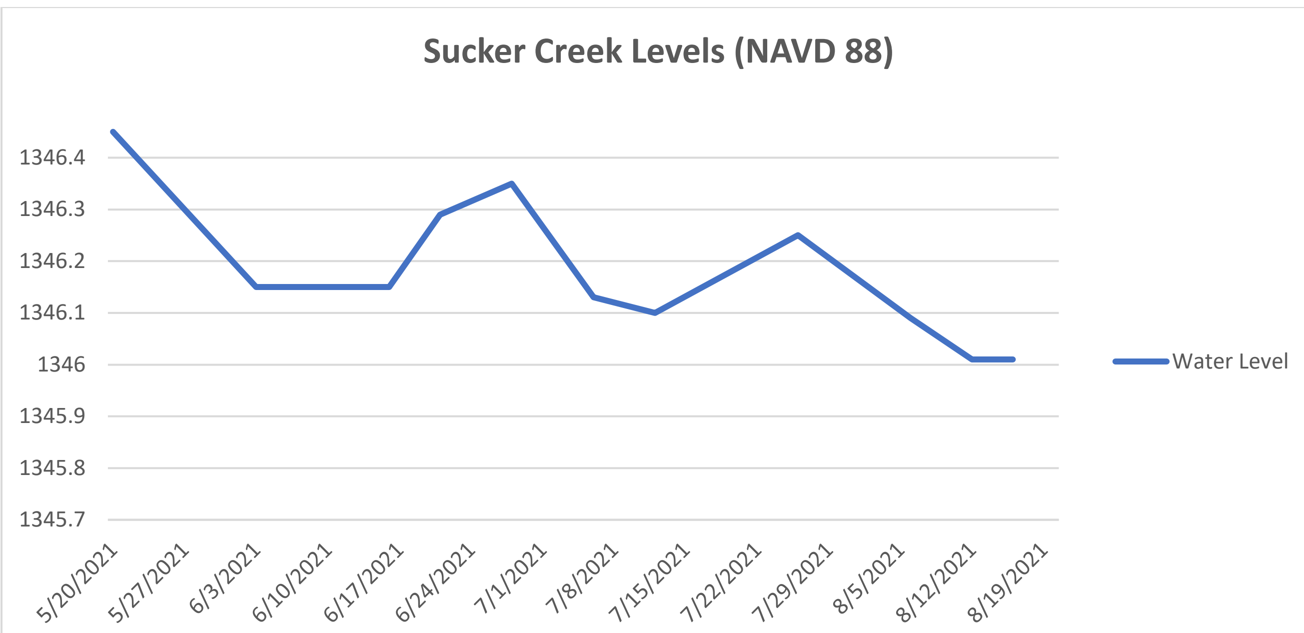
Figure 6.17. Sucker Creek sampling location.

6.2.2.1 Water Quality/ Quantity

Water Quality – Sucker Creek

Staff collected 10 samples from April – July, until the creek stopped flowing in August. Average TP was at 33 µg/L and OP was at 13 µg/L. Average TP concetration during routine sampling was 27 µg/L however, the TP average spiked up to 41 µg/L during storm events (3) which increased the overall annual average TP concentration. Dissolved Oxygen (DO) readings averaged 8.58 mg/l, sufficient for trout to use the stream for spawning Because of the major drought conditions (July – September) there was little to no water flow in the creek for latter part of the summer, there was an insufficient number of flow measurements taken and nutrient loads could not be calculated.

Water Quantity – Sucker Creek



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 leave 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).

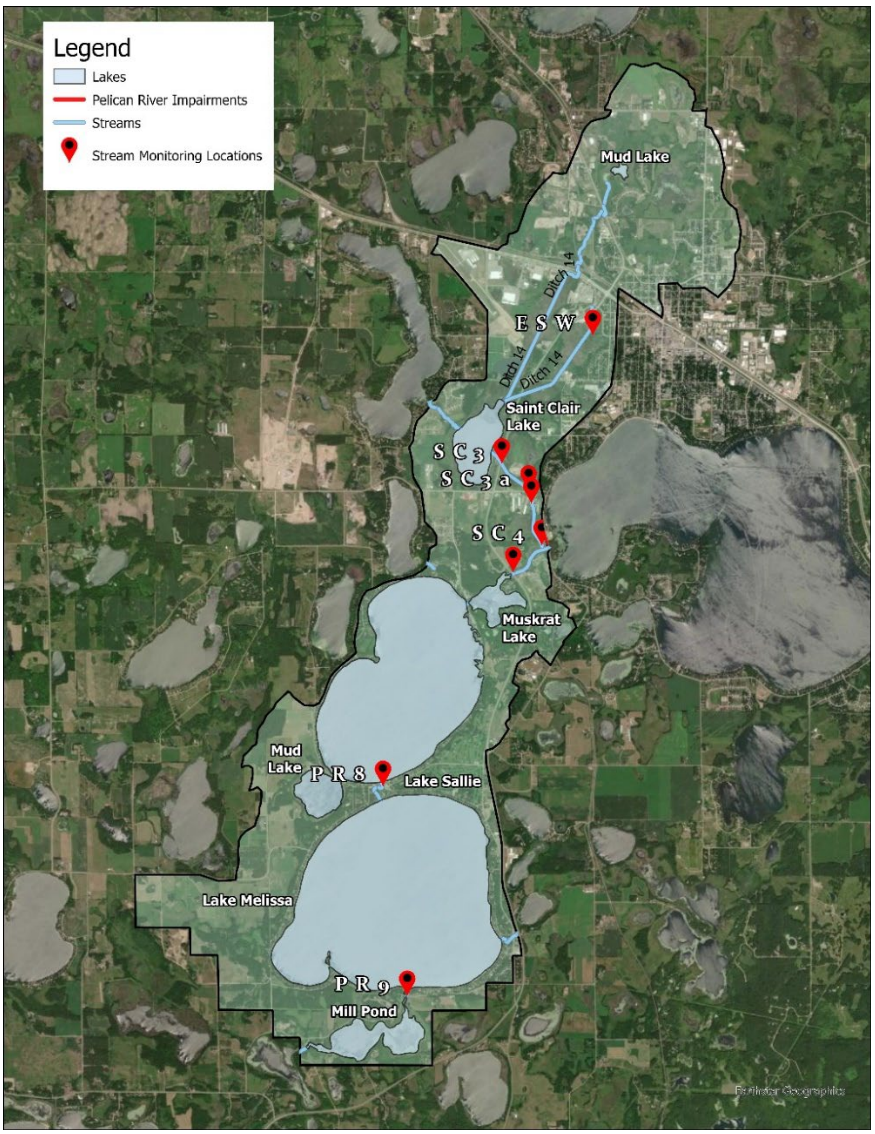


Figure 7.1. Sallie/Melissa Water Management Area.

7.1 Lakes

The Sallie/Melissa WMA has 6 lakes within its borders (Mill Pond, Lake Melissa, Mud Lake, Lake Sallie, Muskrat Lake, and St. Clair Lake), all of which are sampled in the 2020-2030 Monitoring Plan (Mud Lake is not sampled). In 2021, The District sampled St. Clair Lake, Lake Sallie, Lake Melissa, and Muskrat Lake for water quality. Lakes Sallie, Melissa, and Muskrat received chemical treatments for Flowering rush and/or Curly-leaf pondweed. A vegetation survey was conducted on Lake Sallie and Lake Melissa.

7.1.1 St. Clair Lake

St. Clair Lake originally was a 591-acre lake located west of the Detroit Lakes. In about 1915 the lake was drained to its present size of 140 acres because of the "awful stench" it presented to the local residents. This was caused by more than seventy years of untreated sewage 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%. The city continues to discharge treated effluent wastewater on the north side of the lake. 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 131µg/L to 72µg/L, with a similar reduction in orthophosphate. Phosphorus level began to trend upward beginning in the early 2010's showing that the ALUM treatments effectiveness had begun to wear and that another dose will be required to maintain a phosphorus concentration below 80 µg/L.

In 2016, the MPCA accepted the St. Clair Lake Total Maximum Daily Load (TMDL) study. The study showed that the lake is capable of a daily loading capacity of 2.75 lbs. of phosphorus a day. This equates to a 24% reduction of the current load. The TMDL report allowed for an increase in nutrient load for the City of Detroit Lakes Wastewater Treatment Facility by 95 lbs/yr, a 28% increase to allow for population growth and annexation within the city. To meet the reduction goal, the total reduction of phosphorus in non-point sources (stormwater runoff from within the City of Detroit Lakes) is 277 lbs/yr, a 49% decrease from the existing condition.

7.1.1.1 Water Quality/Quantity

Water Quality- St. Clair Lake

St. Clair Lake was right around average for water quality in 2021. Average TP was 55 µg/L, which is well below the 20-year average, CHL-A (Figure 7.3), and secchi depths (Figure 7.4) of 55 µg/L, 19.03 µg/L, and 4.5' were improved from the historic averages of 84 µg/L, 38.87 µg/L, and 3.2'. All of the TP, CHL-A and Secchi samples taken were above the MPCA impairment standards. Only once did all 3 fall below the MPCA impairment standards of which was on 7/7/21.

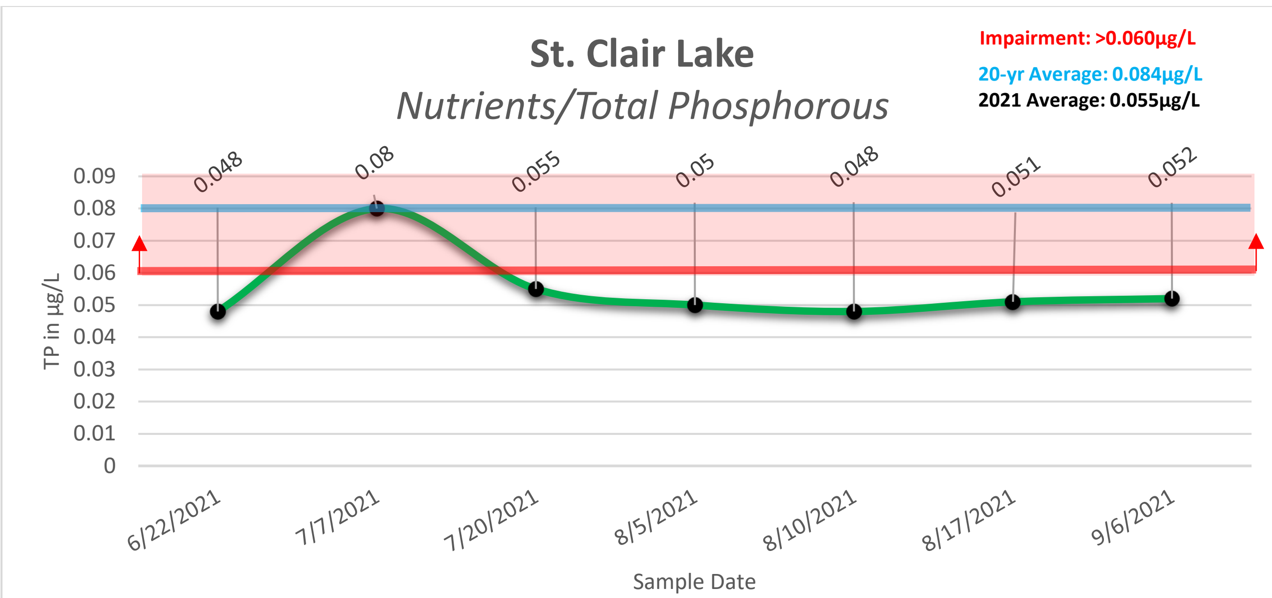


Figure 7.2. St. Clair Lake 2021 total phosphorous.

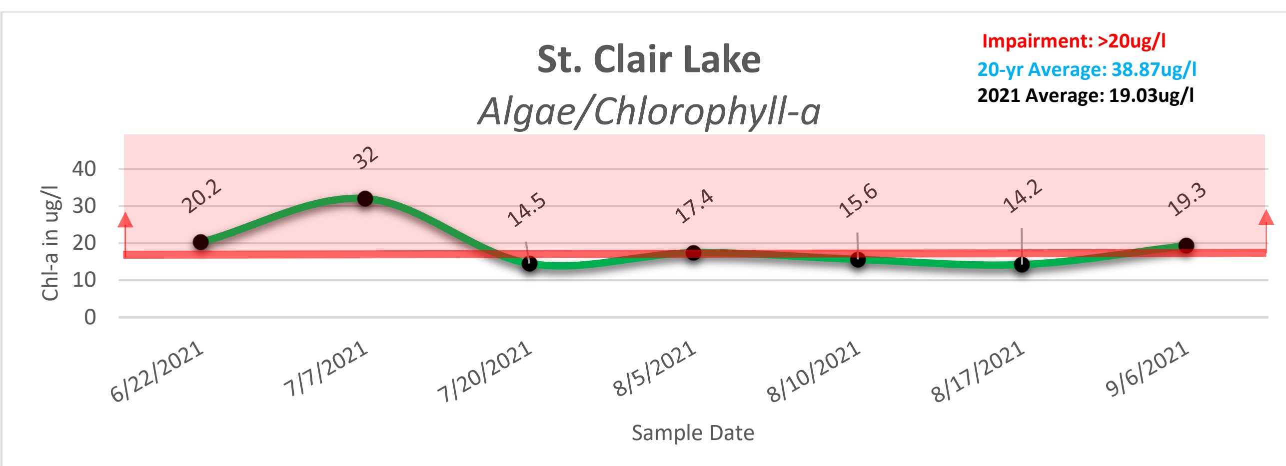


Figure 7.3. St. Clair Lake 2021 chlorophyll-a.

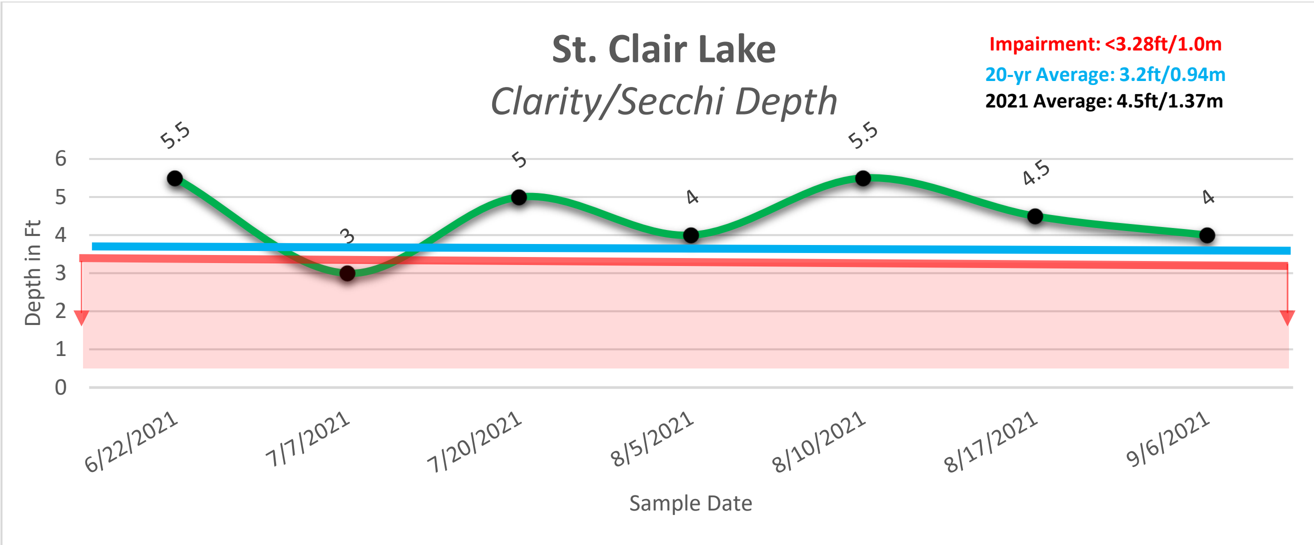


Figure 7.4. St. Clair Lake 2021 secchi depth.

An increased improvement of water quality in St. Clair Lake was noted in 2021 with TP averaging 55/ µg/L (20-year average of 84 µg/L) (Figure 7.2). The new wastewater treatment plant discharges daily into St. Clair Lake – an operational change from the previous treatment methods which discharged treated water into spray irrigation fields, rapid infiltration basins and holding ponds. Since treated water is being discharged daily directly into St. Clair, it may be diluting the higher TP in-lake concentrations. For comparison, 2017 average TP was 107/ µg/L, in 2018 average TP was 111/ µg/L; in 2019 average TP was 82/ µg/L; and 2020 average TP dropped to 57/ µg/L (the upgraded wastewater treatment plant (WWTP) went online in 2020). CHL-A average was 19 µg/L an improvement from the 20-year average of 39 µg/L (Figure 7.3). Secchi depths were 4.5 feet, also an improvement from the 20-year average of 3.2 feet (Figure 7.4).

Water Quantity – St. Clair Lake

The District has a gage at HWY 59 and records Ditch 14 downstream of Lake St. Clair.

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. It should be noted, beginning the 2018 the City of Detroit Lake began to upgrade the WWTP which discharges wastewater effluent into St. Clair Lake. While the water will be low in nutrients, the volume will increase to about 1 million gallons per day, which was previously land applied during summer months. This may increase the nutrient load from the Ditch 14 wetlands.

7.1.2.1 Water Quality/Quantity

Water Quality – Muskrat Lake
Muskrat Lake had great water quality in 2021. Average TP was 26 µg/L compared to the 20 year average of 44µg/L, CHL-A for 2021 was 5.98 µg/L, the 20 year average was 6.03 µg/L, and secchi depths in 2021 were 9.9 feet and the 20 year average was 8.83 feet. All were great compared to the MPCA impairment standards of TP >60µg/L, CHL-A >20 µg/L, and Secchi depths of 3.3'.

