Middle St. Croix Watershed Management Organization 2024 Water Monitoring Summary

Prepared For:

MIDDLE ST. CROIX
WATERSHED MANAGEMENT ORGANIZATION

Prepared by:

WASHINGTON CONSERVATION DISTRICT

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ABBREVIATIONS, DEFINITIONS, ACRONYMS, AND SYMBOLS

Anoxic	Lacking oxygen
BCWD	Brown's Creek Watershed District
Benthic	The area nearest lake bed
Biweekly	Every two weeks
BMP	Best management practice
cf	cubic feet
cfs	cubic feet per second
Chl-α	Chlorophyll-α
DO	Dissolved oxygen
E. coli	*Escherichia coli*
IESF	Iron enhanced sand filter
Littoral zone	The area of a body of water where sunlight penetrates to the sediment and allows aquatic plants (macrophytes) to grow
MCES	Metropolitan Council Environmental Services
mg/L	milligram per liter
mL	milliliter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MPN	Most probable number
MSCWMO	Middle St. Croix Watershed Management Organization
NAVD 88	North American Vertical Datum of 1988, used for determining lake elevations
NGVD 29	National Geodetic Vertical Datum of 1929, used for determining lake elevations
OHW	Ordinary high water level
SOP	Standard operating procedure
TKN	Total Kjeldahl nitrogen
TP	Total phosphorus
TSI	Trophic State Index
TSMP	Trout Stream Mitigation Project
TSS	Total suspended solids
µg/L	micrograms per liter
VSS	Volatile suspended solids
WCD	Washington Conservation District

EXECUTIVE SUMMARY

This report focuses on the summary and comparison of lake and stream water quality data collected by the Washington Conservation District (WCD) in 2024, as well as previous years. In 2024 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored water quality and water surface elevation on McKusick Lake and Lily Lake, water surface elevation on Brick Pond, and flow and water quality at Perro Creek at the Diversion Structure (Figure 1). The purpose of this monitoring is to assess and document current water quality conditions of the lakes and streams, as well as continuation of a long-term monitoring program that will enable the MSCWMO to identify trends associated with best management practice (BMP) implementation and land use changes in the watershed. Also included in this report is data collected at the Brown's Creek Diversion Structure, which is a tributary to McKusick Lake that is monitored by the WCD for the Brown's Creek Watershed District (BCWD).

Lake Monitoring

Lily Lake was classified as mesotrophic and received an A grade in 2024 (APPENDIX A). All samples collected June – September met the Minnesota Pollution Control Agency's (MPCA) standards for total phosphorus (TP) and for chlorophyll-α (chl-α) corrected for pheophytin. All Secchi disk transparency measurements also met the MPCA standard (APPENDIX A).

In 2024 McKusick Lake was classified as eutrophic and received a grade of C+ (APPENDIX A). Three of the nine samples collected June – September did not meet the Minnesota Pollution Control Agency's standard for total phosphorus and one sample did not meet the standard for chlorophyll-α corrected for pheophytin. All Secchi disk transparency measurements met the MPCA shallow lake standard (APPENDIX A).

Stream Monitoring

Water quality sampling continued on Perro Creek at the Diversion Structure in 2024 and the total recorded discharge to the St. Croix River was 26,605,792 cubic feet, which included discharge through the overflow structure. This was an increase from 2023 as a result of a wet spring and

summer. The average baseflow TP concentration was 0.034 mg/L (similar to 2018-2021) and the average baseflow TSS concentration was 3 mg/L (consistent since 2018). The average TP concentration from storm samples was 0.283 mg/L (highest since 2021) and the average TSS concentration from storm samples was 208 mg/L (highest since 2021). TP and TSS loads to the St. Croix River were calculated only during monitored periods, and in 2024 the TP load was 76.4 lbs. and the TSS load was 21,247 lbs.

Discharge at the Brown's Creek Diversion Structure site doubled from 2023 to 2024 due to the wet spring and summer, with a volume of 72,832,083 cubic feet exported to McKusick Lake. The total annual TP and TSS loads also increased, and were 573 lbs. and 230,855 lbs., respectively. Concentrations of metals were again low in 2024. There was one copper result and three lead results that exceeded MPCA chronic standards.

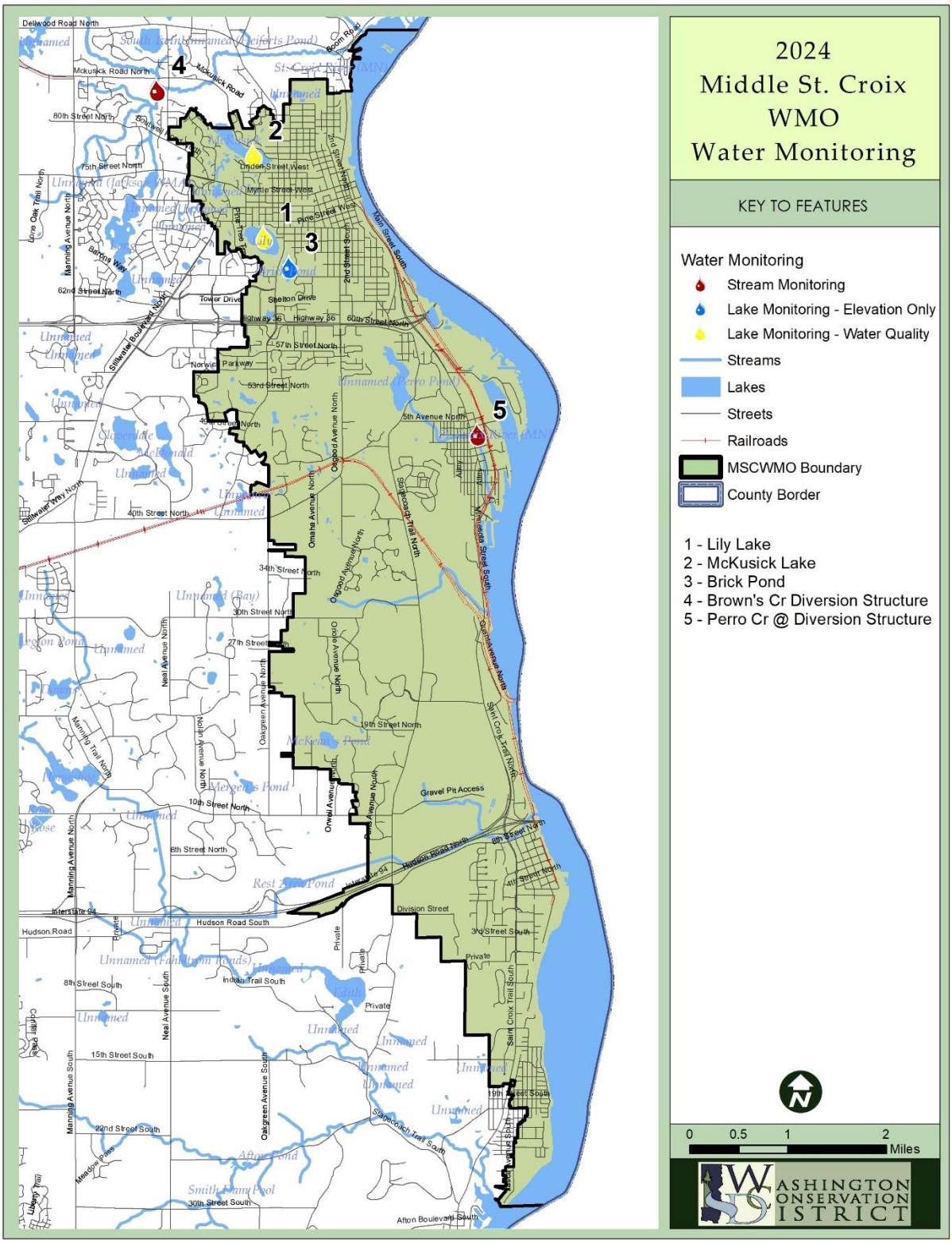

Figure 1. MSCWMO 2024 Water Monitoring Locations

LAKE MONITORING

A. METHODS, RESULTS AND DISCUSSION

In 2024 water quality data was collected biweekly on Lily Lake and McKusick Lake, over seven consecutive months (April–October) by the WCD. Measurements obtained during the summer sampling season (June–September) are averaged for a comparison of individual lake dynamics from year to year between lakes within the watershed and to the Minnesota Pollution Control Agency's (MPCA) impairment standards. Lake grades are based on the averages of samples collected May–September. Average values for all parameters are presented in APPENDIX A and Figure 2 through Figure 5, which show the current and historic summer averages for each parameter. Water quality samples were collected by the WCD with a two-meter (6.56 feet) integrated surface water column sampler. A full description of WCD Standard Operating Procedures (SOP) is available on the Washington Conservation District website at http://www.mnwcd.org/water-monitoring. The Metropolitan Council Environmental Services (MCES) Laboratory analyzed the surface water samples for TP, chl-α, and total Kjeldahl nitrogen (TKN).

Total phosphorus is analyzed as it is a major nutrient involved in the eutrophication of lakes and is generally associated with the growth of aquatic plants and/or algal blooms. Common sources of phosphorus include runoff from agricultural fields, livestock areas, urban areas, lakeshore lawns, and improperly operating septic systems. With most lakes in this region, phosphorus is the least available nutrient; therefore, its abundance or scarcity controls the extent of algal growth. Excess algal growth, in turn, negatively affects the clarity, or transparency, and ability of light to penetrate the water. The MPCA sets lake eutrophication standards for aquatic life and recreation. The standard for TP is 0.040 mg/L for deep lakes and 0.060 mg/L for shallow lakes. In general, shallow lakes are defined as less than 15 feet deep, with greater than 80% littoral area, and less than 10 acres. The 2024 summer average of TP values of MSCWMO lakes can be found in Figure 2.