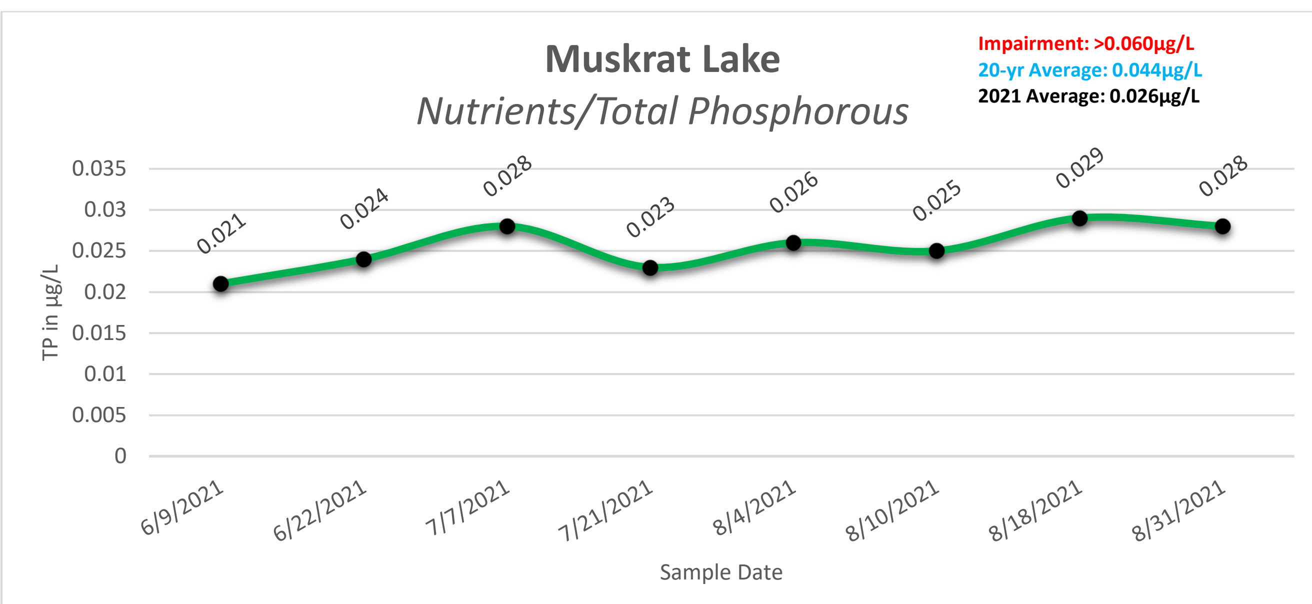


Figure 7.5. Muskrat Lake 2021 total phosphorous.

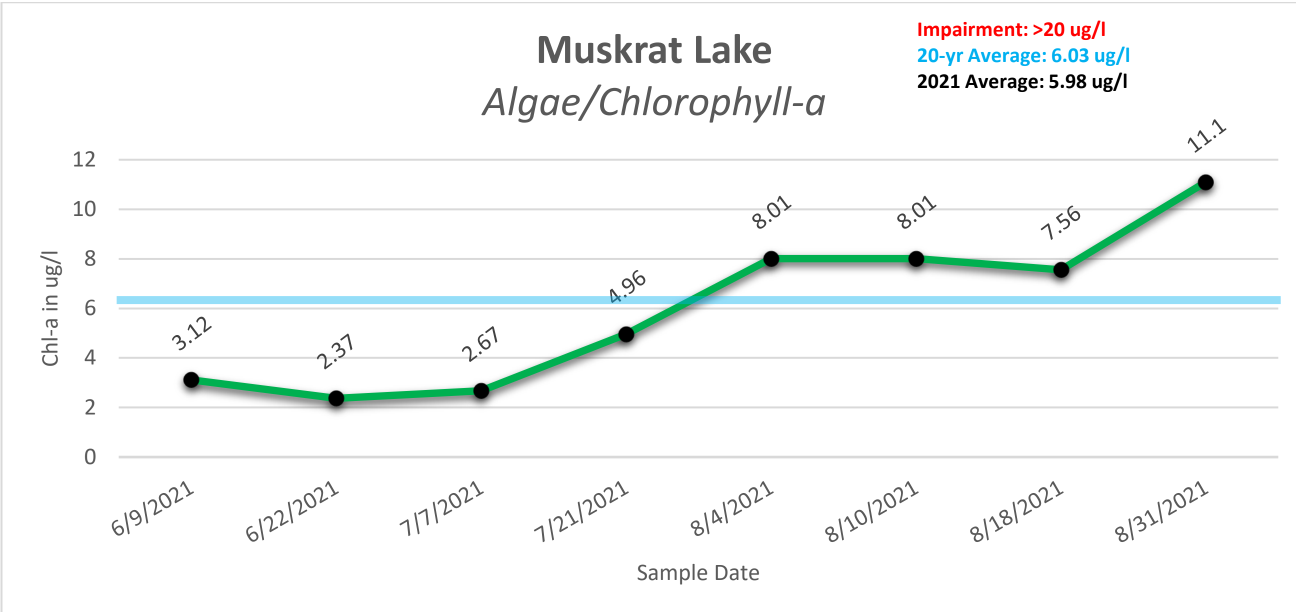


Figure 7.6. Muskrat Lake 2021 total Chlorophyll-a.

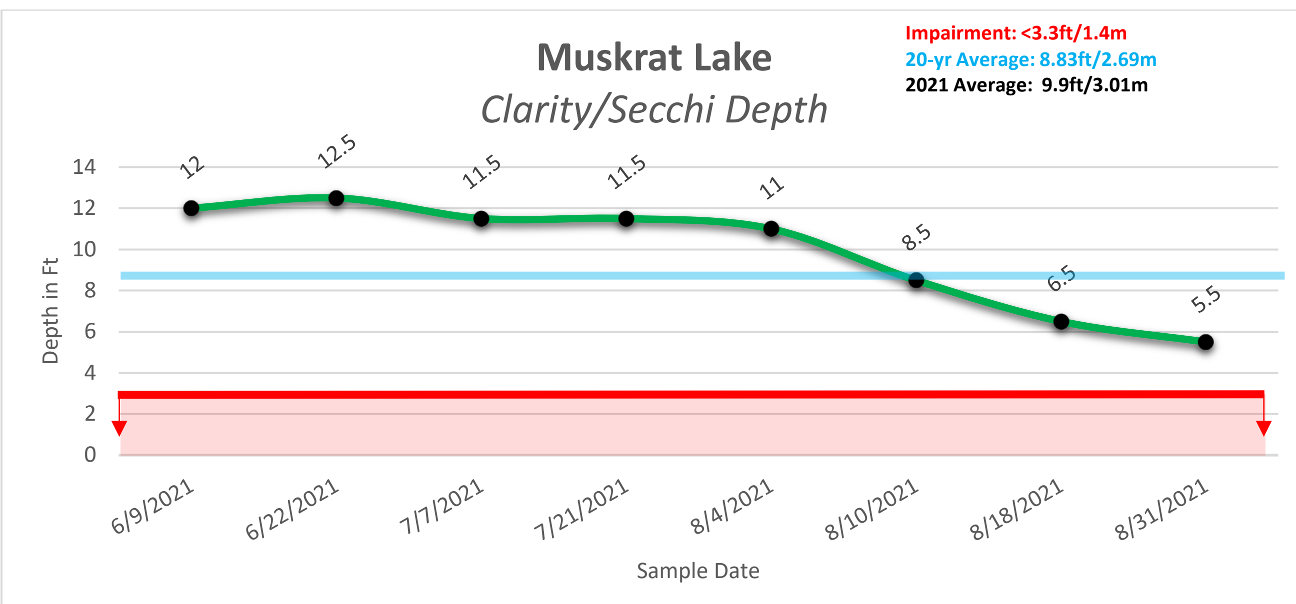


Figure 7.5. Muskrat Lake 2021 secchi depth.

7.1.2.2 Ecological Integrity

Aquatic Invasive Species Control

The District treated a total of 8.98 acres of curly-leaf pondweed on Muskrat Lake in 2021 (Figure 7.6). A mixture of Endothall and Diquat were used to treat this bed. Unfortunately, the treatment was not effective, and the bed persisted after the treatment. Since Muskrat Lake is a small reservoir, water flow through the system is faster than other lakes, limiting the chemical's contact time. The District has tried treating AIS in Muskrat Lake several times with little success. The District needs to explore new methods to increase chemical contact time in this system, perhaps diverting water flow away from the treatment area.

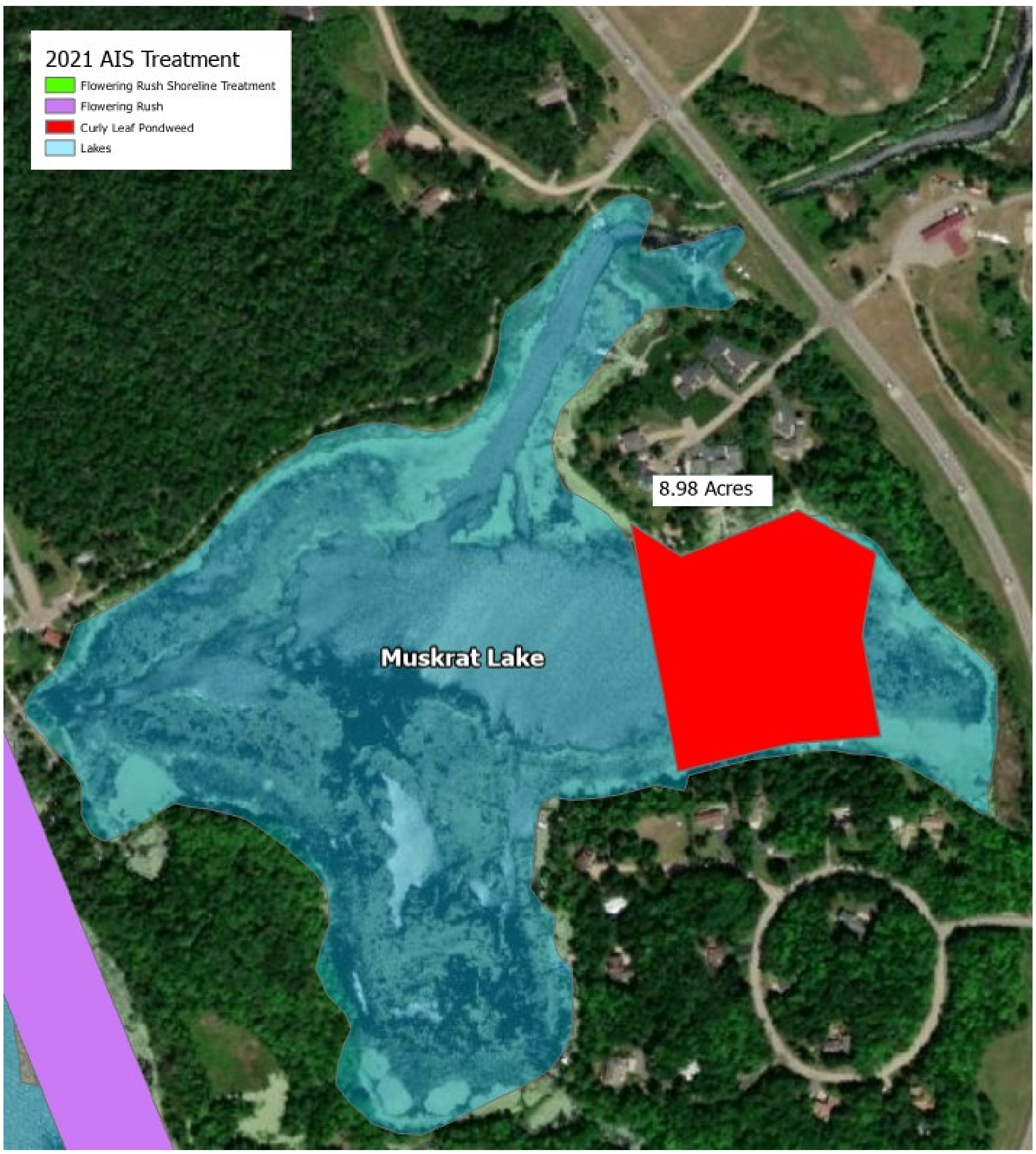


Figure 7.8. Curly-leaf Pondweed treatment on Muskrat Lake 2021.

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 is 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, 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. The current facility, upgraded in 2002, further reduced load to Lake Sallie, resulting in the current mean summer levels between 35 µg/L and 37 µg/L.

While it 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 the 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

Lake Sallie experienced an improvement in water quality in 2021 compared to historic averages. The average TP 20 µg/L, improved from the 20-year average of 32 µg/L, CHL-A average in 2021 was 4.73 µg/L which as a big improvement from the 20-year average of 11.66 µg/L and secchi depth for 2021 was 13.06 feet, another drastic improvement from the historic average of 8.73 feet. These improved readings are likely due to multiple factors including improvement of upstream phosphorous sources (impervious surfaces in the City of Detroit Lakes, St. Clair loading, Detroit Lake water quality improvement etc.), shoreline restorations and stabilizations, outflow of in lake nutrients over the years.

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. The effects of zebra mussels also cannot be negated as seen in the increase in secchi depth and decreasing CHL-A. Even the worst readings for both did not reach the 20-year average.

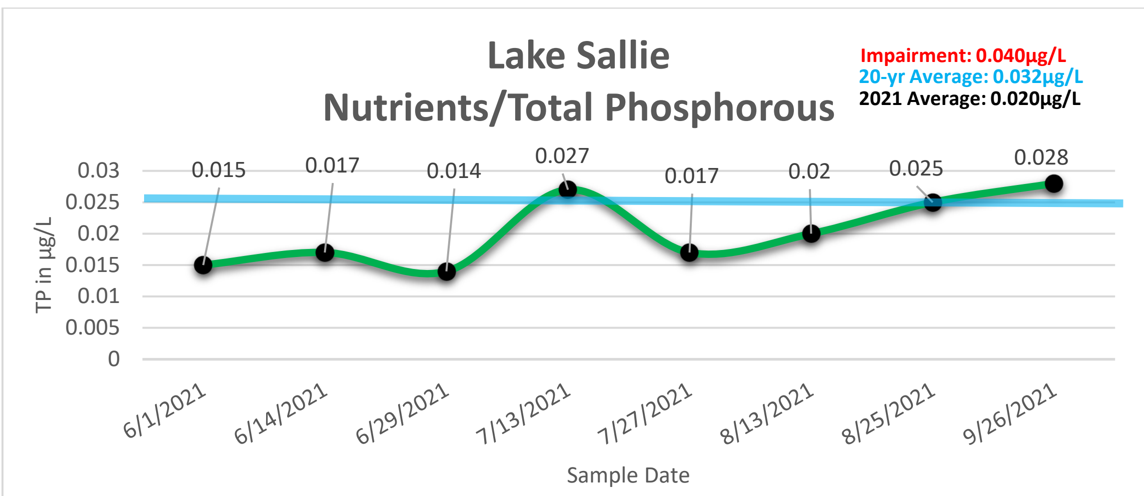


Figure 7.9. Lake Sallie 2021 total phosphorous.

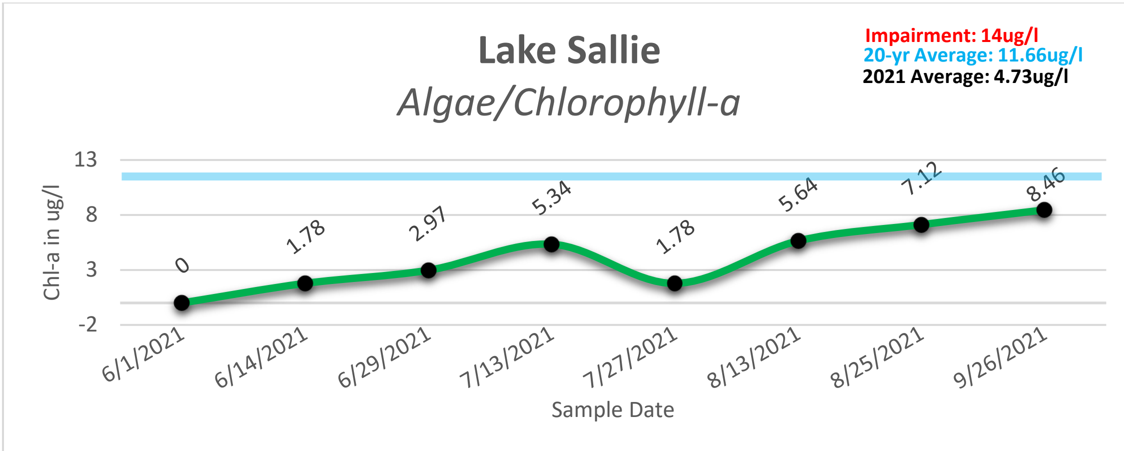


Figure 7.10. Lake Sallie 2021 chlorophyll-a.

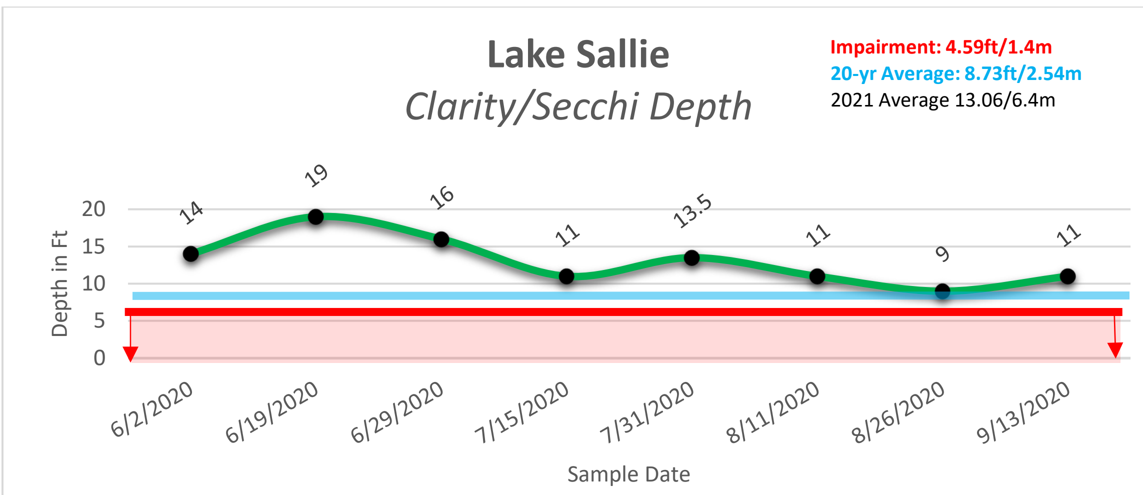


Figure 7.11. Lake Sallie 2021 secchi depth.

Water Quantity – Lake Sallie
Water levels on Lake Sallie are recorded at the outlet, at County HWY 22. Water Levels in 2021 were extremely low (Figure 7.10), falling way below the OHW for the majority of the year (Figure 7.11). Water levels fluctuated between the low 1325.57' MSL on 5/25/21 to high of 1329.44' MSL on 6/11/21.

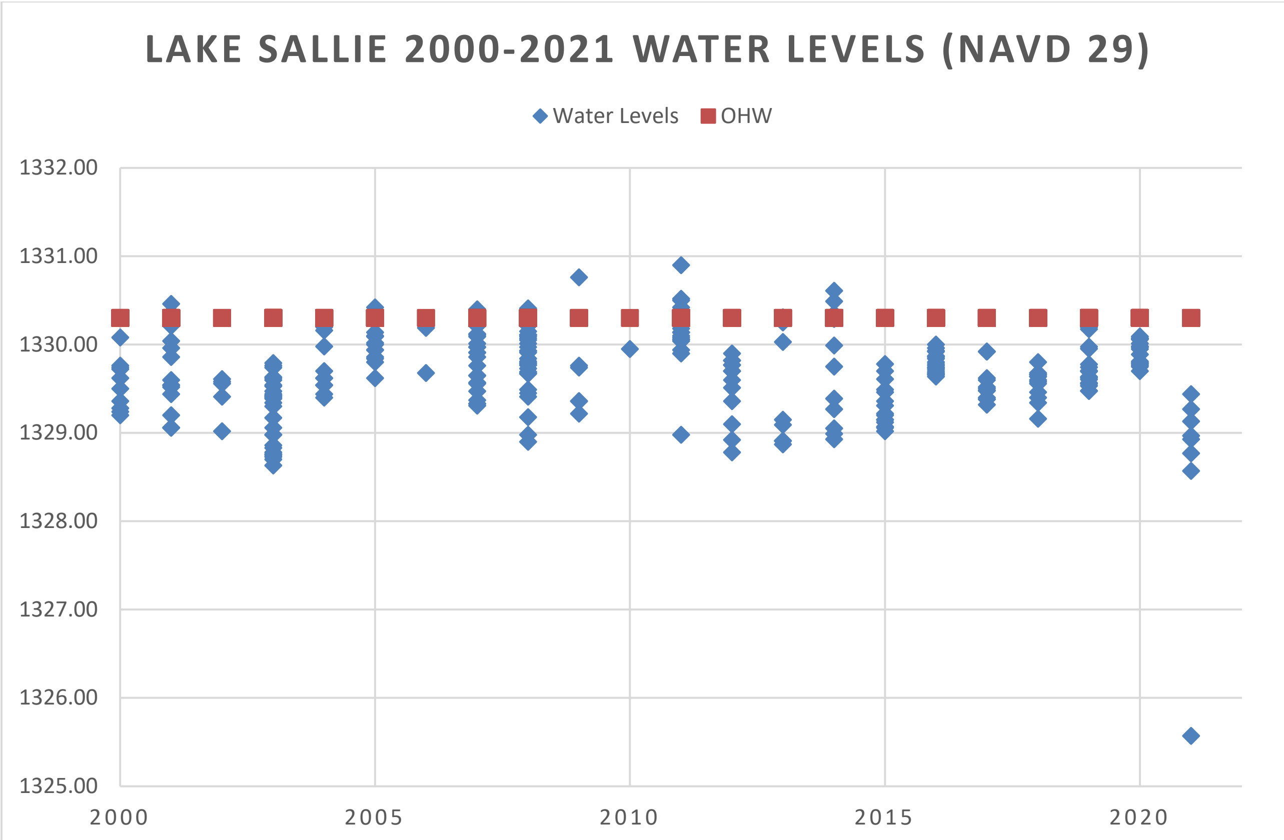


Figure 7.62. Lake Sallie water levels from 2000-2021.

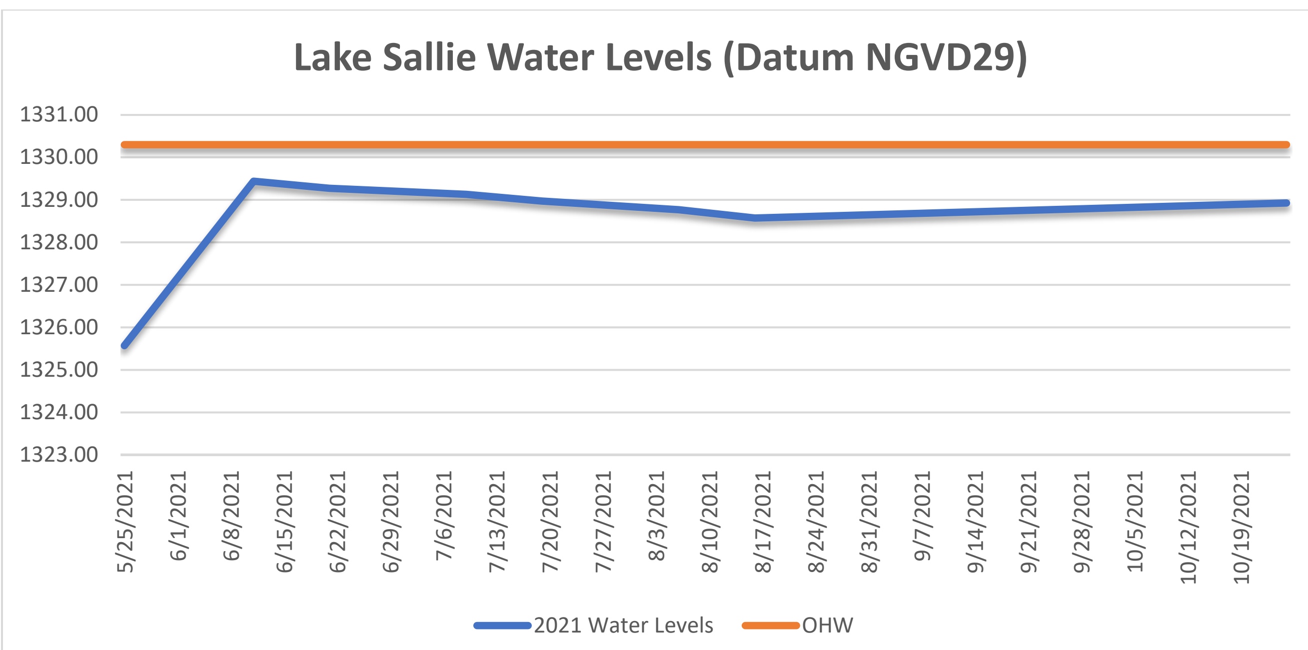


Figure 7.13. Lake Sallie water levels in 2021.

7.1.3.2 Ecological Integrity

Aquatic Invasive Species Control – Lake Sallie

The District performed reduced chemical treatments of flowering rush, and no treatments of curly leaf pondweed on Lake Sallie in 2021 (Figure 7.12). For the 35.88-acre bed on the East shore of Lake Sallie, 2 treatments with Diquat were performed (June 28th and August 9th). This stand is intermixed with hardstem bullrush, making it difficult to access. There is also a flowing water problem associated with where the Pelican River drains into Lake Sallie. The next step to effectively control this patch is to control the flow of water and increase contact time between the chemical and the plant. A possible method to look into would include using a silt curtain or a "bubble curtain", a device that inhibit water flow by producing a wall of air bubbles from the bottom to the surface.

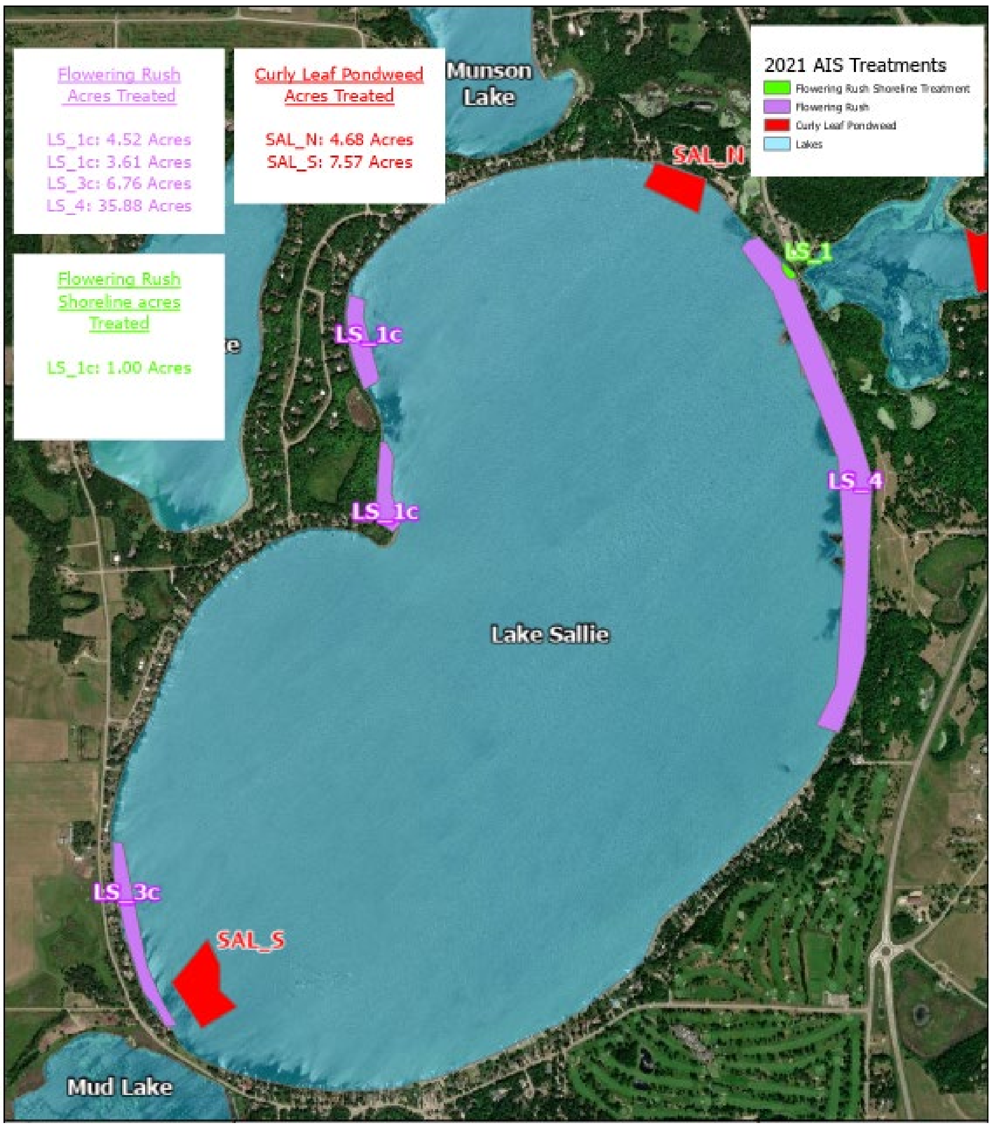


Figure 7.74. Aquatic invasive species treatments on Lake Sallie in 2021.

Table 7.1 AIS Treatment costs on Lake Sallie in 2021.

	CLP #1 Trmt Acres 5/26/2021	CLP #1 Trmt Cost	FR #1 Trmt Acres 5/26/2021	FR #1 Trmt Cost	FR #2 Trmt Acres 8/9/2021	FR #2 Trmt Cost	Totals Per Lake
Sallie	12.3	$8,917.50	50.93	$7,245.92	37	$5,298.40	$21,461.82

Zooplankton Survey- Lakes Sallie

District Staff have been involved in a cooperative project with the MN DNR and Concordia College in Moorhead to examine the effect of zebra mussels on the microscopic communities of zooplankton which form the base of the food web. Zebra mussels filter large amounts of water and strip the water column of resources. Through this study, District Staff collect monthly zooplankton samples and preserve them for later analysis. Analysis of these samples requires specialized identification knowledge. Staff from MN DNR and Concordia College will analyze the samples and report to the District once multiple years of population data has been collected. This project is on-going.

Vegetation Survey – Lake Sallie

Lake Sallie was the second basin sampled during a 3-week period in July of 2021 and this lake contained 150 sampling points in the littoral zone around the lake. The most common plant sampled in Lake Sallie was Star Duckweed with a plant frequency of 66% and was closely followed by northern watermilfoil having a plant frequency of 50%. Across the 150 sampling points spread across the lake, only 7 sampling points came back without plants present, accounting for 5% of the total number of points.

Lake Sallie is like Lake Melissa in that it is a heavily developed lake and is commonly used for recreation. Lake Sallie tends to be deeper closer to shore in spots where Lake Melissa remains shallow for quite some time. As with Lake Melissa, Lake Sallie had the highest plant diversity in areas where the water depth was between 10 and 15 feet deep. In these areas, northern watermilfoil and Richardson's pondweed were the dominant species but other native pondweeds and some macroalgae were mixed in among them. In the shallower areas, macroalgae and naiads were commonly found as well as large amounts of water celery and the occasional common bladderwort. Star duckweed was present throughout the entire lake and density did not change between shallow and deep areas of the lake. Although both Lakes Sallie and Melissa had common bladderwort, the density and frequency of the plant was higher on Lake Melissa than it was on Lake Sallie. Both lakes had high star duckweed densities and was a common plant across the lakes. Compared to lake Sallie, Lake Melissa has more diversity and a greater number of native pondweeds. The most common pondweeds were Illinois pondweed and Richardson's Pondweed. Lake Sallie had larger amounts of aquatic mosses that were more frequent than macroalgae was in similar depths on Lake Melissa.

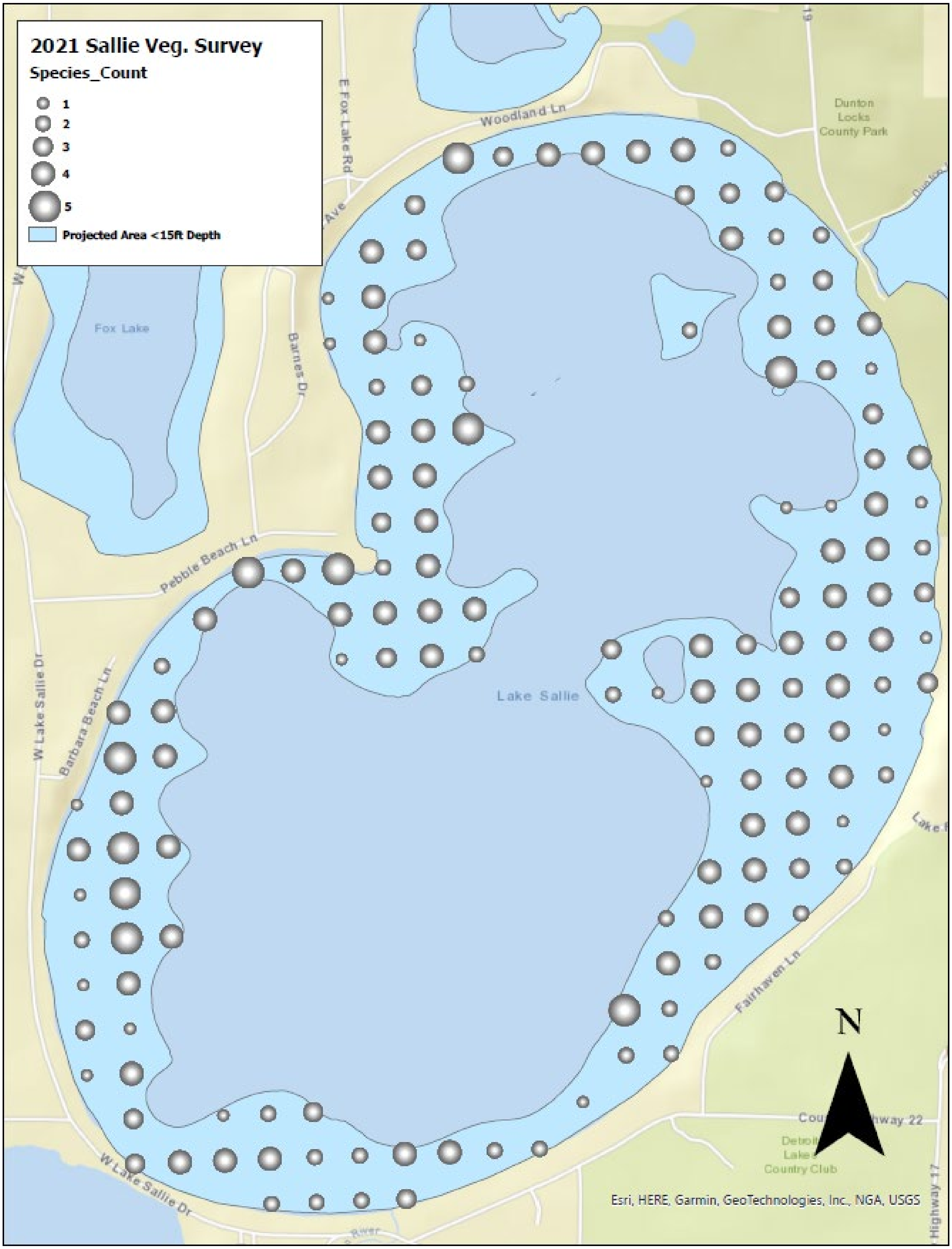


Figure 7.15 Vegetation survey points on Lake Sallie.