Chlorophyll-α is measured because it's the photosynthetic component found in algae and aquatic plants and is an indicator of algal productivity. The MPCA standard for pheophytin-corrected

chl-α is 14 µg/L for deep lakes and 20 µg/L for shallow lakes. The 2024 summer average chl-α concentrations of MSCWMO lakes can be found in Figure 3.

TKN, the sum of organic nitrogen and ammonia, was analyzed in MSCWMO lakes. While no standard exists for TKN because TP is often the limiting nutrient, TKN can contribute to eutrophication. The 2024 summer average TKN concentrations of MSCWMO lakes can be found in Figure 4.

Field measurements are recorded while collecting lake samples, including Secchi disk transparency. The measurement of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. A reduction in water transparency is typically the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). The MPCA standard for Secchi disk transparency is 1.4 meters for deep lakes and 1.0 meter for shallow lakes. The 2024 summer average transparency of MSCWMO lakes can be found in Figure 5.

User perception and physical/recreational suitability of lakes were recorded, along with temperature and dissolved oxygen (DO) profile measurements taken by the WCD during each sampling event. Profiles are recorded at one-meter increments from the water surface to the lake bottom. The data show the extent of summer stratification and are useful in identifying the development of a thermocline (the layer of water in which the temperature rapidly declines). As a lake stratifies, the water column becomes more stable and mixing is less likely to occur. If mixing occurs during the growing season, nutrients from the lake bottom become available and can result in increased algal production. Lake DO profile data is useful in determining excessive production (algae/plants) in a lake. Increased production creates more DO, for a time, but as plants and algae die off and decay, the bacteria that decompose them consume DO. Low DO conditions may stress fish populations and under anoxic conditions nutrients may be released from the sediment. Data collected from the rankings and profiles are contained in a database at the WCD, and can be obtained by request, as well as on the MPCA website at https://webapp.pca.state.mn.us/surface-water/search.

A lake grading system is used in this summary, to allow for a better understanding of lake water quality data and to aid in the comparison of lakes. The lake water quality grading system was developed following the 1989 sampling season by MCES. The concept of the lake grading system is a ranking of water quality characteristics by comparing measured values to those of other metro area lakes. The grading system represents percentile ranges for three water quality indicators: the May through September average values of TP, uncorrected trichromatic chl-α, and Secchi disk transparency. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 1. This method has since been replicated and the grading system has been verified with more recent data. The variables used in the grading system strongly correlate to open-water nuisance aspects of a lake (i.e. algal blooms), which can indicate accelerated aging (cultural eutrophication). There is a strong correlation when comparing trophic status to the lake grade. Summaries of all lake results are presented in APPENDIX A.

Table 1. Lake Grade Ranges

Grade	Percentile	TP (µg/L)	Chl-α (µg/L)	SD (m)
A	<10	<23	<10	>3.0
B	10-30	23-32	10-20	2.2-3.0
C	30-70	32-68	20-48	1.2-2.2
D	70-90	68-152	48-77	0.70-1.2
F	>90	>152	>77	<0.70

There are several metrics and systems that can also be used to assess lakes including the Carlson Trophic State Index (TSI) and ecoregion values. The Carlson Trophic State Index is used to quantify the relationship between water quality data and trophic status. Trophic states vary from oligotrophic (low biological activity and high clarity) to hypereutrophic (highly productive with very low clarity). The MSCWMO is located in the North Central Hardwood Forest Ecoregion where lakes are often mesotrophic. Ecoregion values are assigned for TP, TKN, chl- α, and Secchi disk transparency. This report will focus on the methods used by the MPCA and the Metropolitan Council, as previously discussed.

Water elevation monitoring was conducted on two lakes, McKusick and Lily, from April to October 2024. Lake elevation readings are compared to the lake's Ordinary High Water level (OHW)[1]. The OHW for Lily and McKusick Lakes are 844.8 ft. and 851.7 ft., respectively (NGVD 29). Changes in lake water elevation are often attributed to the changes in precipitation. The highest recorded elevation in 2024 for Lily Lake occurred on 6/20/2024 at 846.83 ft. and on 6/20/2024 at 855.05 ft. for McKusick Lake. Complete lake elevation data for 2024 can be found in APPENDIX A. For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

Water elevation monitoring also occurred on Brick Pond by a citizen volunteer, April to September. The lowest recorded elevation was on 9/10/2024 at 847.73 ft. and the highest was on 6/19/2024 at 848.61 ft. (NAVD 88).

1. LILY LAKE

In 2024 WCD staff conducted two-tailed Kendall's Tau statistical analysis based on data collected by professional agencies for both lakes monitored in MSCWMO to determine trends for TP, Secchi, and chl-α ($p<0.05$). Lily Lake had a statistically significant improving trend for TP, average Secchi disk transparency, and chl-α. Lily Lake had an average summertime TP concentration of 0.017 mg/L, which was lower than 2023 average of 0.022 (Figure 2). All nine summertime results met the MPCA lake nutrient impairment standard for TP. The 2024 average summertime concentration of chl-α was 4.5 μg/L, higher than the 2.5 μg/L measured in 2023 (Figure 3). All nine summertime water quality results for chl-α met the MPCA lake impairment standard (APPENDIX A). Lily Lake had an average summertime TKN concentration of 0.53 mg/L in 2024; higher than the average of 0.50 mg/L in 2023 (Figure 4). Secchi disk readings

[1] Minnesota State Statutes defines the ordinary high water level (OHW) as follows: Minnesota Statutes 103G.005 Subd. 14. Ordinary High Water Level. "Ordinary high water level" means the boundary of water basins, watercourses, public waters and public waters wetlands, and: The ordinary high water level is an elevation delineating the highest water level that has been maintained for a sufficient period of time to leave evidence upon the landscape, commonly the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial;

1) For watercourses, the ordinary high water level is the elevation of the top of the bank of the channel; and
2) For reservoirs and flowages, the ordinary high water level is the operating elevation of the normal summer pool.

were measured in 2024 with a summertime average of 3.42 meters (Figure 5), with all nine summertime water quality readings meeting the MPCA lake standard for Secchi disk transparency (APPENDIX A). Lily Lake received an A grade in 2024, matching the A it received in 2023. Temperature and DO profiles indicate that Lily Lake exhibited thermal stratification during the summer months with the thermocline between 4 and 5 meters; therefore, the lake was less likely to completely mix throughout the summer. The elevation was above the OHW for the entire monitoring season, with the highest recorded level occurring on 6/20/2024 with a level of 846.83 ft. The lowest recorded level of the monitoring season occurred on 10/28/2024 with an elevation of 844.99 ft. A summary of all lake results is presented in APPENDIX A.

2. MCKUSICK LAKE

A two-tailed Kendall's Tau analysis based on data collected by professional agencies showed that McKusick Lake has statistically significant ($p<0.05$) improving trends for TP and average Secchi transparency, and no trend for chl-α. The McKusick Lake summertime average TP concentration in 2024 was 0.064 mg/L; higher than the 0.037 mg/L observed in 2023 (Figure 2). Three of the nine summertime samples collected in 2024 did not meet the MPCA shallow lake standard for TP (APPENDIX A). McKusick Lake had a summertime average chl-α concentration of 15.6 μg/L; higher than the chl-α average of 8.7 μg/L from 2023 (Figure 3). One of the nine summertime samples collected in 2024 did not meet the MPCA shallow lake standard for chl-α. The average summertime TKN concentration in 2024 was 0.79 mg/L, higher than the 0.70 mg/L in 2023 (Figure 4). The 2024 summertime average water transparency measured by Secchi disk was 1.79 meters (Figure 5). All nine summertime Secchi disk readings in 2024 met the MPCA shallow lake impairment standard. McKusick Lake received a grade of a C+ in 2024, a downgrade from the B- it received in 2023. No temperature and DO profiles were collected so the occurrence of thermal stratification in the deepest part of the lake cannot be determined. A majority of McKusick Lake is very shallow and does not stratify, and therefore is likely to have mixed throughout the summer. The elevation of McKusick Lake remained above the OHW for the entire monitoring season, reaching its highest recorded level of the season on 6/20/2024 with a level of 855.05 ft. and the lowest recorded level of the season occurred on 10/08/2024 with an elevation of 854.14 ft. A summary of all lake results is presented in APPENDIX A.