Table 7.2 Results from 2021 Lake Sallie vegetation survey.

Lake Sallie 2021 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	1.70	23	15%
Chara spp./Nitella spp.	Macroalgae	2.05	66	44%
Drepanocladus spp.	Aquatic Mosses	1.92	36	24%
Myriophyllum sibiricum	Northern Watermilfoil	2.11	75	50%
Najas guadalupensis	Southern Naiad	1.00	1	1%
Nymphaeaceae spp.	Water Lilies	2.00	2	1%
Potamogeton amplifolius	Large-leaf Pondweed	1.50	2	1%
Potamogeton illinoensis	Illinois Pondweed	1.22	45	30%
Potamogeton richardsonii	Richardson's Pondweed	1.46	26	17%
Potamogeton zosteriformis	Flat-stem Pondweed	1.81	36	24%
Scirpoides holoschoenus	Bulrush	2.00	7	5%
Utricularia spp.	Bladderwort	1.17	18	12%
Vallisneria americana	Water Celery	1.68	34	23%
lemna trisulca	Star Duckweed	1.62	99	66%
Najas flexilis	Slender Naiad	1.44	16	11%
Empty Points	-	-	7	5%
Total Points	-	-	150	100%

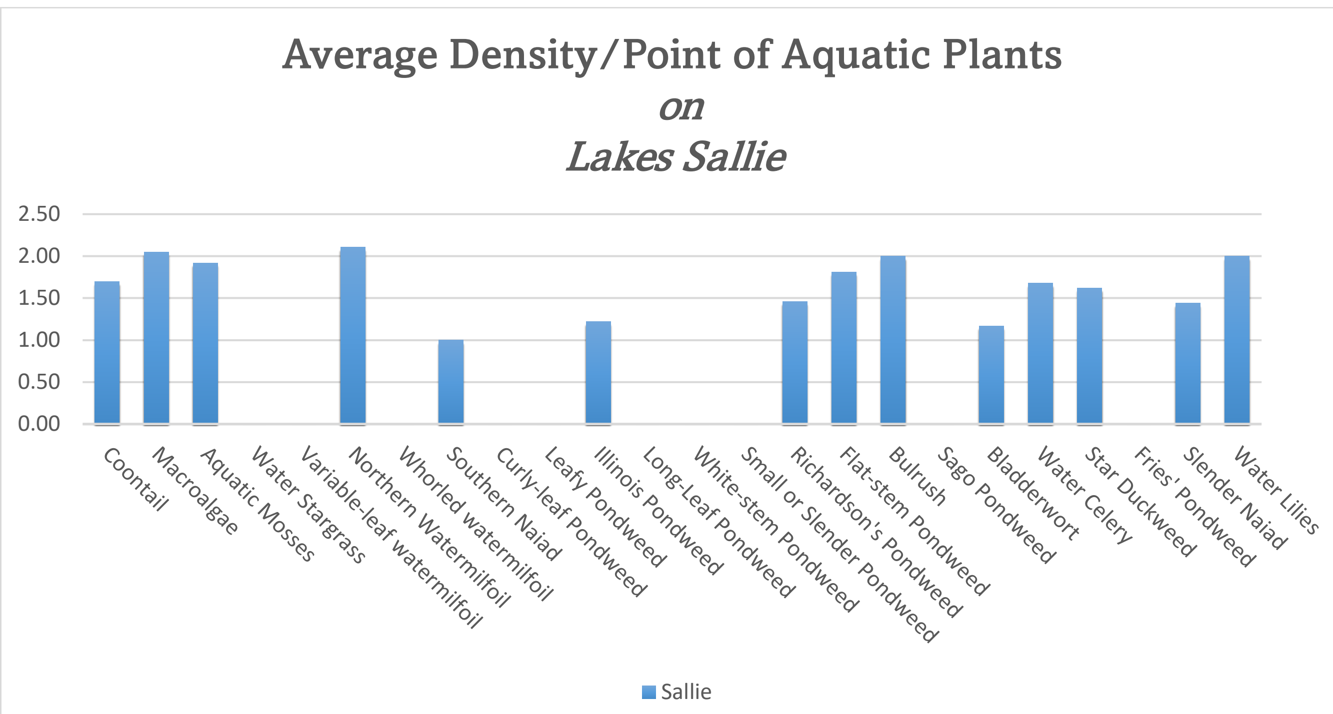


Figure 7.15. 2021 Lake Sallie density of aquatic plants.

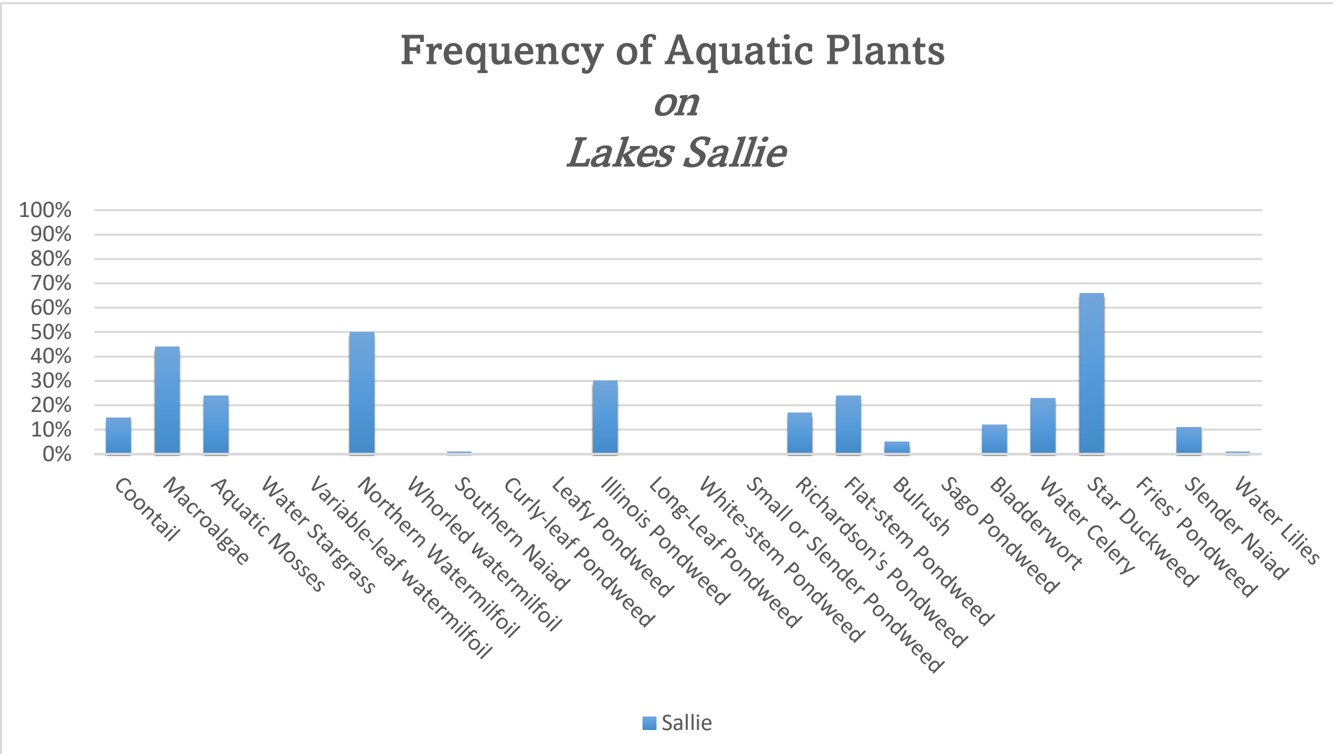


Figure 7.16. 2021 Lake Sallie frequency of aquatic plants.

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 is 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), and 16.5 (2017). 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 average water quality in 2021. The 2021 average for TP was 15 µg/L a decrease from the historic average of 20µg/L and secchi depth average of 16 feet was similar to historic average 11.4 feet. The average CHL-A of 4.84 µg/L was decreased from the historic average of 6.52 µg/L. The effects of zebra mussels have been less pronounced on Lake Melissa. Other lakes have experienced a dramatic increase in secchi depth and decrease in CHL-A. While a decrease in CHL-A has been observed, samples still peaked above the average on 8/13/21, 8/25/21 and 9/26/21 (8.46 µg/L). Both TP and secchi depth remained average throughout the season. Overall, water quality is good with little changes from previous years.

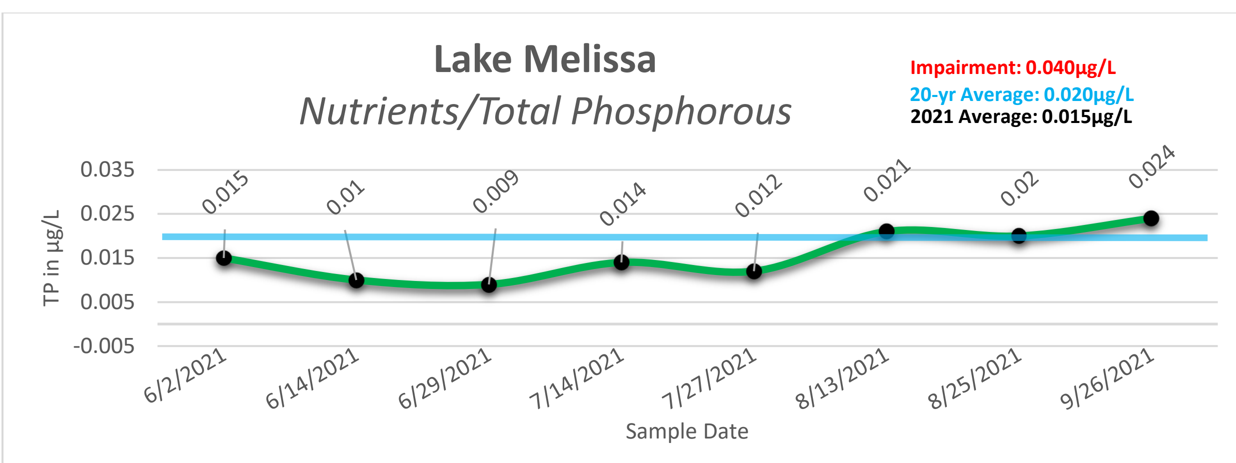


Figure 7.17. Lake Melissa 2021 total phosphorous.

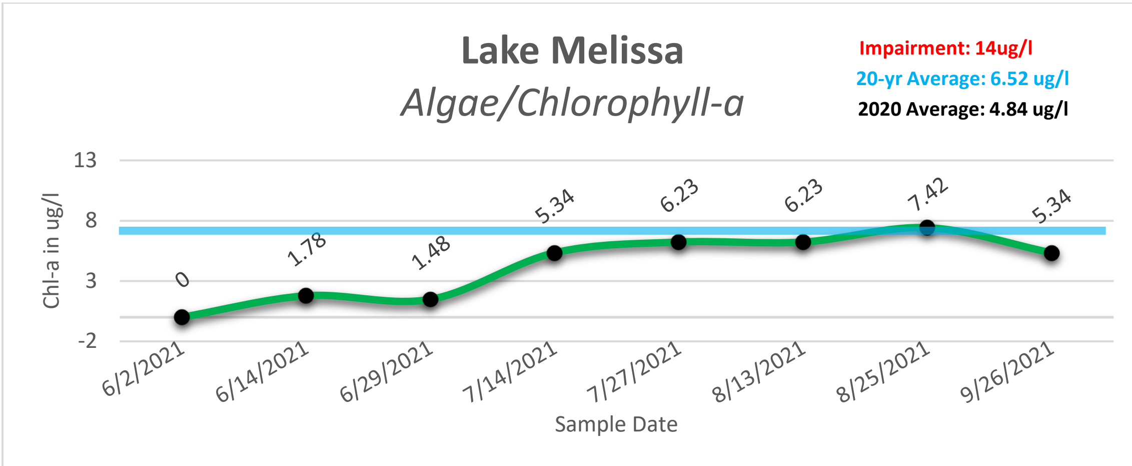


Figure 7.18. Lake Melissa 2021 chlorophyll-a.

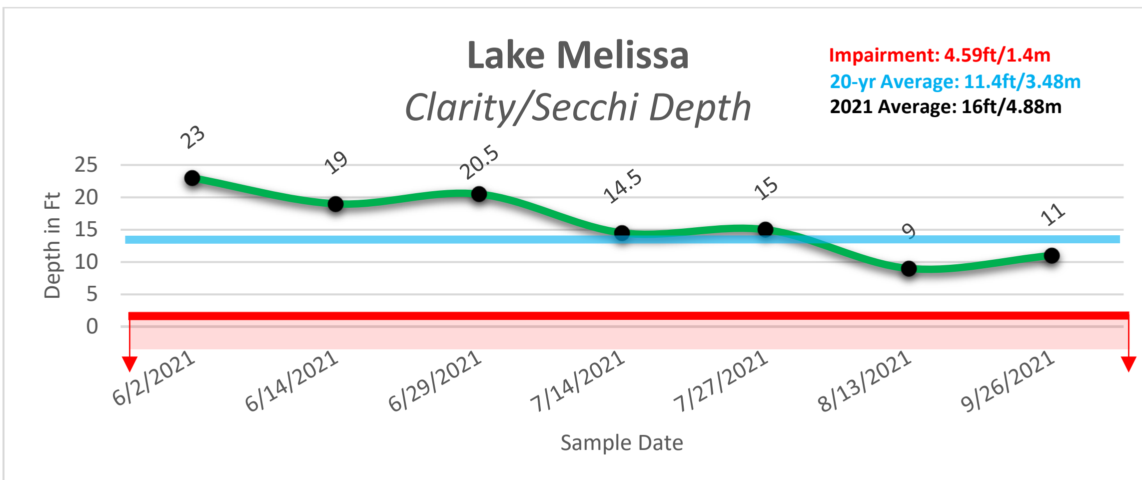


Figure 7.198. Lake Melissa 2021 secchi depth.

Water Quantity – Lake Melissa

Water Levels on Lake Melissa in 2021 were very low and stayed below the OHW for the season (Figure 7.16). Water levels fluctuated between 1328.26’ MSL and 1327.50’ MSL throughout the season (Figure 7.17).

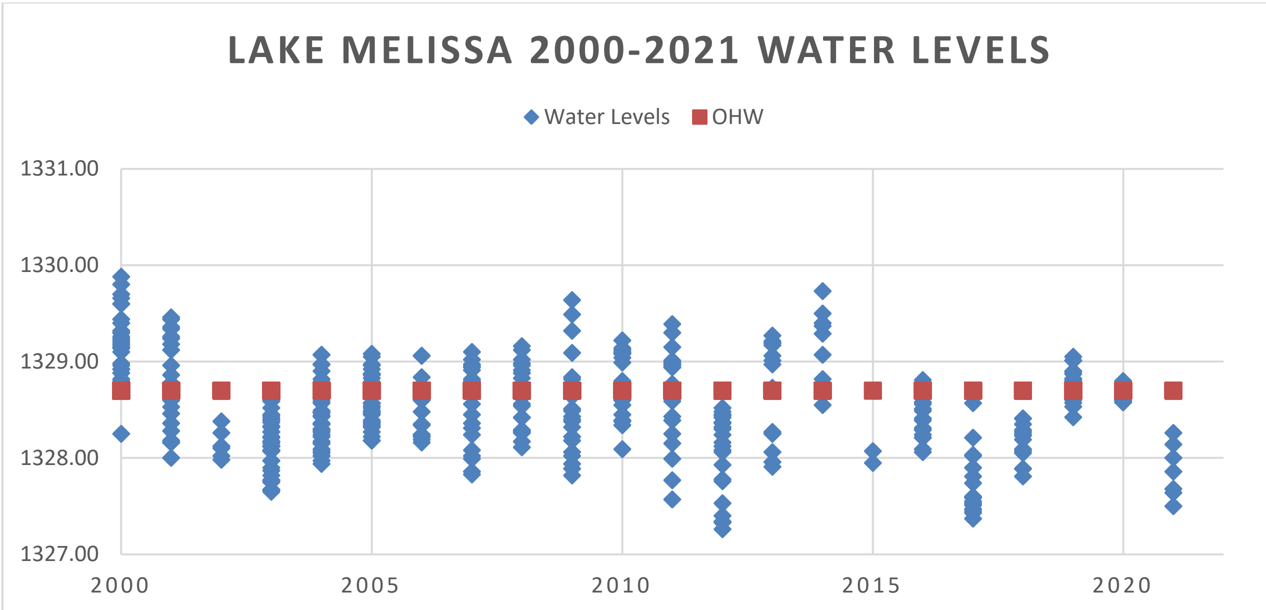


Figure 7.20. Water levels on Lake Melissa from 2000-2021.