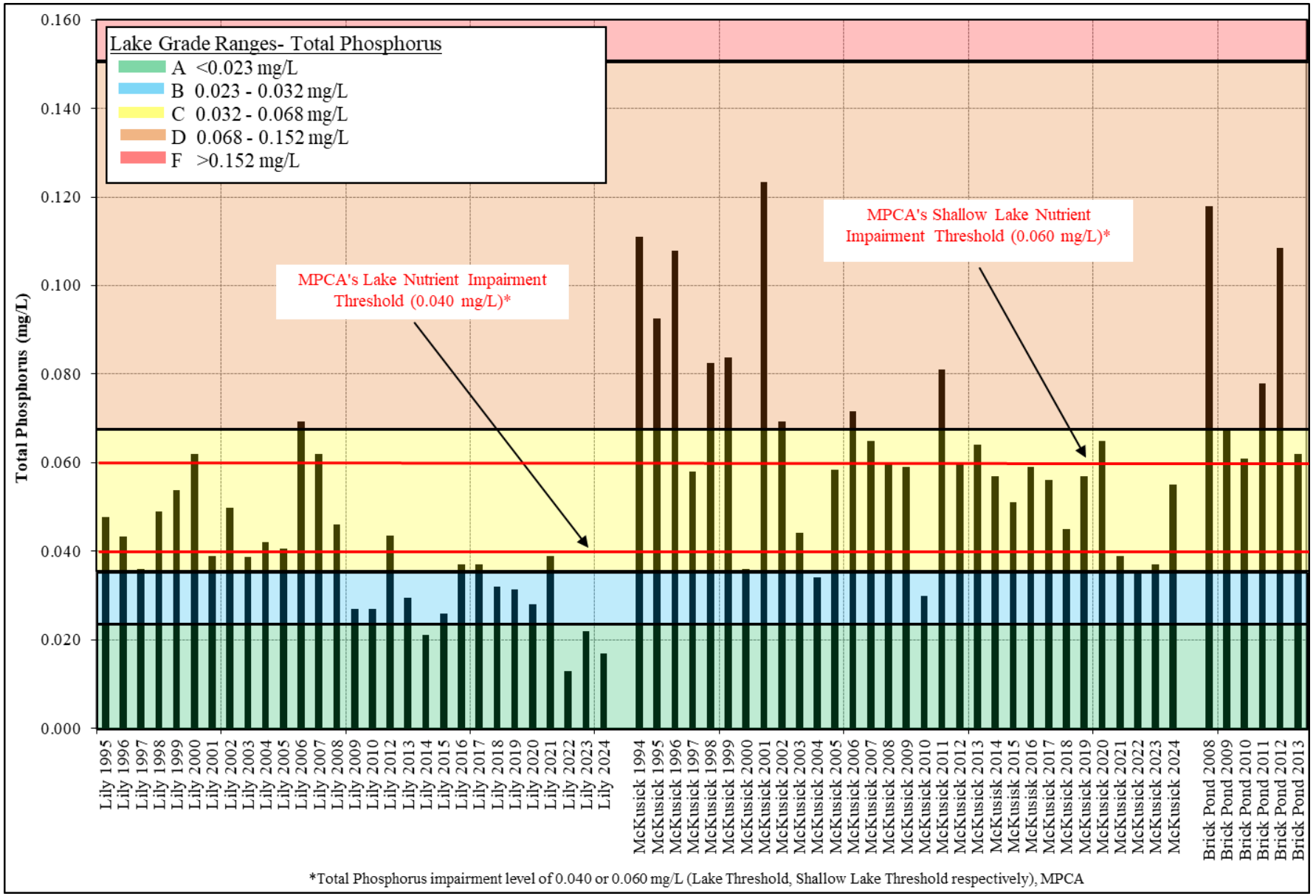

Figure 2. MSCWMO Historic Summer Average Total Phosphorus

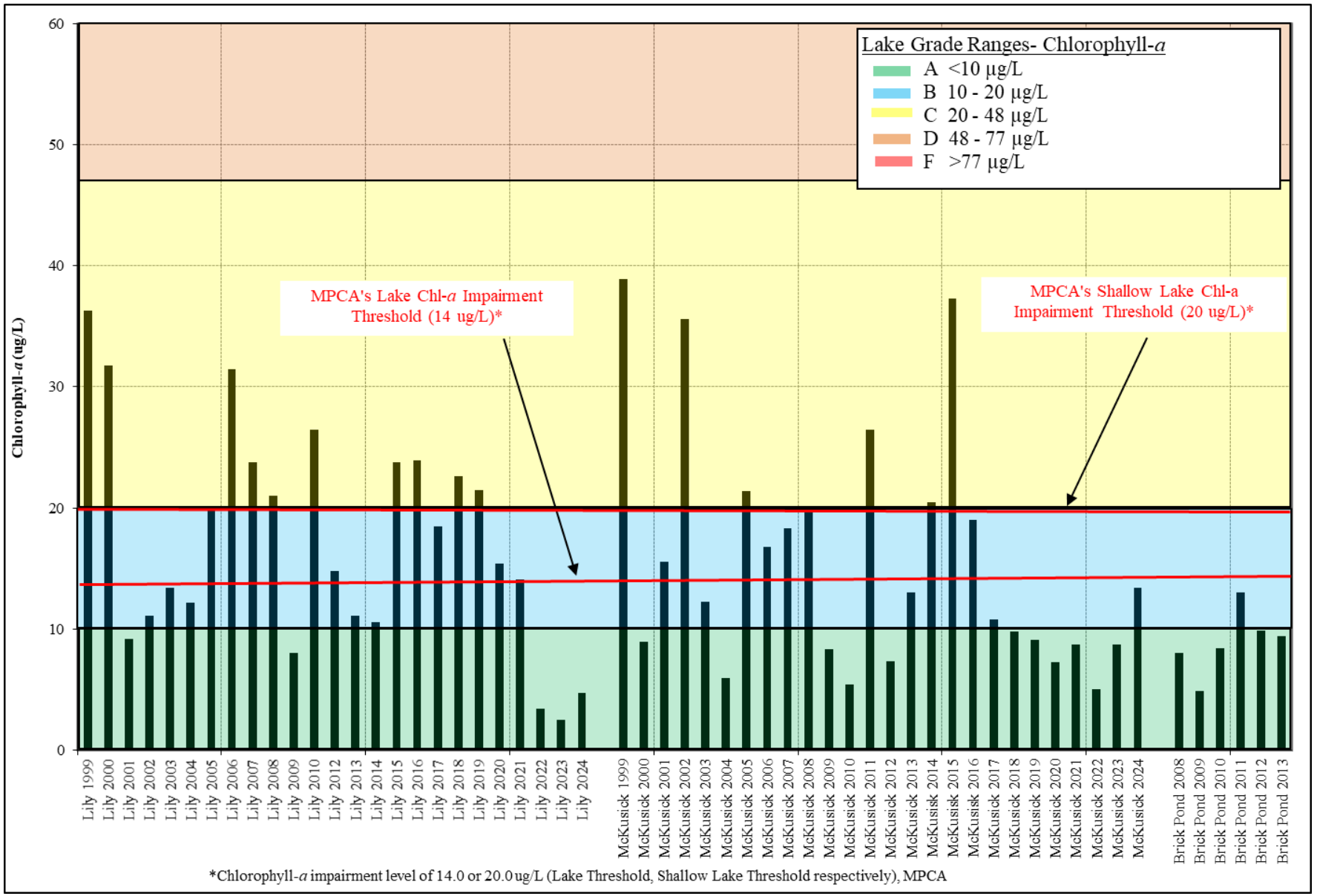

Figure 3. MSCWMO Historic Summer Average Chlorophyll-α

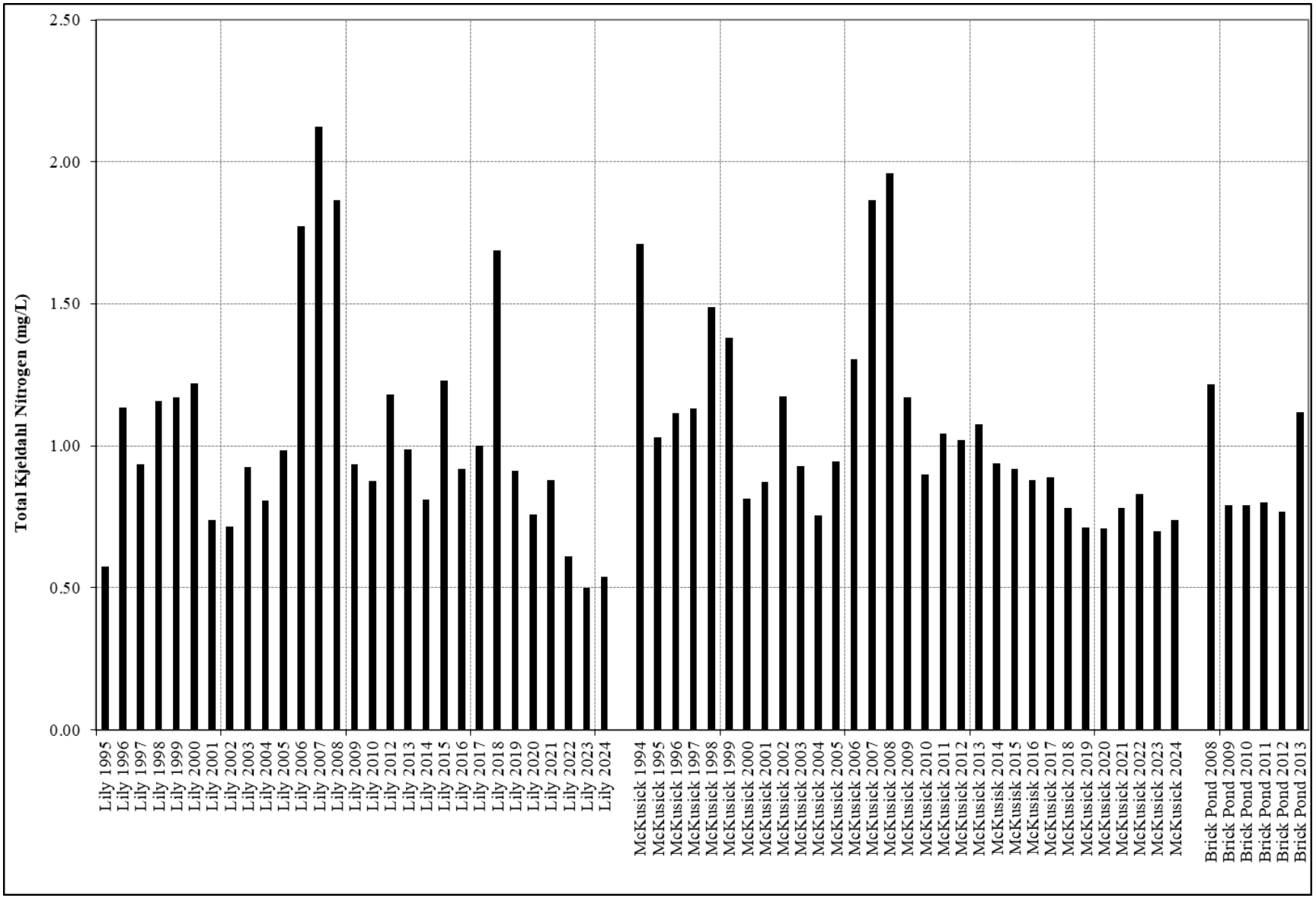

Figure 4. MSCWMO Historic Summer Average Total Kjeldahl Nitrogen

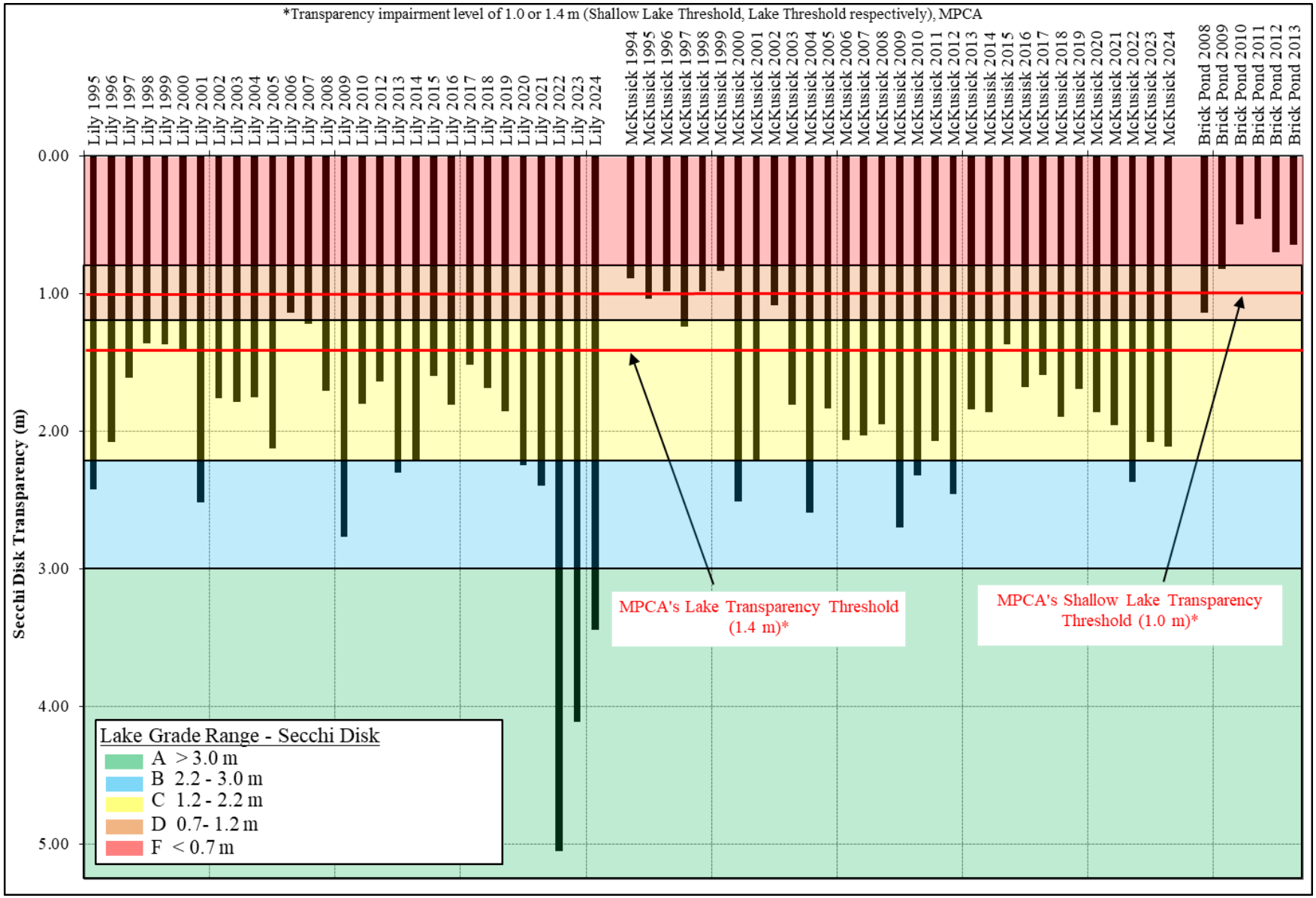

Figure 5. MSCWMO Historic Summer Average Secchi Disk Transparency

STREAM MONITORING

A. PERRO CREEK MONITORING

The goal of monitoring Perro Creek in 2016-2017 was to identify where the greatest contribution of nutrients and sediment to the St. Croix River was occurring. Monitoring continued in 2018 and 2019 to further refine previous observations. In 2020 water monitoring activities were reduced on Perro Creek and no traditional water quality samples were collected. Beginning in 2021, and continuing through 2024, water quality sampling was conducted on Perro Creek at the Diversion Structure site by collecting in-stream grab samples during baseflow periods and using an automated sampler to collect flow-weighted composite storm samples. The automated sampler allowed for multiple samples to be collected during storm events, which were then combined into one sample representing the storm event. This methodology can provide more accurate data for calculating nutrient loads during storm events than grab samples alone. Continuous 15-minute stage and velocity data were collected at the site and in the Diversion Structure Overflow from 4/10/24 – 10/30/24. Discharge was calculated using an area/velocity relationship, and the recorded discharge in 2024 to the St. Croix River was 26,605,792 cubic feet (Table 2).

Twelve water quality samples were collected in 2024 and analyzed for several parameters, including total phosphorus and total suspended solids (Table 3). Seven baseflow grab samples were collected May – October, one of which was only analyzed for E. coli. Four storm composite samples and one storm grab were collected April – August. The 2024 baseflow average TP concentration was 0.034 mg/L, which is similar to the baseflow averages for 2018-2021 (Table 4). The baseflow average TSS concentration was 3 mg/L, which is similar to the baseflow averages since 2018. The average TP concentration from storm samples collected in 2024 was 0.283 mg/L, which is similar to 2022 and is the highest since 2021 (Table 4). The average TSS concentration from storm samples was 208 mg/L, which was the highest since 2021. The 7/23 storm grab sample was collected during a high flow period after a storm event but the sample results indicate the water quality had already returned to baseflow conditions. Therefore the results from this sample were excluded from the storm averages. TP and TSS loads

to the St. Croix River were calculated for both the creek and the Diversion Structure Overflow during monitored periods. In 2024 the TP load was 76.4 lbs. (Table 2 and Figure 6) and the TSS load was 21,247 lbs. (Table 2 and Figure 7).

Perro Creek is listed as impaired for TSS on the MPCA's 303(d) Impaired Waters List. The stream is in the Central River Nutrient Region and the MPCA standard is 30 mg/L for class 2B waters. The MPCA's protocols for assessments are as follows:

"A stream is considered to exceed the standard for TSS if 1) the standard is violated more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and 2) at least three measurements violate the standard. A stream is considered to meet the standard for TSS if the standard is met at least 90% of the days of the assessment season. A designation of meeting the standard for TSS generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when exceedances are most likely to occur, a smaller number of measurements may suffice."

Perro Creek is also listed as impaired for *E. coli* bacteria on the MPCA's 303(d) Impaired Waters List. *E.* coli is used as an indicator in waterbodies for the possible presence of fecal contamination, including pathogens. The primary source of *E. coli* is human and animal waste, making high *E. coli* presence a concern for human health. A summary table by month can be found in Table 5. The MPCA standard is defined as follows, and is based on the latest ten years of data as per MPCA protocol:

"*Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31*."

Table 2. Perro Creek 2024 Monitored Discharge and TP & TSS Loading

Site	Date range	Discharge (cf)	Discharge (ac-ft)	Percent of Total Discharge	TP Load (lbs)	Percent of TP Load	TSS Load (lbs)	Percent of TSS Load
Perro at Diversion Structure Baseflow	4/10/24 - 10/30/24	18,228,352	418.68	69%	38.5	50%	3,129	15%
Perro at Diversion Structure Stormflow [1]	4/10/24 - 10/30/24	540,569	12.42	2%	9.3	12%	6,809	32%
Perro at Diversion Overflow Baseflow [2]	4/10/24 - 10/30/24	7,063,928	162.25	27%	14.9	20%	1,213	6%
Perro at Diversion Overflow Stormflow [1 2]	4/10/24 - 10/30/24	772,943	17.75	3%	13.7	18%	10,097	48%
Total to the St. Croix River		26,605,792	611.10	100%	76.4	100%	21,247	100%

[1] *7/23 results were excluded from averages used for load calculations*

[2] *Result averages from samples collected in-stream at the Diversion Structure were used for Diversion Overflow loading calculations*