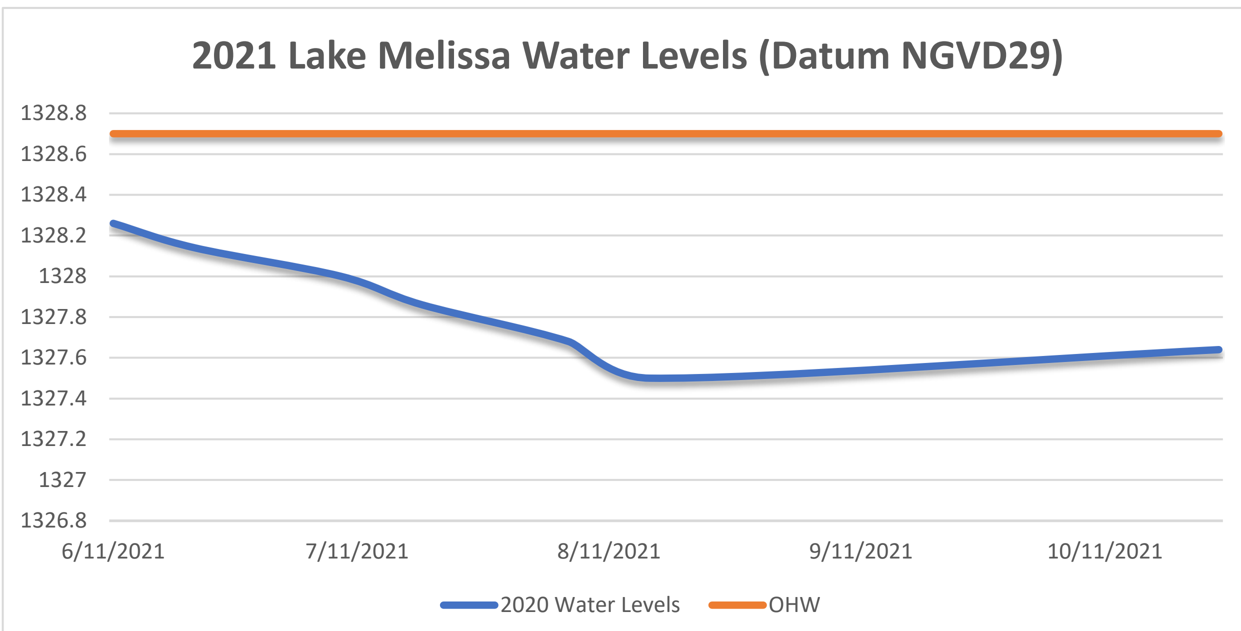


Figure 7.219. Water levels on Lake Melissa in 2021.

7.1.4.2 Ecological Integrity

Zooplankton Survey- Lake Melissa

District Staff have been involved in a cooperative project with the MN DNR and Concordia College in Moorhead to examine the effect of zebra mussels on the microscopic communities of zooplankton which form the base of the food web. Zebra Mussels filter large amounts of water and strip the water column of resources. Through this study, District Staff collect monthly zooplankton samples and preserve them for later analysis. Analysis of these samples requires specialized identification knowledge. Staff from MN DNR and Concordia College will analyze the samples and report to the District once multiple years of population data has been collected. This project is on-going.

The samples that were collected on Big Floyd, North Floyd, Little Floyd, Big Detroit, Little Detroit, Long Lake, Lake Sallie, and Lake Melissa in 2021 are still being analyzed by the MN DNR but due to the position being filled to do the analyzing we will get the results closer to 2023.

Aquatic Invasive Species Control – Lake Melissa

No chemical treatments for Curly Leaf Pondweed were required in 2021. 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 7.18). The District will continue to assess the lake for Flowering Rush and Curly Leaf Pondweed in 2022.

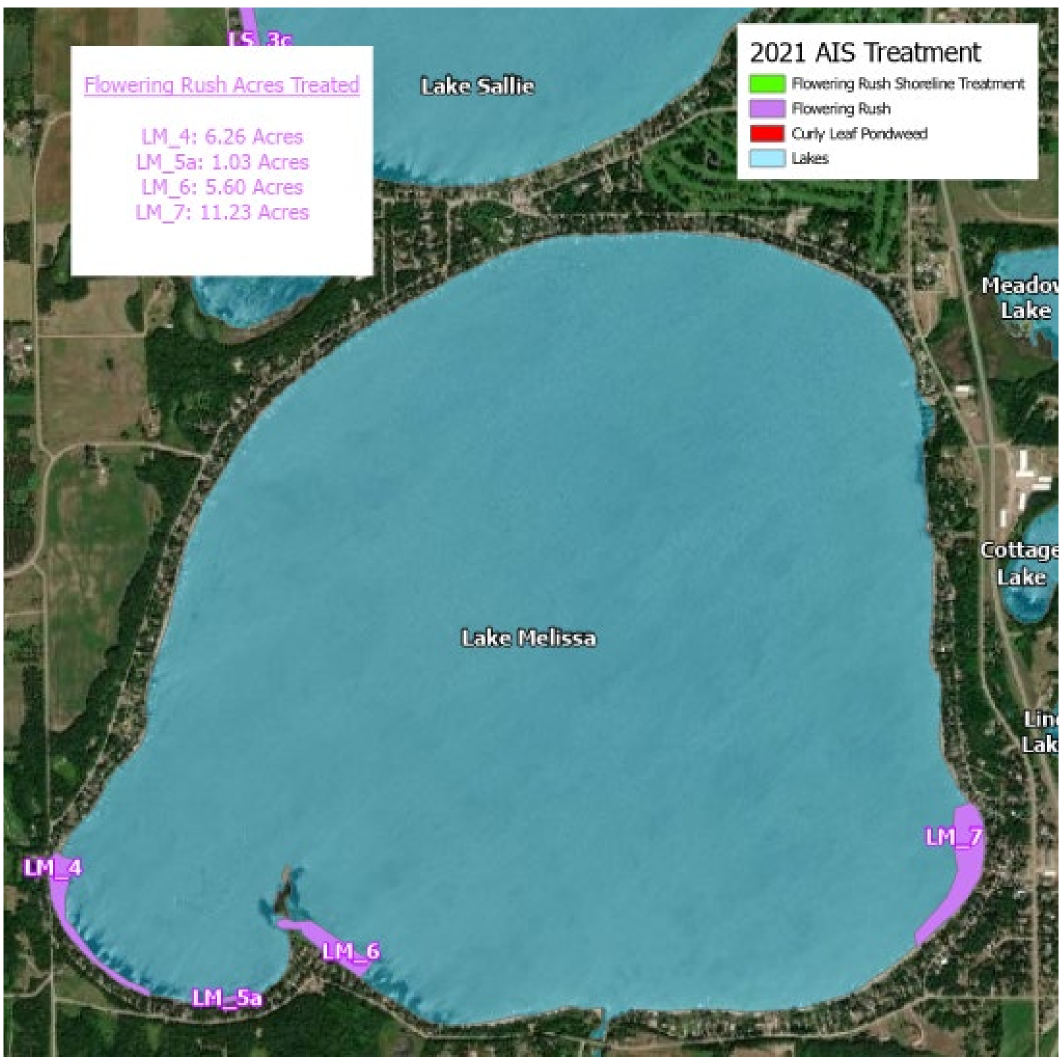


Figure 7.22. Aquatic invasive species treatments on Lake Melissa in 2021.

Table 7.3 AIS Treatment costs on Lake Melissa in 2021.

	FR #1 Trmt Acres 5/26/2021	FR #1 Trmt Cost	FR #2 Trmt Acres	FR #2 Trmt Cost 8/9/2021	Totals Per Lake
Melissa	24.0	$3,436.80	24.0	$3,436.80	$6,873.60

Vegetation Survey – Lake Melissa

Lake Melissa is the larger of the two basins sampled during the 3 weeks period in July of 2021. It contained the most points in the littoral zone (a total of 233 points). The most common plant collected throughout the lake was Macroalgae with 69% frequency and as followed by Common Bladderwort with a plant frequency of 47%. Of the 233 points sampled on Lake Melissa, only 8 points (3%) came back without any plants present.

Lake Melissa is a highly developed lake and often used for recreation. With the lake being shallow near the shore and dropping slightly offshore, recreation and other natural forces, such as strong winds creating large waves, the places where plants can be found can be variable. Deeper areas (10 feet and deeper) saw the most plant diversity and the highest abundance of plants. Shallower areas closer to shore consistently had Macroalgae and Bladderwort present and were spread scarcely across the bottom. With indicator species such as Marestail and Common Bladderwort being present and abundant throughout the lake, Lake Melissa has a healthy ecosystem with and large diversity of plants.

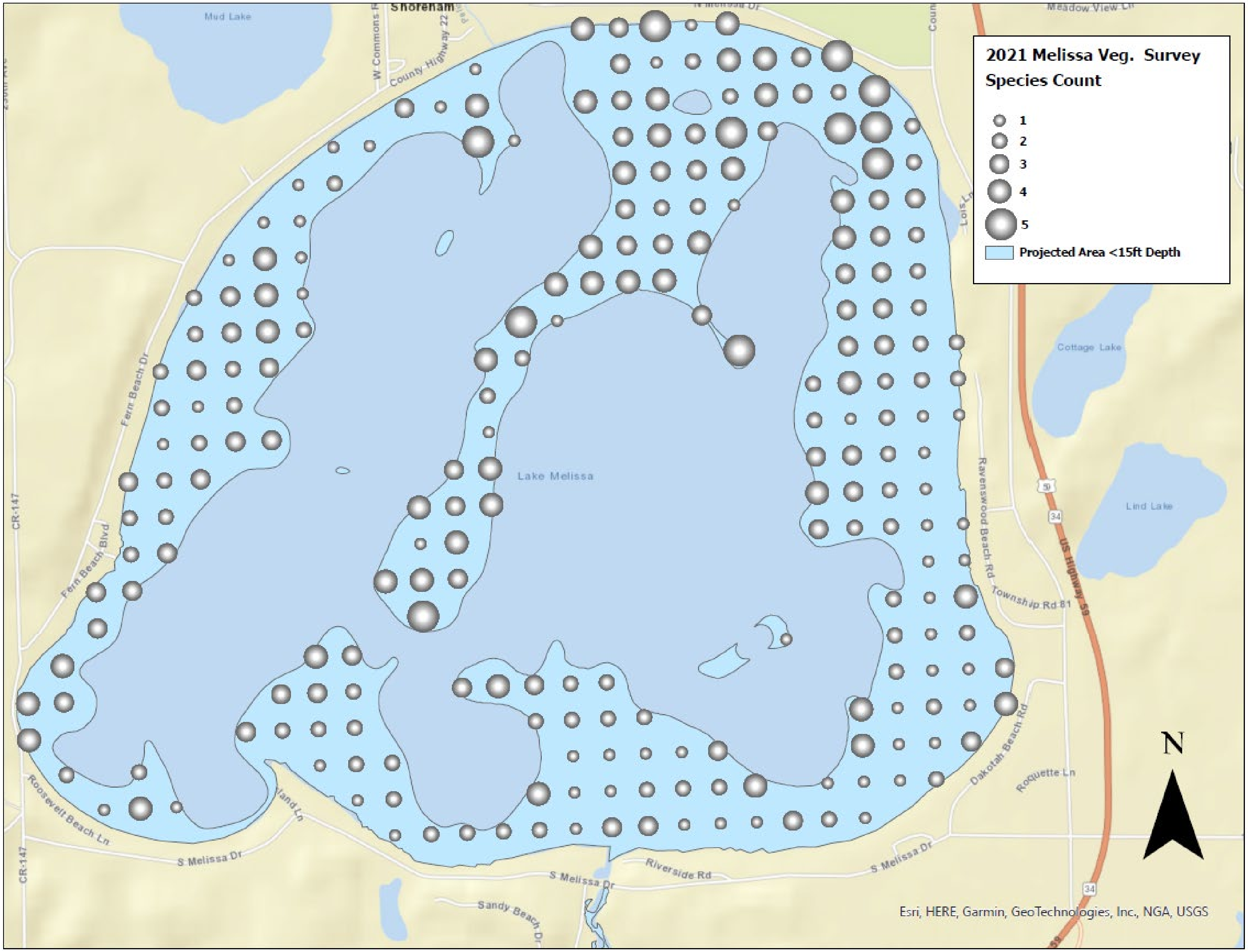


Figure 7.23. 2021 Vegetation survey points on Lake Melissa

Table 7.4 Results from 2021 Lake Melissa vegetation survey.

Lake Melissa 2021 Vegetation Survey				
Scientific Name	**Common Name**	**Average Density/Point**	**Site Count**	**% Frequencies**
Ceratophyllum demersum	Coontail	1.82	45	19%
Chara spp./Nitella spp.	Macroalgae	2.31	160	69%
Drepanocladus spp.	Aquatic Mosses	1.59	17	7%
Heteranthera dubia	Water Stargrass	0.50	4	2%
Myriophyllum heterophyllum	Variable-leaf watermilfoil	1.00	1	1%
Myriophyllum sibiricum	Northern Watermilfoil	1.51	35	15%
Myriophyllum verticillatum	Whorled watermilfoil	1.40	5	2%
Najas guadalupensis	Southern Naiad	2.10	20	9%
Potamogeton crispus	Curly-leaf Pondweed	1.00	6	3%
Potamogeton foliosus	Leafy Pondweed	1.25	8	3%
Potamogeton illinoensis	Illinois Pondweed	1.26	100	43%
Potamogeton nodosus	Long-Leaf Pondweed	1.50	6	3%
Potamogeton praelongus	White-stem Pondweed	1.00	4	2%
Potamogeton pusillus	Small or Slender Pondweed	1.50	12	5%
Potamogeton richardsonii	Richardson's Pondweed	1.46	13	6%
Potamogeton zosteriformis	Flat-stem Pondweed	1.21	14	6%
Scirpoides holoschoenus	Bulrush	2.50	2	1%
Stuckenia pectinata	Sago Pondweed	2.00	6	3%
Utricularia spp.	Bladderwort	1.68	109	47%
Vallisneria americana	Water Celery	1.00	4	2%
lemna trisulca	Star Duckweed	1.44	18	8%
Potamogeton friesii	Fries' Pondweed	1.47	15	6%
Empty Points	-	-	8	3%
Total Points	-	-	233	100%

Figure 7.23. Vegetation survey points on Lake Melissa.

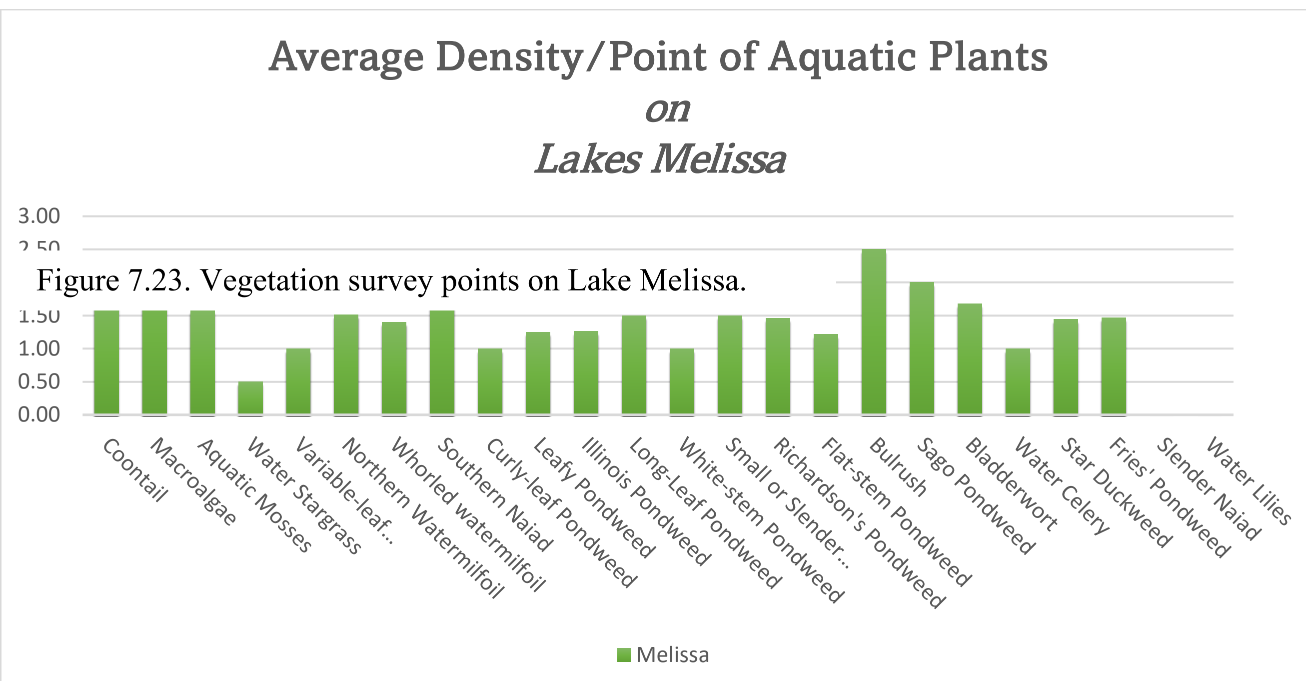


Figure 7.24. 2021 Lake Melissa density of aquatic plants.

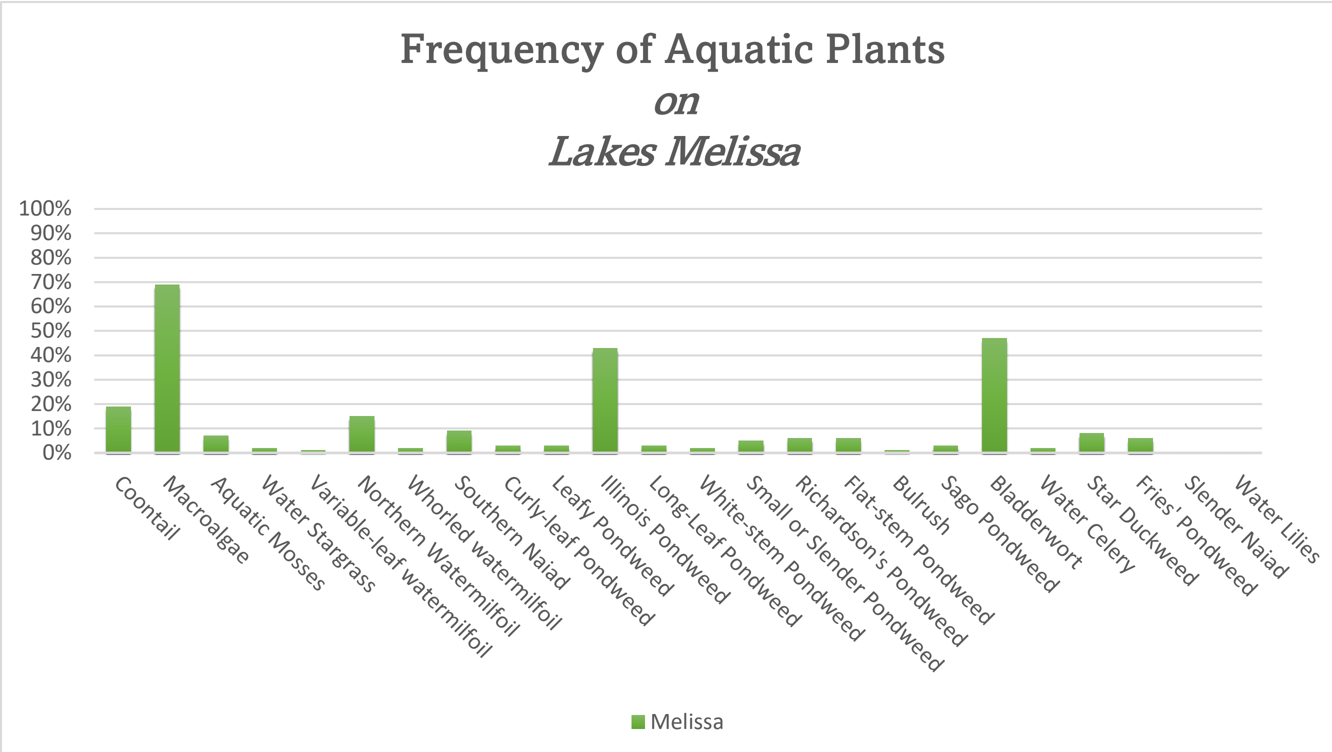


Figure 7.25. 2021 Lake Melissa frequency of aquatic plants.