Table 3. Perro Creek at Diversion Structure 2024 Water Quality Results

Sample Type	Start	End	TP (mg/L)	Dissolved P (mg/L)	TSS (mg/L)	TKN (mg/L)	Ammonia Nitrogen (mg/L)	Nitrate N (mg/L)	Nitrite N (mg/L)	*E. coli* (mpn/100 mL)
Base Grab	5/16/24 10:13	5/16/24 10:13		0.015	6					96
Base Grab	6/26/24 13:33	6/26/24 13:33	0.054	0.042	3					48
Base Grab [1]	7/25/24 12:37	7/25/24 12:37	0.033	0.020	<3					111
Base Grab	8/28/24 9:13	8/28/24 9:13								376
Base Grab [1]	9/12/24 12:42	9/12/24 12:42	0.026	0.024	<3					
Base Grab	9/24/24 10:00	9/24/24 10:00	0.034	0.022	3					488
Base Grab [1]	10/21/24 15:20	10/21/24 15:20	0.022	0.022	<3					120
Storm Composite	4/16/24 16:22	4/16/24 17:03	0.302		225	1.74				
Storm Composite	5/21/24 17:39	5/21/24 20:19	0.295	0.025	232					
Storm Grab [2]	7/23/24 11:01	7/23/24 11:01	0.040	0.019	5		0.15	0.30	0.07	
Storm Composite	8/5/24 10:28	8/5/24 12:33	0.139	0.034	47	0.99	0.38	0.52	<0.06	
Storm Composite	8/27/24 6:04	8/27/24 6:39	0.396	0.098	327					

[1] *TSS results that are less than the Reporting Limit were divided in half for calculating averages*

[2] *Results excluded from averages*

Table 4. Perro Creek Historical TP and TSS Averages and Ranges

Perro @ Diversion Sample Type	2016	2017	2018	2019	2020	2021 [b]	2022 [b]	2023 [c]	2024
Baseflow Samples	**8**	**6**	**8**	**6**	**No**	**6**	**5**	**6**	**7**
Stormflow Samples	**5**	**5**	**4**	**3**	**Samples**	**8**	**9**	**5**	**5**
TP (mg/L) - Baseflow Average	0.051	0.046	0.036	0.034		0.035	0.015	NA	0.034
Baseflow Range	*~0.023 - 0.090*	*<0.020 - 0.120*	*0.020 - 0.058*	*0.021 - 0.065*		*0.024 - 0.210*	*<0.020 - 0.065*	*<0.05*	*0.022 - 0.054*
TP (mg/L) - Stormflow Average	0.435	0.108	0.124	0.372		0.427	0.279	0.216	0.283
Stormflow Range	*0.126 - 1.330*	*~0.023 - 0.218*	*0.047 - 0.252*	*0.133 - 0.597*		*0.185 - 0.862*	*<0.020 - 0.524*	*0.089 - 0.370*	*0.040 - 0.396*
TSS (mg/L) - Baseflow Average	16	12	4	2		2	3	2	3
Baseflow Range [a]	*<1 - 77*	*~1 - 60*	*1 - 16*	*1 - 3*		*1 - 33*	*<3 - 18*	*<3 - 18*	*<3 - 6*
TSS (mg/L) - Stormflow Average	118	36	20	58		217	86	102	208
Stormflow Range	*32 - 308*	*12 - 76*	*8 - 31*	*21 - 97*		*75 - 429*	*3 - 154*	*10 - 243*	*5 - 327*

[a] *Beginning in 2022 the laboratory changed TSS reporting to as low as the Reporting Limit (3 mg/L) rather than the Method Detection Limit (1 mg/L)*

[b] *Results from base composite sample excluded from averages (Sampled during initial opening of Perro Pond outlet)*

[c] *In 2023 the laboratory reported TP results to as low as the Reporting Limit (0.05 mg/L) rather than the Method Detection Limit (0.02 mg/L). All baseflow results were <0.05 mg/L*

Table 5. Monthly Geometric Means of *E. coli*- Latest Ten Years

Site	April	May	June	July	August	September	October
Perro at Diversion Structure [1]	Insufficient Data	109	310	210	158	444	160

Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month, collected in last 10 yrs

[1] *>10% of samples collected in the last 10 years exceeded 1,260 #/100mL*

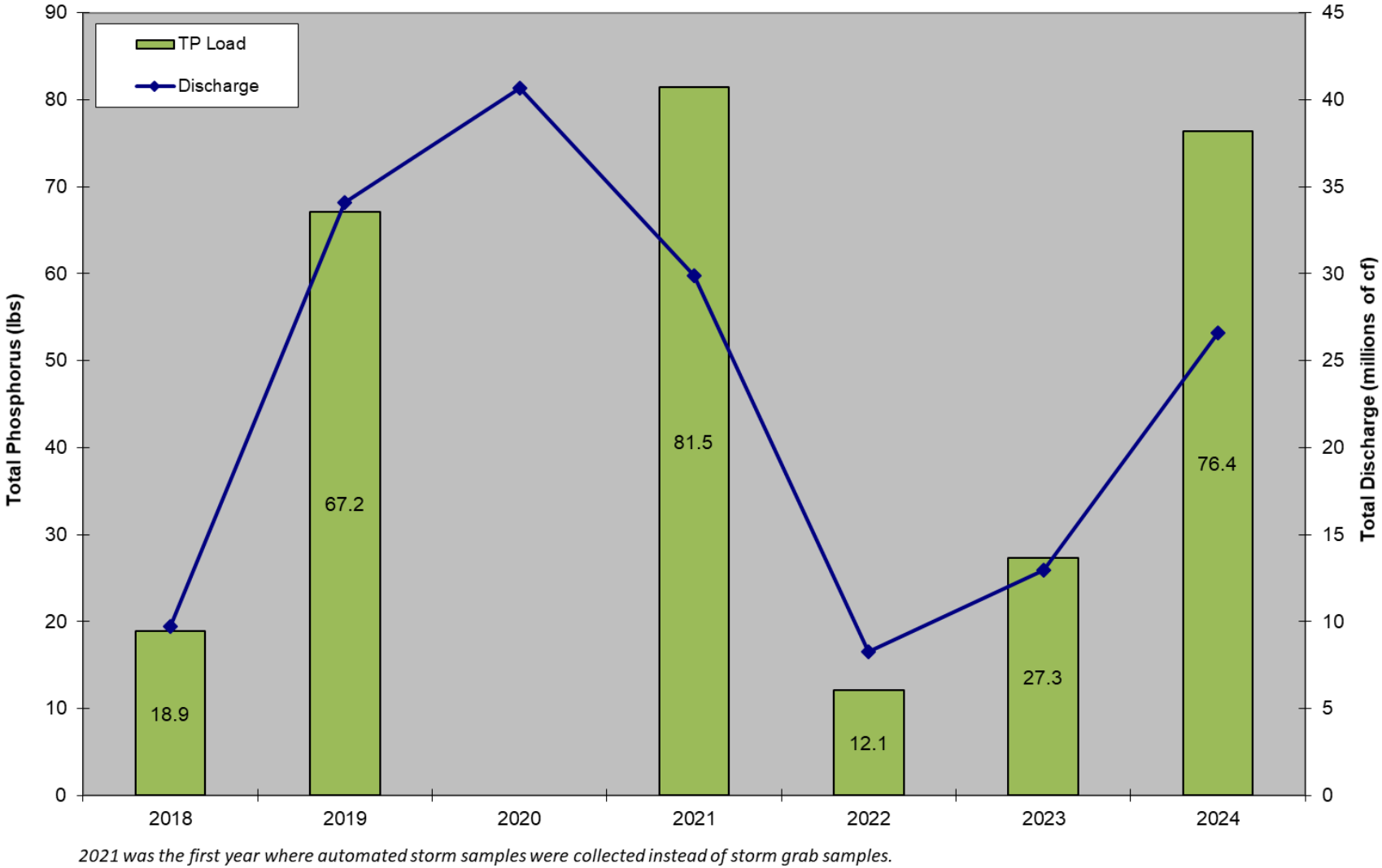

Figure 6. Perro Creek at Diversion Structure Monitored Discharge and Total Phosphorus Load