7.2 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). Recent chloride samples suggest a possible impairment in Ditch 14. The District will continue to assess the chlorides in the system in 2022 using the YSI Sonde.

7.2.1.1 Water Quality/Quantity

Water Quality – Ditch 14

St. Clair in-lake TP concentrations averaged 55 µg/L and at SC3 (Ditch 14) just downstream of the lake, TP concentration also averaged 55 µg/L, but started increasing within a short distance to 78 µg/L at County Rd 6 and continued to increase to 80 µg/L at the confluence of Ditch 14/Pelican River SC4 (bike trail). Ditch 14 TP concentrations between St. Clair Lake and the Pelican River increased by 45% and OP followed a similar pattern with 7 µg/L at SC3 and increasing to 67 µg/L at the Pelican River (SC4). In comparison, TP concentrations at the outlet of Detroit (PR6) located just upstream of SC4 were much lower at 16 µg/L . The good water quality coming from Detroit Lake/Pelican River dilutes the nutrient-rich Ditch 14 waters. Downstream at Muskrat Lake, TP concentrations averaged 51 µg/L (Figure 7.19). One E. coli sample was taken, and the result was within MPCA standards.

Water Quantity – Ditch 14

The District collected 2 storm event samples at the outlet of the Fairgrounds stormwater wet pond (Site ESW). This basin treats about half of the City of Detroit Lake's stormwater runoff before discharging into the Ditch 14 wetlands North of St. Clair. The two storm event sample results averaged 70 µg/L TP and 20 µg/L OP, respectively.

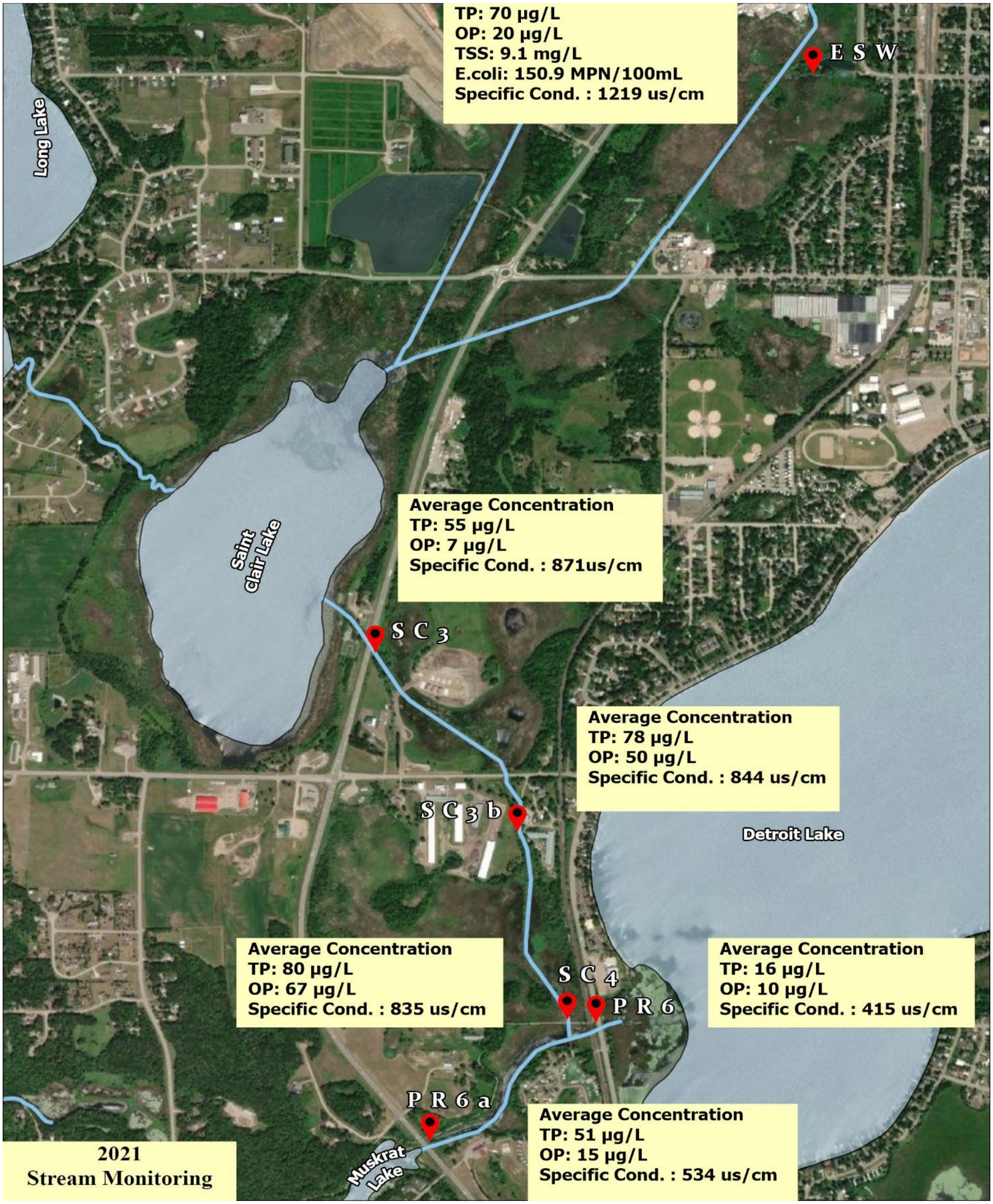


Figure 7.26. Nutrient concentrations on Ditch 14 in 2021.

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 23µg/L phosphorus concentration (2008-2017). The prior ten years (1998-2007) exhibited lower water quality with 5-foot water clarity and 44µg/L 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.

8.1.3 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 87ppm and water clarity of 3 feet, which exceeds the shallow lake standard of 60ppm 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.

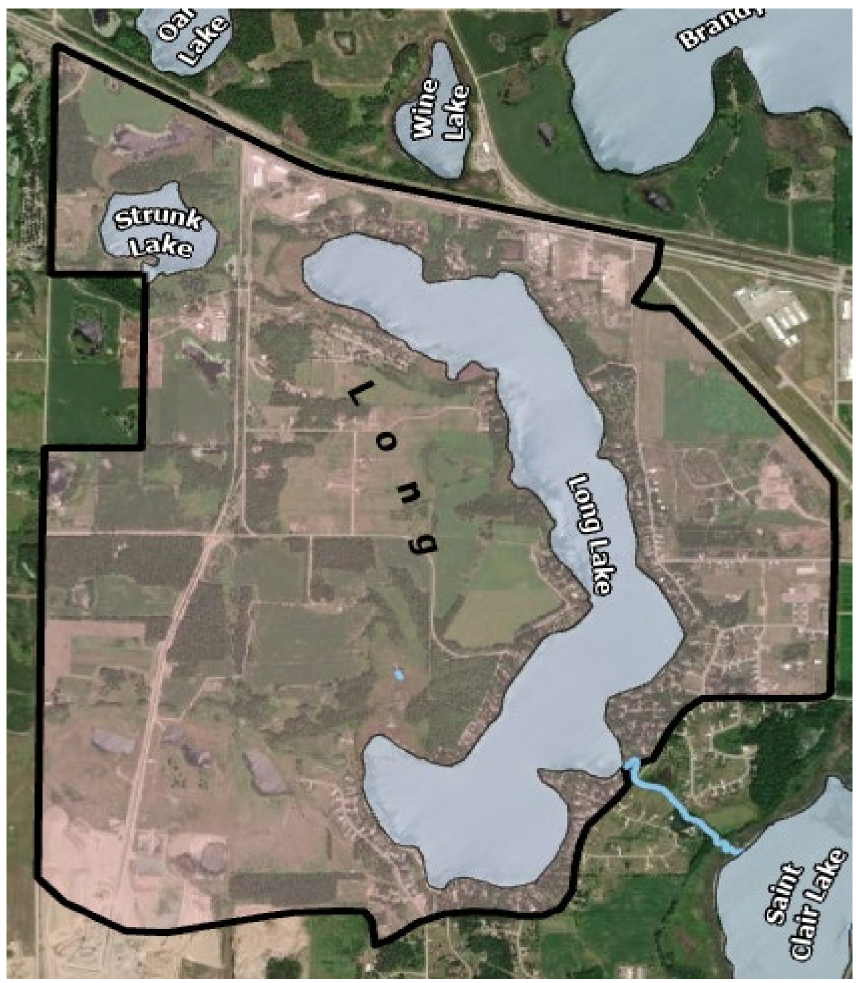


Figure 9.1. Long Water Management Area

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 12µg/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 in time it may be converted to a PUD or subdivision. 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 2021, Long Lake's average Total Phosphorus (TP) was 23 µg/L, much higher than the 20-year average of 14 µg/L, however the summertime average was skewed due to the mid-August water "turnover" event, where TP was 130 µg/L. Without this high reading, Long's average TP would be 7 µg/L – much lower than the 20-year average of 14 µg/L. CHL-A (algae) was significantly lower at 3.68 µg/L (20-year – 4.05 µg/L) and water clarity (secchi depths) averaged 16.9 feet, 2.8 feet better than the 20-year average of 14.1 feet. The drought weather conditions had a positive water clarity impact due to the lack of nutrients entering the lake from rainfall events.

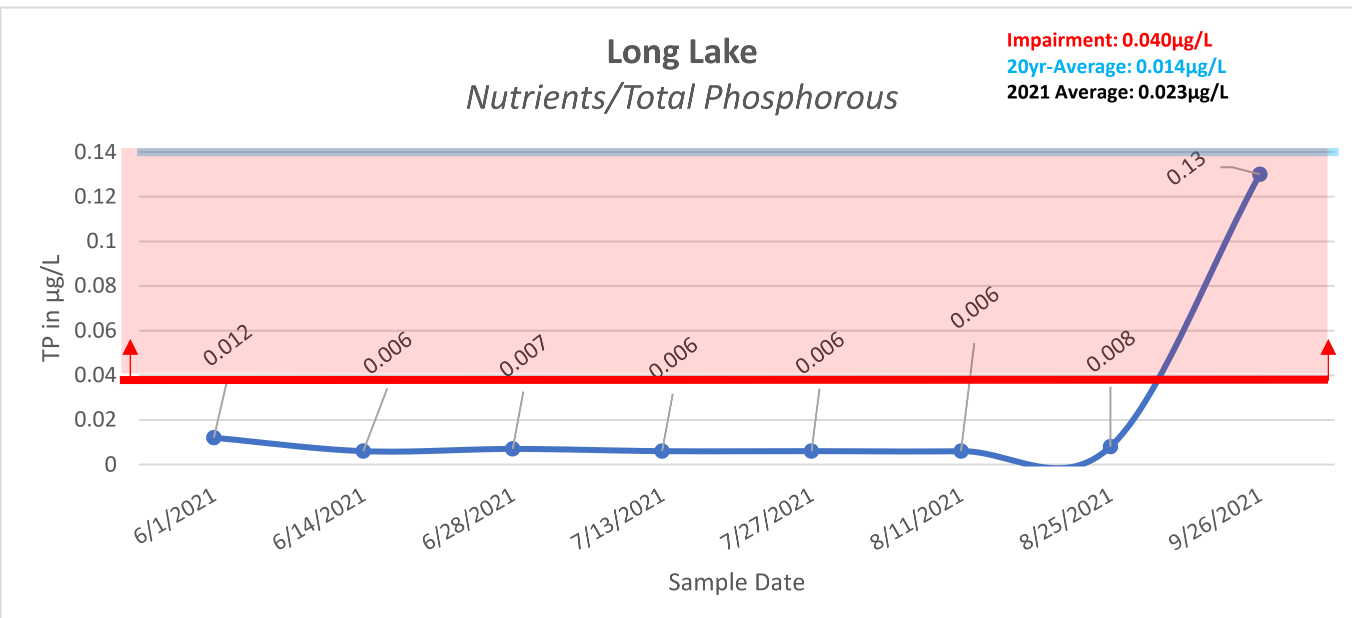


Figure 9.2. Long Lake 2021 total phosphorous

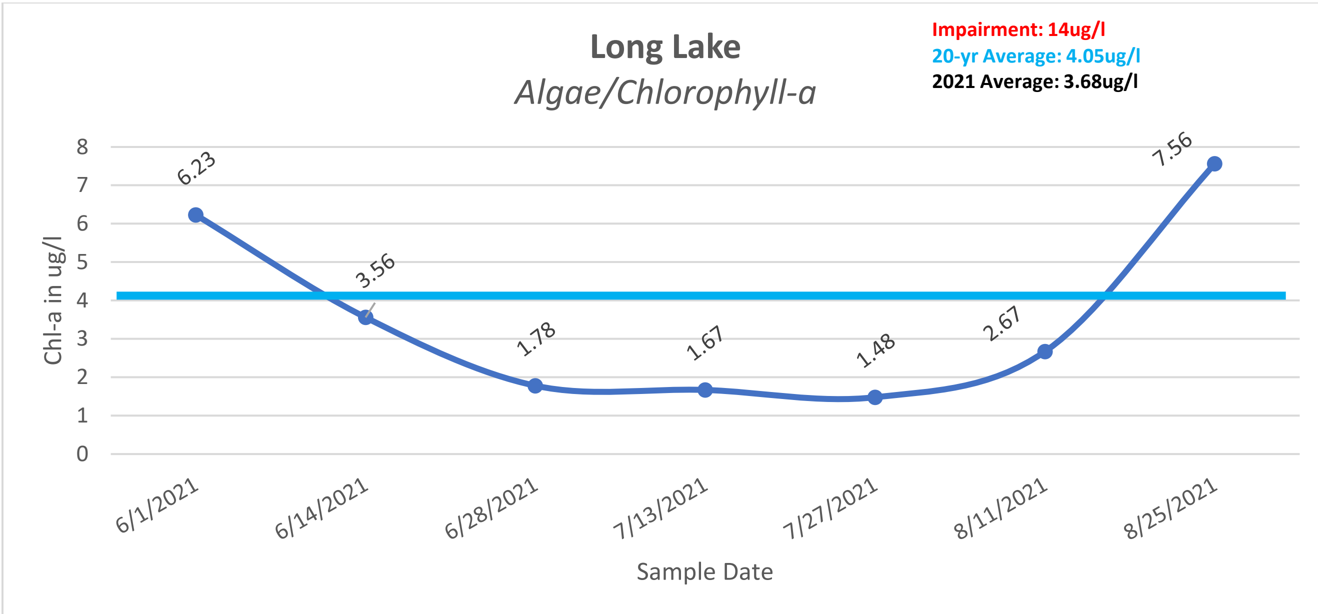


Figure 9.3. Long Lake 2021 chlorophyll-a

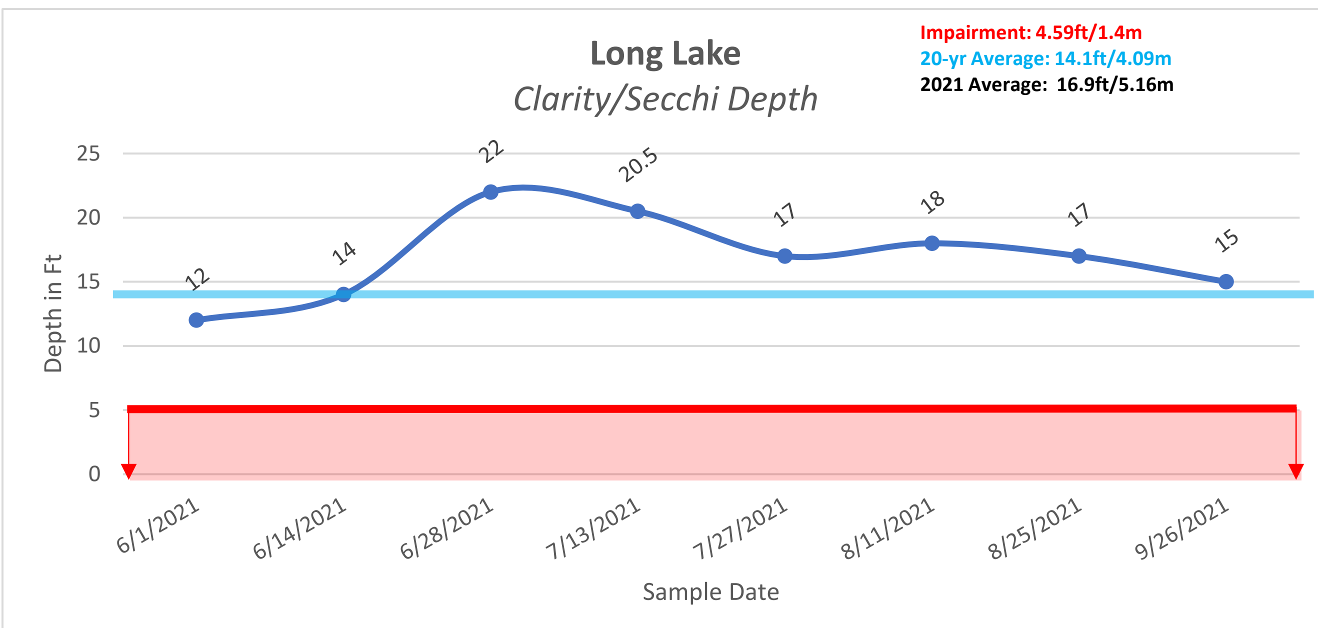


Figure 9.4 Long Lake 2021 secchi depth

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. Lakes tested for water quality in 2021 were Pearl Lake and Dart Lake.