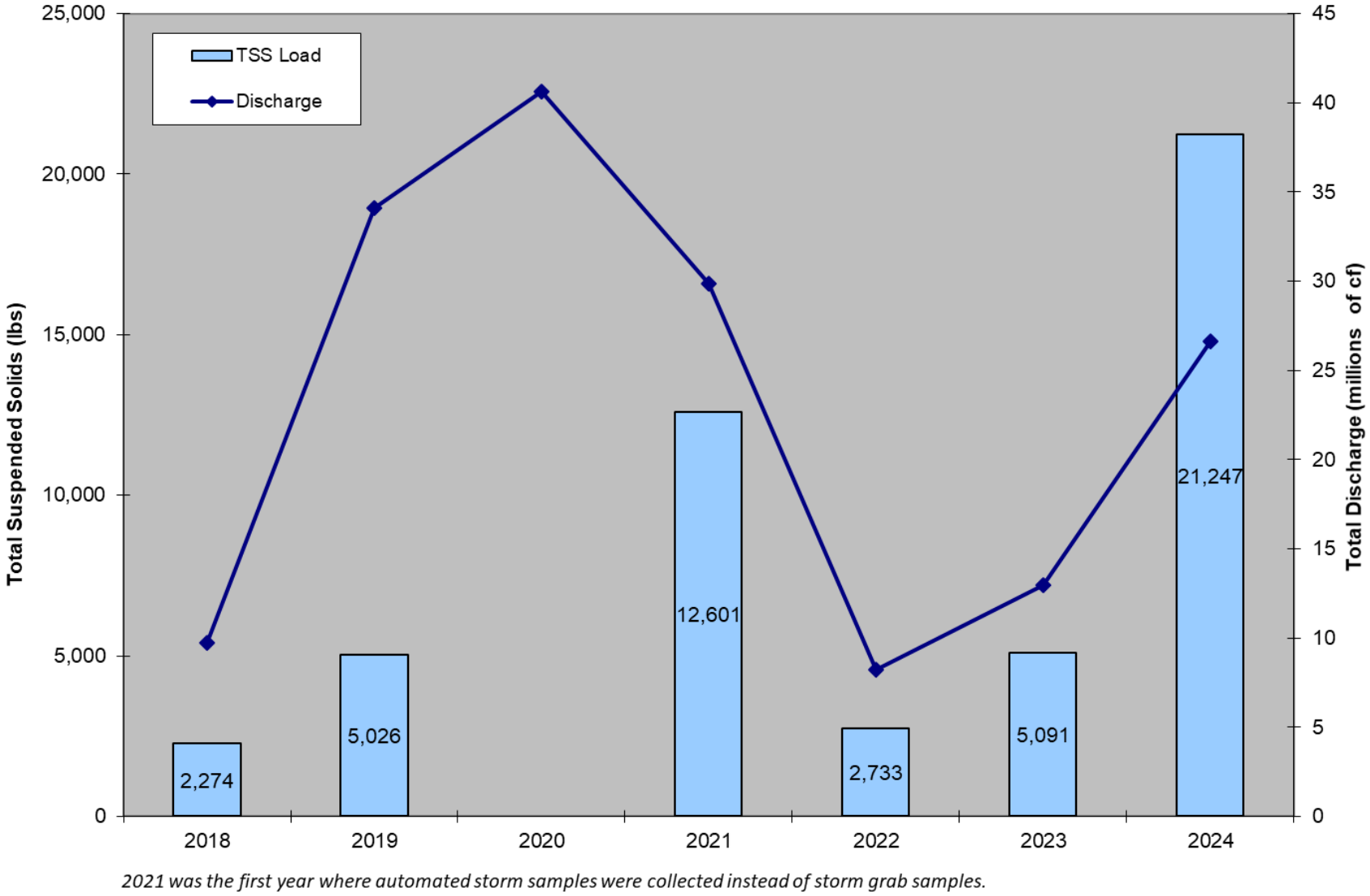

Figure 7. Perro Creek at Diversion Structure Monitored Discharge and Total Suspended Solids Load

B. BROWN'S CREEK DIVERSION STRUCTURE

As part of Brown's Creek Watershed District's long-term monitoring, the WCD collected grab samples and automated flow-weighted samples during both baseflow and storm event conditions at the Brown's Creek Diversion Structure for BCWD in 2024, and that data is provided to the MSCWMO. The City of Stillwater constructed the diversion structure in June of 2003, as part of the completion of the Trout Stream Mitigation Project (TSMP). It has been functioning to divert water from the 1,800-acre annexation area away from Brown's Creek through McKusick Lake, and ultimately to the St. Croix River. While this diversion structure keeps the warmer urban stormwater runoff from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine, it means that this is discharged to McKusick Lake and does affect the lake water quality. Data collected at this site by the WCD includes continuous stage and total discharge, and water quality samples analyzed for nutrients, sediment, and metals. Discharge in 2024 was 72,832,083 cubic feet, which was twice as much as in 2023 (Table 6). This was due to a wet spring and summer. All stream flow and chemistry data from 2024 can be found in Table 6 and Table 7.

The TP load to McKusick Lake was 573 lbs., or 0.149 lbs. of phosphorus per acre of watershed land, and the TSS load was 230,855 lbs. of sediment, or 59.88 lbs. per acre (Table 6). Erosional head cuts on the tributary branches of the creek were identified as a source of TP and TSS loads. BCWD has worked since 2018 to repair head cuts and increase floodplain connectivity through the installation of rock vanes. Beavers were again active in the area in 2024, creating dams between the Iron Enhanced Sand Filter (IESF) harvest pond and the monitoring site. The dams can enhance floodplain connectivity and settling of nutrients while improving habitat, and a resulting reduction in TP and TSS loads is likely reflected in annual loads. Due to these considerations BCWD has opted to leave dams in place. The IESF also continues to operate to reduce TP loads in the drainage.

The calculation of MPCA metal standards is described in the Minnesota Administrative Rules Part 7050.0222 and are divided into three categories of toxicity; chronic, maximum, and final acute value (FAV). The chronic standard protects organisms from long term exposure to a pollutant with minimal effects, the maximum standard from short term exposure with no or little

mortality, and the FAV is the concentration at which mortality can be expected. In 2024 one sample result exceeded the chronic standard for copper and three results exceeded the chronic standard for lead. The number and severity of exceedances of metals standards at this site were again among the lowest observed since metals analysis began in 2007. Improvements made to reduce erosion and the natural settling of sediments that may have metals bound to them in beaver impoundments are the most likely drivers of this. In most cases, severe exceedances of metals seem to be associated with extreme TSS concentrations. Sources of metals may include improperly disposed wastes, such as deep cycle batteries. The combination and concentration of metals observed over time appear to point to this as a possible source.

Table 6. Brown's Creek Diversion Historic Annual Discharge and Loading- Latest Ten Years

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Brown's Creek Diversion Structure										
Discharge (cf)	46,276,327	70,780,581	39,625,672	45,453,990	112,468,888	68,165,935	46,792,341	41,610,620	35,622,586	72,832,083
Total pounds of Phosphorus exported	1,837	1,574	784	964	3,598	760	446	389	367	573
TP (lbs/ac/yr)	0.447	0.408	0.203	0.250	0.933	0.197	0.116	0.101	0.095	0.149
Total pounds of TSS exported	1,008,346	1,533,496	596,382	505,314	2,707,186	246,238	401,069	75,429	74,875	230,855
TSS (lbs/ac/yr)	261.57	397.79	154.70	131.08	702.25	63.87	104.01	19.57	19.42	59.88

Table 7. Brown's Creek Diversion 2024 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L _CaCO3)
Storm Composite	4/16/2024 16:47	4/17/2024 0:42	90	27	2.23	0.373	0.058	0.00370	0.00290	0.00170	0.01600	0.00020	<0.00250	60.3	<0.06	0.73	<0.06	134
Storm Composite	5/21/2024 18:11	5/22/2024 6:11	186	53	2.18	0.432	0.081	0.00460	0.00420	0.00260	0.01370	0.00019	0.00400	40.9	<0.06	0.23	<0.06	99
Storm Composite	6/3/2024 5:43	6/3/2024 12:23	96	28	1.44	0.193	0.032	0.00260	0.00230	0.00140	0.00820	0.00020	<0.00250	70.6	<0.06	<0.20	<0.06	121
Storm Composite	6/4/2024 19:53	6/4/2024 23:34	1,080	336	4.68	0.905	0.064	0.01120	0.01110	0.00910	0.04380	0.00030	0.00970	51.8	<0.06	0.20	<0.06	121
Storm Composite	6/16/2024 2:29	6/16/2024 5:52	148	42	1.92	0.344	0.054	0.00400	0.00380	0.00240	0.01240	0.00018	0.00320	42.0			<0.06	111
Storm Composite	6/28/2024 6:34	6/28/2024 8:33	758	184	1.86	0.675	0.060	0.00870	0.00860	0.00710	0.03100	0.00030	0.00840	39.9			<0.06	158
Storm Composite	7/22/2024 18:31	7/22/2024 21:26	396	104	4.02	0.697	0.072	0.00800	0.00790	0.00570	0.03260	0.00024	0.00720	34.2	<0.06	0.40	<0.06	144
Storm Composite	8/5/2024 12:11	8/5/2024 23:28	234	57	2.91	0.483	0.072	0.00560	0.00640	0.00350	0.02070	0.00020	0.00510	26.3	<0.06	0.36	<0.06	123
Base Grab	5/20/2024 14:27	5/20/2024 14:27	6	3	0.60	0.080	0.044	<0.00100	0.00077	<0.00050	<0.00500	<0.00010	<0.00250	76.1	<0.06	0.23	<0.06	158
Base Grab	6/27/2024 13:56	6/27/2024 13:56	5	<3	0.58	0.073	0.040	<0.00100	0.00056	<0.00050	<0.00500	<0.00010	<0.00250	73.4	<0.06	<0.20	<0.06	90
Base Grab	7/25/2024 13:47	7/25/2024 13:47	3	<3	0.46	0.051	0.039	0.00130	0.00052	<0.00050	<0.00500	<0.00010	<0.00250	56.8	<0.06	<0.20	<0.06	79
Base Grab	9/3/2024 9:51	9/3/2024 9:51	3	<3	0.48	0.054	0.039	<0.00100	0.00054	<0.00050	<0.00500	<0.00010	<0.00250	38.9	<0.06	<0.20	<0.06	73
Base Grab	9/24/2024 9:18	9/24/2024 9:18	3	<3	0.46	0.073	0.044							42.2	<0.06	0.28	<0.06	136
Base Grab	10/21/2024 14:30	10/21/2024 14:30	3	<3	0.37	0.065	0.023	<0.00100	0.00070	<0.00050	<0.00500	<0.00010	<0.00250	46.6	<0.06	0.32	<0.06	295

Exceeds Water Quality Standard
No Exceedance Determinable
Exceeds Chronic Standard
Exceeds Max Standard
Exceeds Final Acute Standard

MSCWMO: CONCLUSIONS AND RECOMMENDATIONS

A. LAKES

Lake monitoring in MSCWMO continues to provide valuable baseline water quality information. To determine the health of the lakes in MSCWMO, physical and chemical parameters are compared on a year-to-year basis and to other lakes in the region. Water quality in a lake depends on a number of different variables such as: size of the contributing watershed, external nutrient sources, depth of the lake, and the current amount of nutrients available to be periodically released from the lake bottom. Low water quality ratings of MSCWMO lakes are most likely due to long-term contribution of urban runoff (Lily Lake) or due to the sensitivity of shallow lakes being prone to summertime mixing (McKusick Lake). Shallow lakes typically exist in a low algal production, clear-water state with abundant aquatic macrophytes or in a high-algal production, turbid water state. Shallow lakes may not completely stratify in the summer, and therefore have the capability to continually mix throughout the summer. That mixing causes phosphorus to be distributed throughout the water column, causing more frequent and heavy algal blooms. This is unlike deeper, stratified lakes where phosphorus below the thermocline is not available for primary production.