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

Figure 10.2. Pearl Lake.

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.

10.1.1.1 Water Quality/Quantity

Water Quality – Pearl Lake

Pearl appears to be in really good shape for water quality compared to the MPC impairment standards. The 2021 average TP was 18 µg/L (20-year average 35 µg/L) Chl-a was 5.47 µg/L (20-year average 8 µg/L) and secchi depth was 10.3 feet (20-year average 10.6 ft) were all well above the MPCA impairment standards of >60 µg/L, >20µg/L and <3.3'.

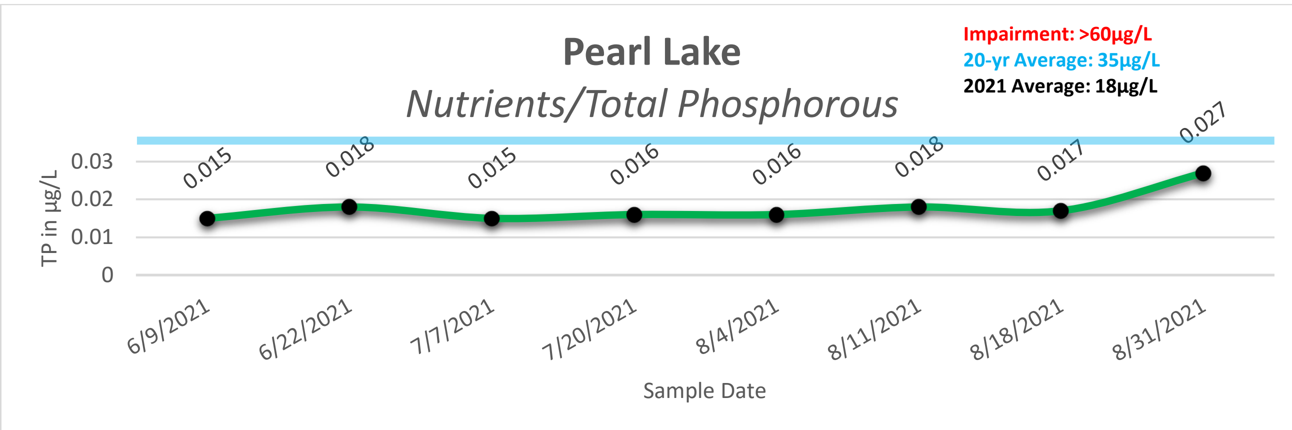


Figure 10.2. Pearl Lake 2021 Total Phosphorous.

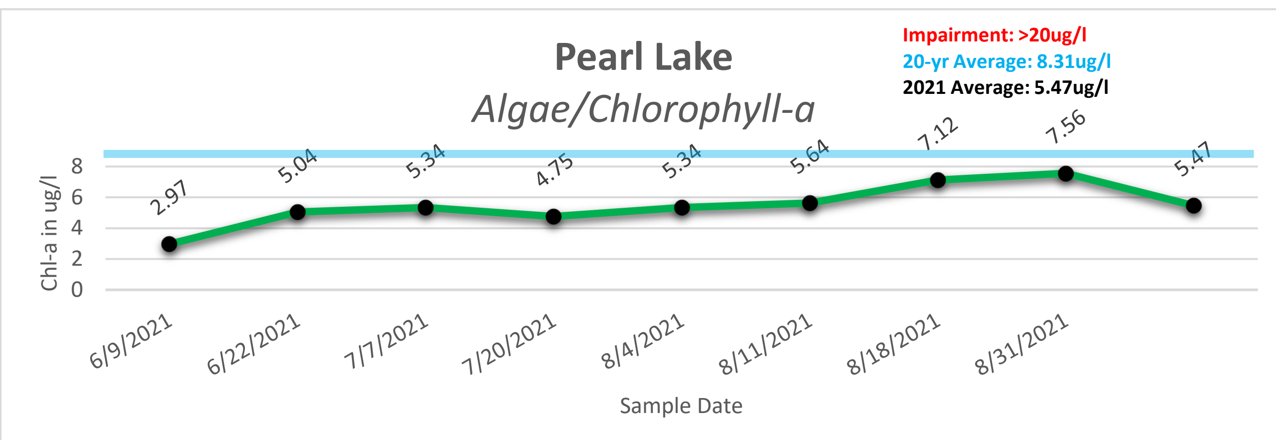


Figure 10.3. Pearl Lake 2021 Chlorophyll-a.

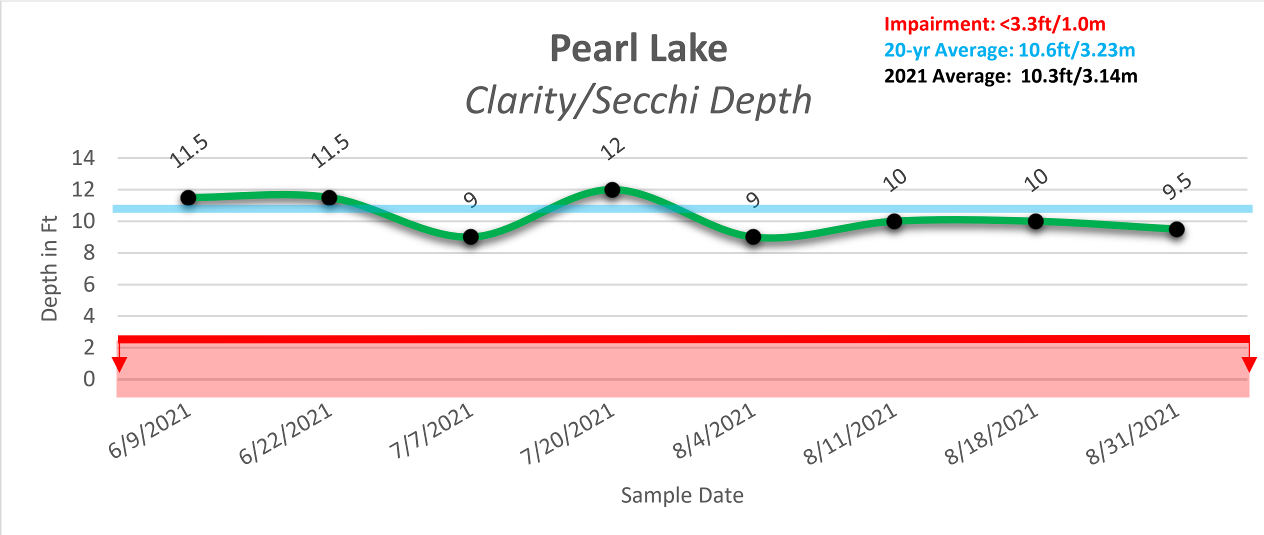


Figure 10.4. Pearl Lake 2021 Secchi Depth.

10.1.2 Loon Lake

Loon Lake is a shallow 264-acre natural environment lake with little residential development (Figure 9.6). 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 (Figure 9.2). 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

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.

10.1.4.1 Water Quality/Quantity

Water Quality – Dart Lake

2021 is the first time we have sampled Dart and all three parameter results are above the MPCA impairment standard thresholds. The 2021 average for TP was 64 µg/L, Chl-a was 20.87 µg/L and secchi depths were 2.63 feet. The MPCA impairment standard is TP >40 µg/L, Chl-a >14ug/L and secchi depth <4.59 feet.

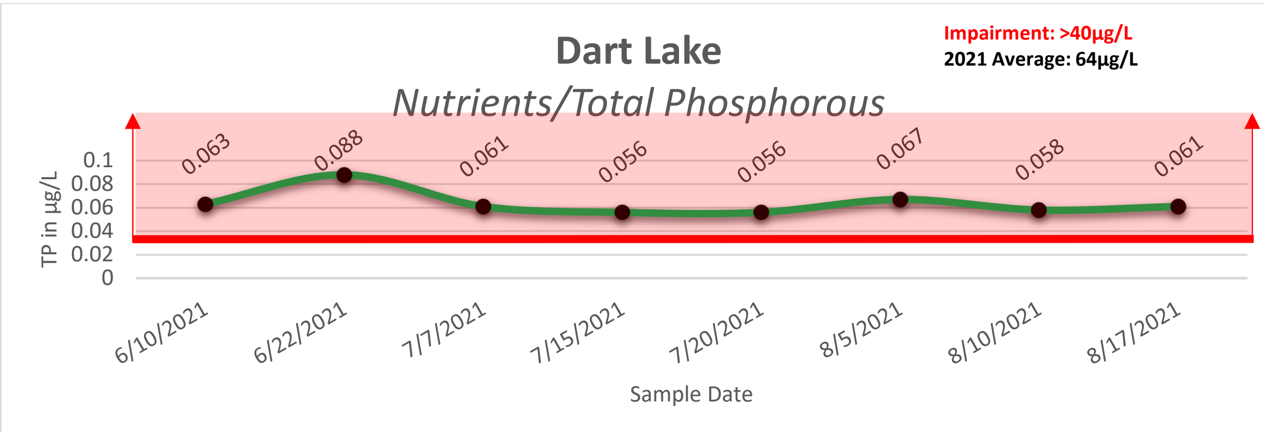


Figure 10.5. Dart Lake 2021 Total Phosphorous.

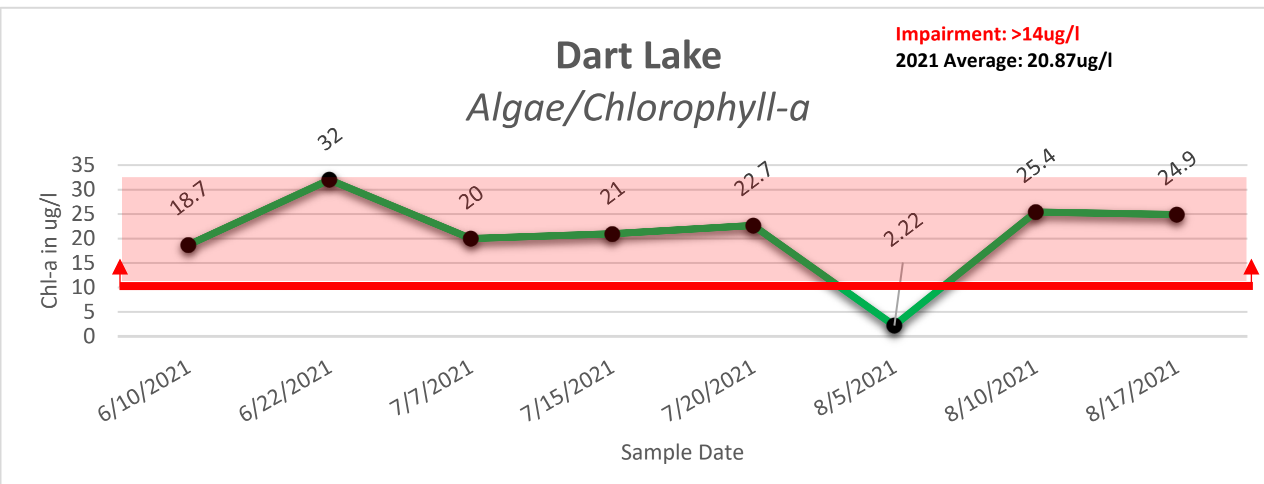


Figure 10.6. Dart Lake 2021 Chlorophyll-a.

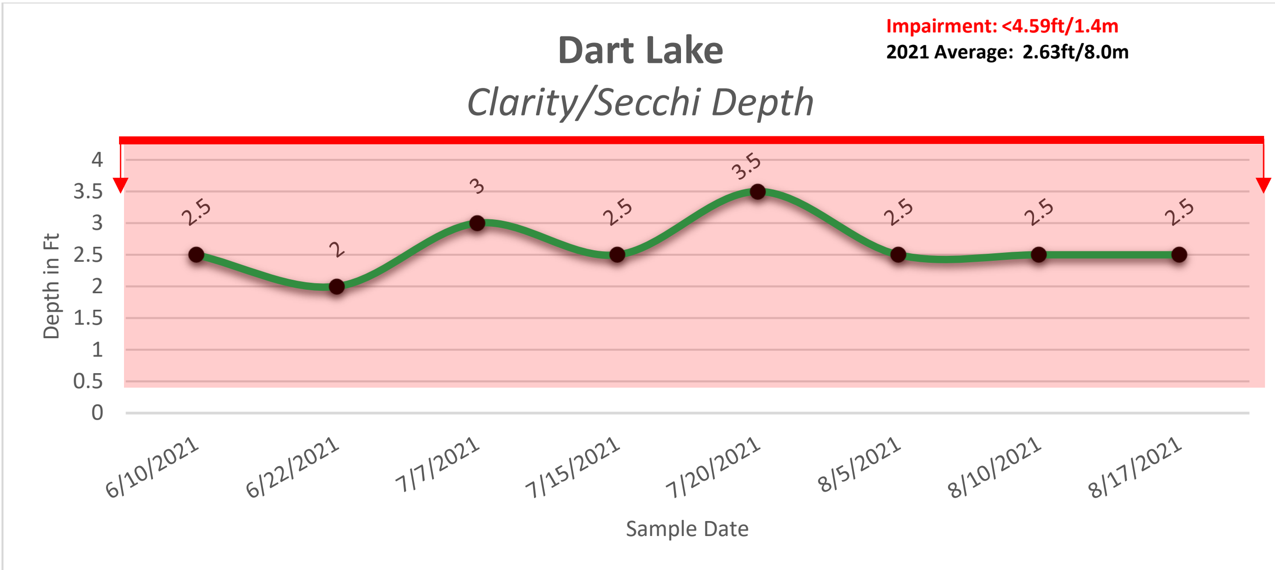


Figure 10.7. Dart Lake Secchi Depth.

11 Small Lakes Water Management Area

The Small Lakes WMA consists of about 11,000 acres in the southeastern corner of the District (Figure 10.1). 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, Reaves, Lind, and Glawe. Lind drains into Melissa Lake in the Sallie-Melissa WMA, making it the last lake in the WMA.

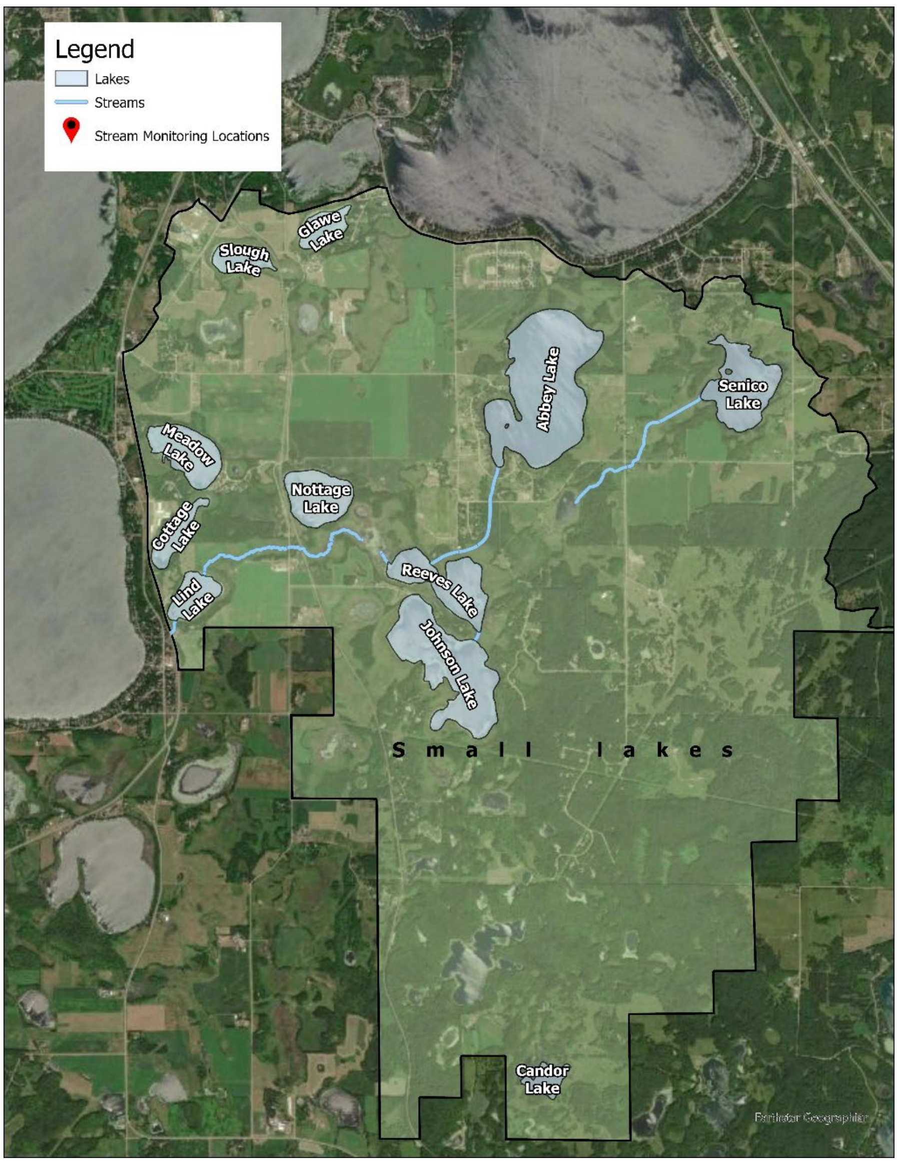


Figure 11.1. The Small Lakes Water Management Area.