The MPCA previously listed both Lily and McKusick Lake on the 303(d) Impaired Waters list for nutrient/eutrophication impairment. If a water body is listed, it indicates that it does not currently meet water quality criteria. McKusick Lake was delisted in 2012 because restoration activities within its watershed led the lake to meet the water quality standards. In 2022, the MPCA delisted Lily Lake because the lake was meeting the standards due to restoration activities within its watershed.

Summertime (June-September) TP, chlorophyll-α, and Secchi disk transparency averages have remained relatively consistent over the last thirty years in Lily Lake with the exceptions of 1995, 2001, 2009, 2013, and 2014 where overall water quality dramatically improved (Figure 2, Figure 3, and Figure 5). In 2001 phosphorus and chl-α levels dropped and the lake grade improved significantly. In 2006-2008, summer average TP, chl-α, and Secchi disk transparency deteriorated when compared to the averages seen from 2001 to 2005. In 2024 Lily Lake received

a grade of an A, matching the grade from 2023 and well above the long-term average lake grade of a C+.

The cause of these one-year increases (1995, 2001, 2009, 2013, and 2014) in water quality is presently unknown, and there may be several possible explanations which could be investigated further in the future. Lily Lake has received herbicide and algaecide treatments from 1995-2011 and 2016-2018. In 2018-2021 the City of Stillwater and the Lily Lake Association did not request any large-scale herbicide and algaecide treatments but individual landowner treatments have occurred. In 2010 a native buffer planting was installed at the public access and the Lily Lake watershed underwent a subwatershed assessment. As a result, fifteen raingardens were constructed in the Lily Lake watershed from 2011-2012, six large raingardens were installed in 2014, a gully stabilization project installed at Lakeview Hospital discharging to Brick Pond in 2017, and a large gully stabilization and stormwater treatment system discharging to Brick Pond in 2018. In 2019 another raingarden was installed. Construction of a large infiltration basin in the Greeley storm catchment subwatershed was completed in 2022 and the lake was treated with alum on May 24th, 2022. The effects of these BMPs may have been seen from 2012 to 2024 monitoring seasons with the 2016-2024 seasons having a statistically significant ($p<0.05$) improving trend for total phosphorus. Continued monitoring is needed to show changes to long term trends due to the implementation of these BMPs. In 2019 the Lily Lake Phosphorus Reductions for Delisting grant was secured. More information about the Lily Lake Impaired Waters Delisting Road Map can be found at http://www.mscwmo.org/subwatershed-assessments.

A subwatershed assessment was conducted on the McKusick Lake watershed in 2010. In 2011 six raingardens were constructed as a result of the subwatershed assessment. With renewed funding, seven additional raingardens were planned to be installed in the McKusick Lake watershed in 2013 but were not due to issues with utilities; instead, six larger raingardens were installed in 2014. The impacts of previously installed raingardens may have been seen in 2017-2024 with statistically significant ($p<0.05$) improving trends for average TP and average Secchi disk transparency. For more information on the McKusick Lake subwatershed assessment refer to the McKusick Lake Stormwater Retrofit Assessment found at http://www.mscwmo.org/subwatershed-assessments.

B. STREAMS

Water quality sampling continued on Perro Creek at the Diversion Structure in 2024. The wet spring and summer led to an increase in flow and higher TP and TSS loads. Stormflow periods accounted for only 5% of the monitored discharge to the St. Croix River but 30% of the TP load and 80% of the TSS load occurred during these periods in 2024. Stormflow periods in 2023 were nearly identical, accounting for 5% of the monitored discharge, 30% of the TP load, and 76% of the TSS load during a year of drought conditions. Flow-weighted composite samples should continue to be collected to more accurately calculate TP and TSS loads during storm events. Sediment and debris was present in the diversion structure channel which made the streambed within the structure artificially high. This may have impacted the automated storm sampling because it allowed more stormwater to flow through the overflow pipe rather than the open channel stream, which is where the sampling equipment is located. The diversion structure should be kept clear of excessive sediment and debris to ensure this doesn't become a problem.

Perro Creek is listed as impaired for TSS on the MPCA's 303(d) Impaired Waters List and is assessed using an unbiased dataset. Flow-weighted composite samples are considered biased towards higher flow periods because more samples are collected during the higher flows, and these samples are therefore not used for TSS assessments. In 2024 there were no TSS results from grab samples collected April – September that exceeded the MPCA standard of 30 mg/L for class 2B waters. Water quality grab samples should continue to be collected at Perro Creek during different levels of flow to provide an unbiased dataset for assessing the stream for TSS impairment.

Perro Creek is listed as impaired for *E. coli* bacteria on the MPCA's 303(d) Impaired Waters List. The 10-year geometric means in June – October exceed the MPCA standard, while the May geometric mean meets the standard. Samples collected in 2024 in May, June, July, and October were less than the monthly geometric means from the last 10 years of data, while the August and September samples were higher than the monthly geometric mean. All samples collected in 2023 were less than the monthly geometric means. Monthly *E. coli* samples should continue to be collected from May through October at Perro Creek to expand the dataset for calculating monthly geometric means.

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APPENDIX A – LILY LAKE AND MCKUSICK LAKE WATER QUALITY DATA

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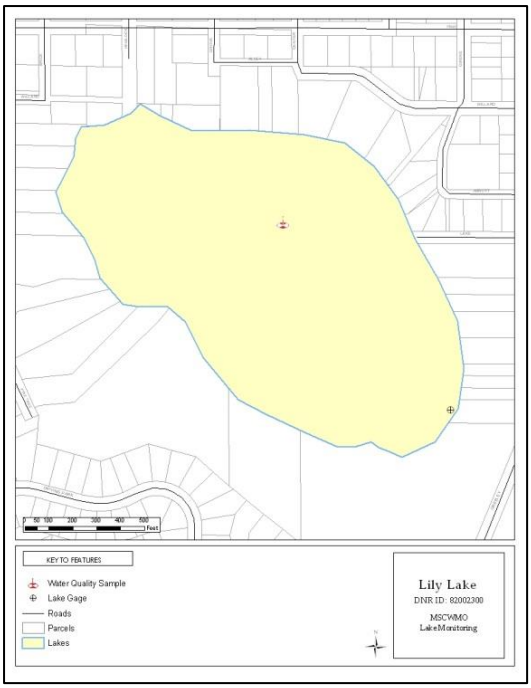
LILY LAKE

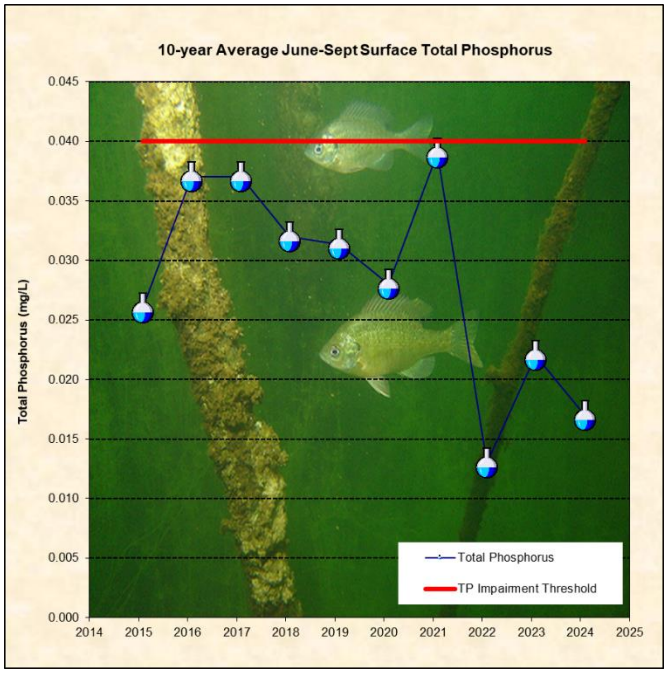
2024 Lake Grade: A

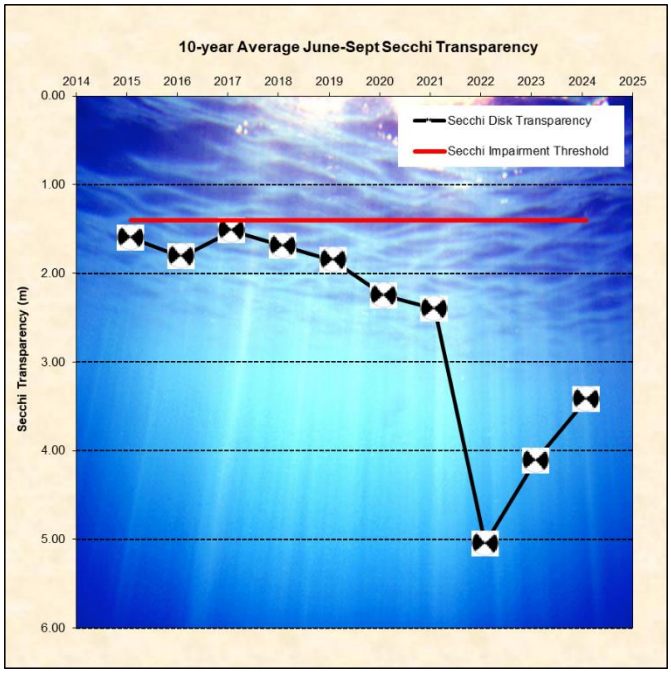
- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth (2024): 51 ft.
- Ordinary High Water Mark: 844.8 ft.
- 55%Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.
- Publicly accessible



Summary Points

- Based on the chlorophyll-α results Lily Lake was considered mesotrophic in 2024, according to the Carlson Trophic State Index.
- Using a Kendall's Tau correlation test ($p<0.05$) there is a statistically significant **improving** trend for average total phosphorus, average Secchi transparency, and average chlorophyll-α.
- The major land use is urban/residential.
- The lake stratified in 2024 with the thermocline around 4 meters deep.
- The lake was treated with alum on May 24th, 2022.
- Lily Lake was delisted in 2022 for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Lab methodology was changed for 2023 total phosphorus sample analysis, as such no results were reported <0.022 mg/L (April-mid September).