11.1 Lakes

There are multiple lakes in the Small Lakes WMA, hence the name. The District monitors 6 of the 10 in the 10-year monitoring plan. In 2021, the District sampled water quality on Cottage and performed a shoreline survey on Abbey. In 2022, the District will be performing aquatic vegetation surveys on Meadow Lake and a shoreline survey 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 (Figure 10.2). 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

Meadow is a 71-acre natural environment lake located approximately 4.5-miles SW of the City of Detroit Lakes (Figure 10.6). 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.

11.1.3 Johnson Lake

Johnson Lake is a moderately developed, natural environment lake located south of the City of Detroit Lakes (Figure 10.11). 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

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.

11.1.4.1 Water Quality/Quantity

Water Quality – Cottage Lake

2021 is the first time the District sampled Cottage Lake and it appears to be in really good shape for water quality compared to the MPCA impairment standards. The 2021 average for TP was 12 µg/L, Chl-a was 5.47 µg/L and secchi depths were 10.3feet – well below the MPCA impairment threshold standards of TP >0.040 µg/L, Chl-a >14 µg/L and secchi depth <4.59 feet.

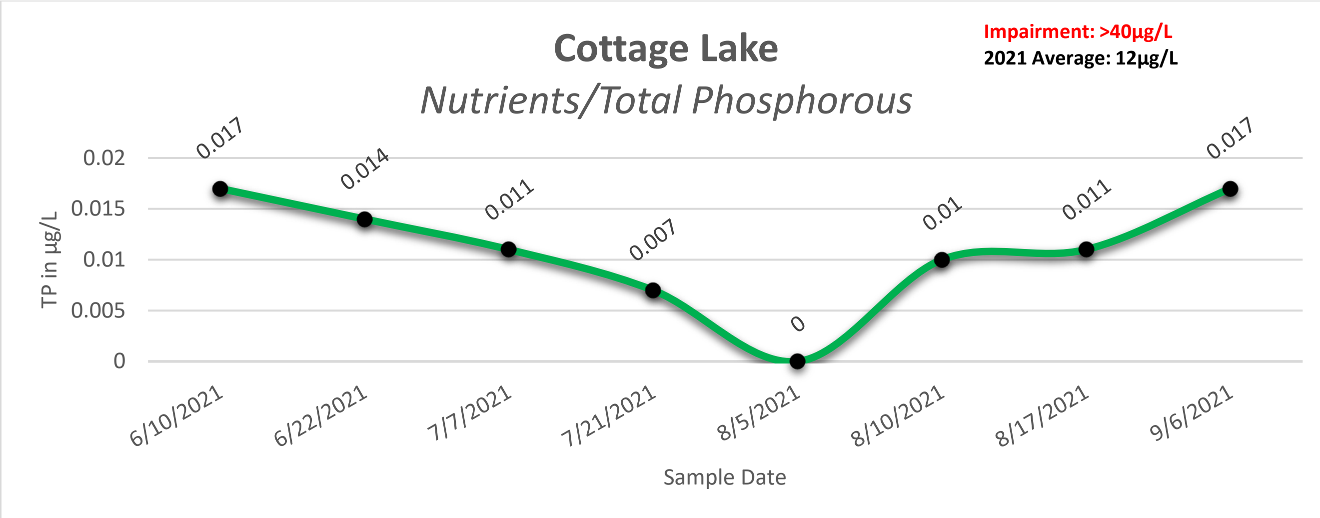


Figure 11.2. Cottage Lake 2021 Total Phosphorous.

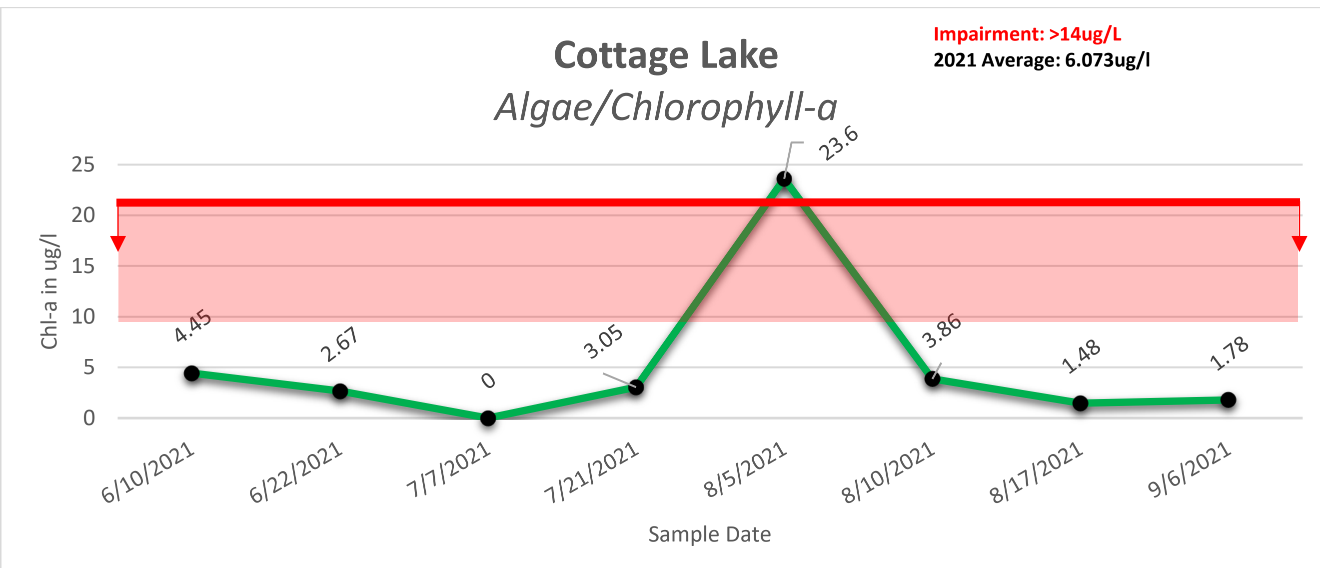


Figure 11.3. Cottage Lake Chlorophyll-a.

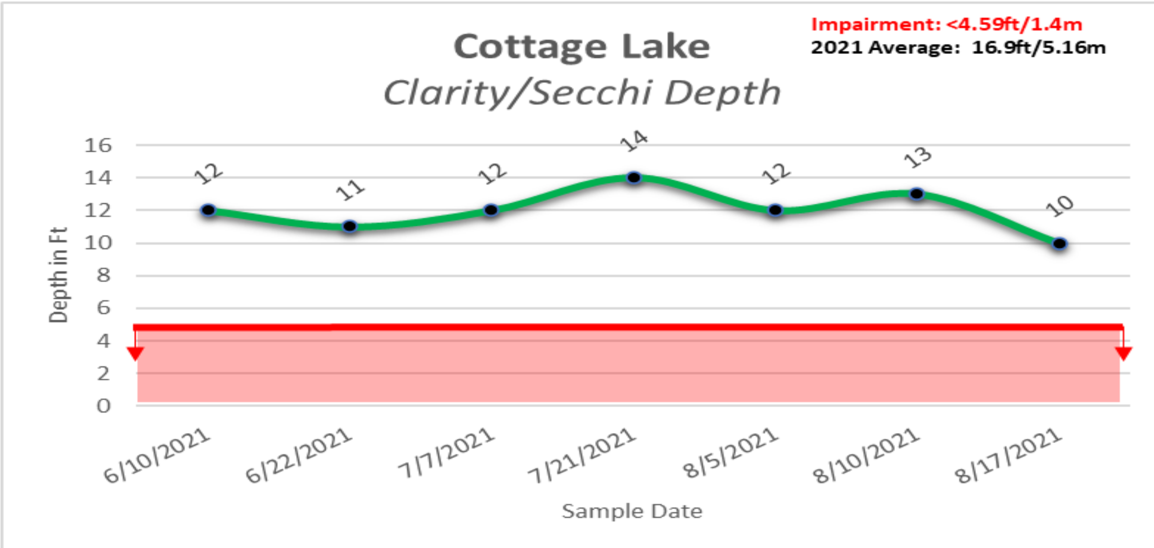


Figure 11.4. Cottage Lake Secchi Depth.

11.1.5 Reeves

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

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.

11.1.6.1 Ecological Integrity

Shoreline Survey – Abbey Lake, 51 Parcels

Shoreline Alteration: This is the first year this lake has had a shoreline survey conducted on it. Abbey Lake's shoreline is 69% natural, 35 parcels. 16% minimally altered, 8 parcels. 10% moderately altered, 5 parcels. 6% greatly altered, 3 parcels. 1 parcel has90% of riprap along the shoreline. Sand blankets are on a total of 2 parcels: both covering 50% or less of their shoreline with sand blankets. There are 2 parcels with retaining walls; 1 parcel has retaining walls along 80% of the shoreline, with the remaining 1 parcel covering 10% of the shoreline area.

Table 11.1. Shoreline alteration grading scale

Natural	Natural vegetation for all of shoreline and shore-impact zone; No Modifications have been made to the shoreline except a small walkway (~4ft) and/or a dock.
Minimally Altered	Naturally vegetated for 80% of shoreline and shore-impact zone; Some modifications maybe made, a small strip of vegetation may be cleared; Only natural sand blanket and rip-rap present
Moderately Altered	20%-50% of shoreline altered from natural state; No retaining walls present; Modifications to Shore-impact zone are present, but limited to less than 50% of shoreline; property retains some trees or shrubs in shore-impact zone
Greatly Altered	More than 50% of shoreline is altered; Retaining walls or concrete patio may be present in Shore-impact Zone; Turf grass all the way to shoreline/riprap/sand blanket; upland may be clear cut

Waterfront Equipment: The number of waterfront equipment for 2021 was 17 docks, 1 raft, 2 uncovered boatlifts, 4 other motorized boats (pontoons, waterski, fishing) and 12 non-motorized boats (kayaks, paddleboats).

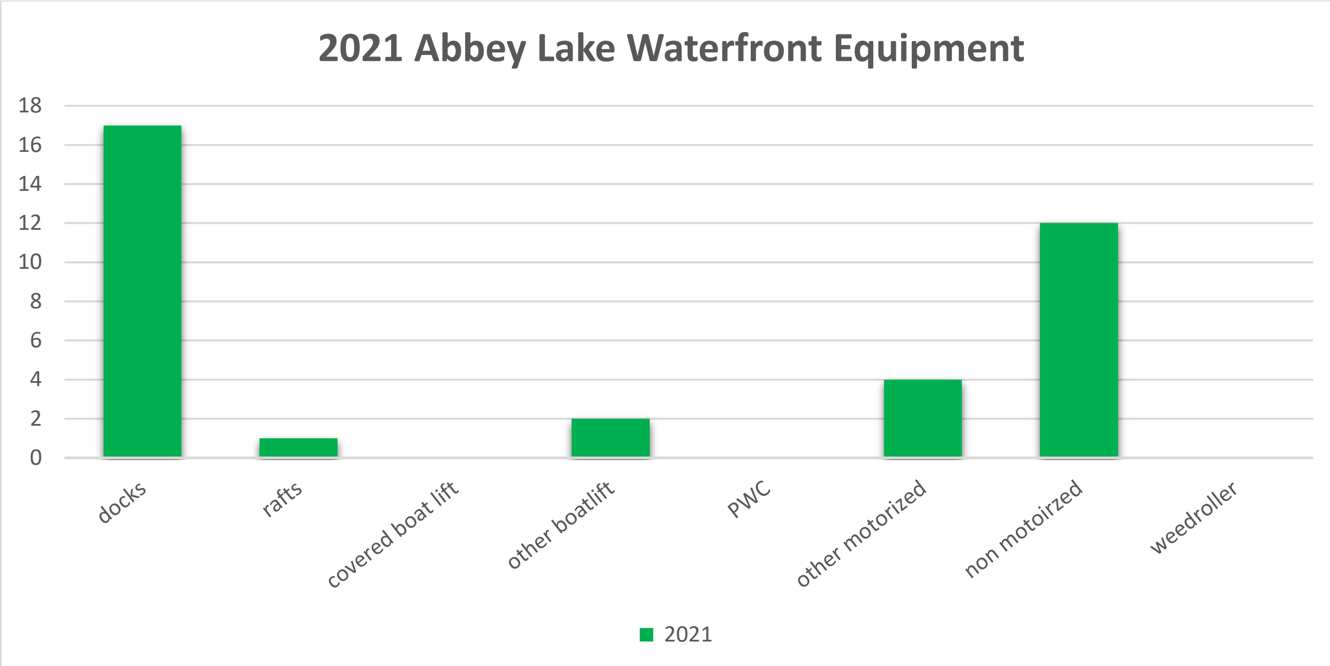


Figure 11.5. Waterfront equipment on Abbey Lake

Waterfront Structures: The number of waterfront structures increased between the surveys with 4 more sheds, 6 more decks, and 1 boat launch.

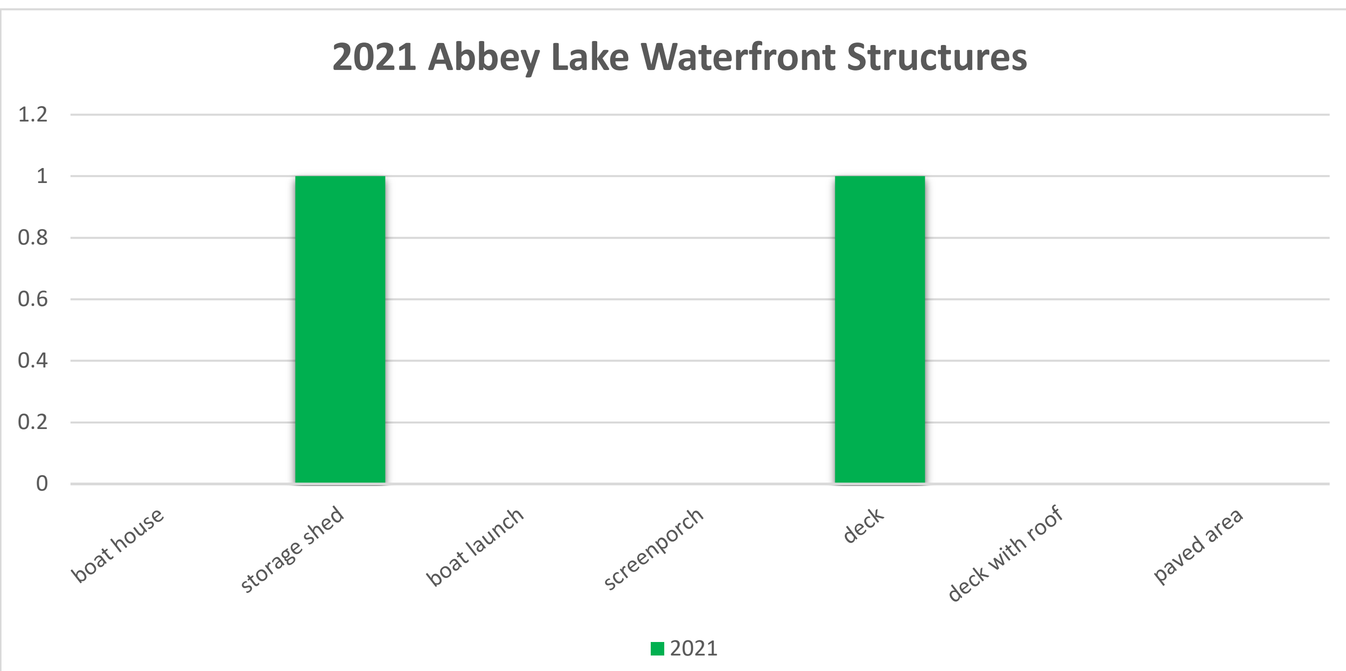


Figure 11.6. Waterfront structures on Abbey Lake.

12 Munson/Fox Water Management Area

The Munson-Fox WMA contains about 1,350 acres (Figure 11.1). 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.

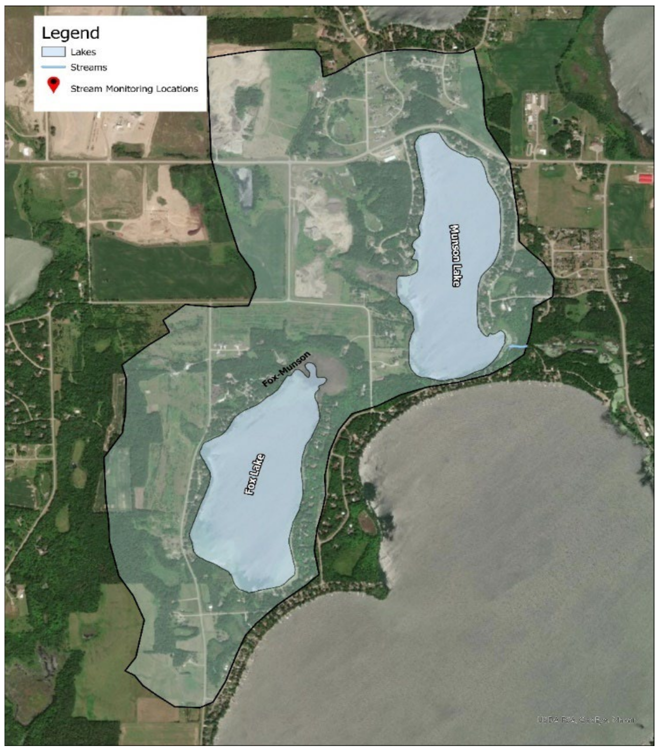


Figure 12.1. The Munson/Fox Water Management Area.

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. In 2022 the District will be conducting a vegetation survey on Fox Lake.

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 18µg/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.