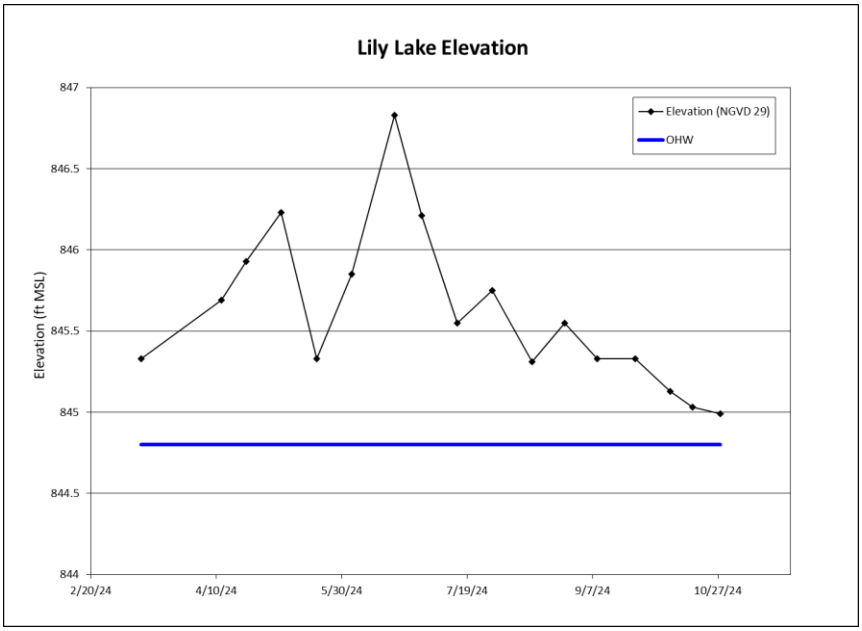
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-*a* (ug/L)	Pheophytin-Corrected Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/22/2024 10:30	0.016	9.2	8.5	0.57	2.90	10.0	16.77
5/6/2024 14:53	0.017	3.8	3.5	0.53	3.20	16.2	10.59
5/20/2024 15:10	0.014	1.3	1.1	0.60	3.20	21.6	8.15
6/3/2024 14:20	0.016	1.2	1.1	0.49	5.18	22.2	8.35
6/20/2024 11:56	0.019	2.5	2.4	0.39	4.88	22.5	8.72
7/1/2024 14:43	0.018	3.9	3.7	0.46	3.35	23.3	10.27
7/15/2024 12:24	0.020	5.6	4.8	0.48	2.74	26.3	10.11
7/29/2024 14:45	0.014	4.9	5.1	0.64	3.20	28.3	10.72
8/14/2024 11:36	0.015	5.9	5.3	0.53	3.20	24.1	13.13
8/27/2024 14:45	0.019	6.5	6.1	0.61	1.98	25.6	11.35
9/9/2024 12:54	0.016	5.4	5.1	0.54	3.05	22.3	12.78
9/24/2024 8:20	0.017	7.2	6.9	0.64	3.20	21.1	11.89
10/8/2024 9:03	0.014	5.3	4.8	0.53	4.11	16.5	9.56
10/17/2024 9:23	0.016	3.7	3.2	0.52	3.96	13.1	10.03
2024 Average	0.017	4.7	4.4	0.54	3.44	20.9	10.89
2024 Summer Average	0.017	4.8	4.5	0.53	3.42	24.0	10.81

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2024 Elevation (ft)	846.83	6/20/2024	844.99	10/28/2024	845.61

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



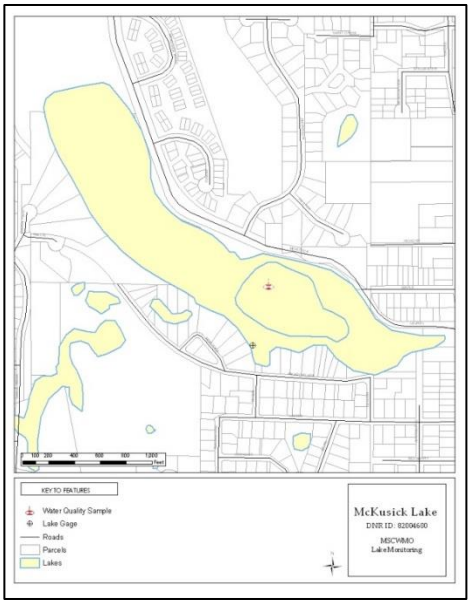
Lake Water Quality Summary										
	Summertime Lake Grades (May-Sept)									
	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
Total Phosphorus (mg/L)	A	A	A	C	B	B	B	C	C	B
Chlorophyll-*a* (ug/L)	A	A	A	C	B	B	B	B	C	C
Secchi depth (ft)	A	A	A	B	B	C	C	C	B	C
Overall	**A**	**A**	**A**	**C+**	**B**	**B-**	**B-**	**C+**	**C+**	**C+**

MCKUSICK LAKE

2024 Lake Grade: C+

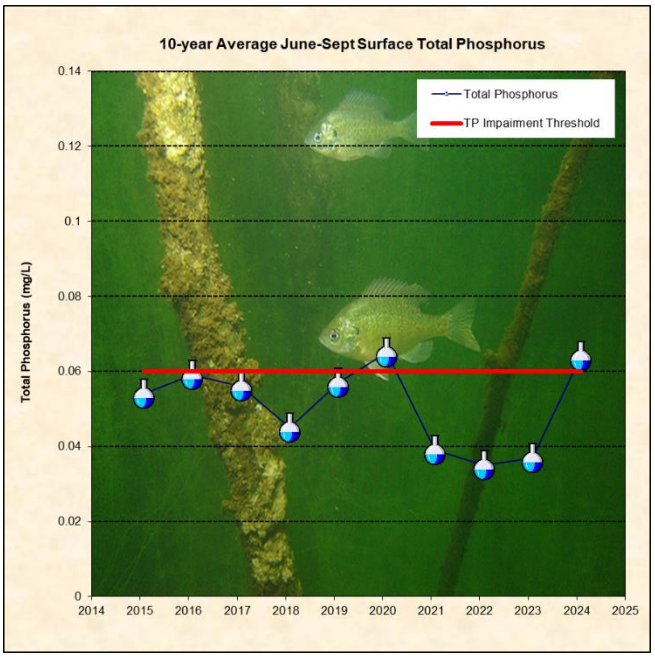
DNR ID #: 820020

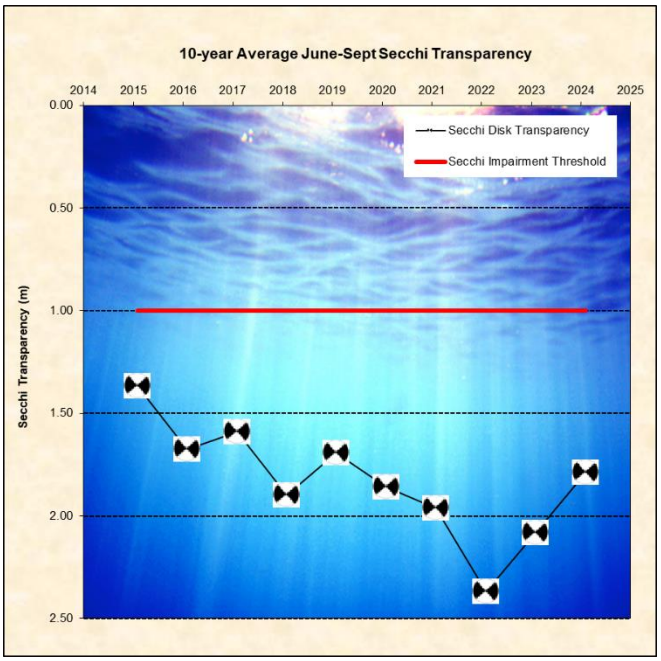
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth (2024): 14 ft.
- Ordinary High Water Mark: 851.7 ft.
- 100% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Based on the chlorophyll-α results McKusick Lake was considered eutrophic in 2024, according to the Carlson Trophic State Index.
- Using a Kendall's Tau correlation test ($p<0.05$) there is a statistically significant **improving** trend for average Secchi transparency, average total phosphorus, and no trend for the average chlorophyll-α.
- The major land use is urban/residential.
- Temperature and dissolved oxygen profiles were not collected in 2024 so stratification cannot be determined.
- McKusick Lake was delisted in 2012 for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





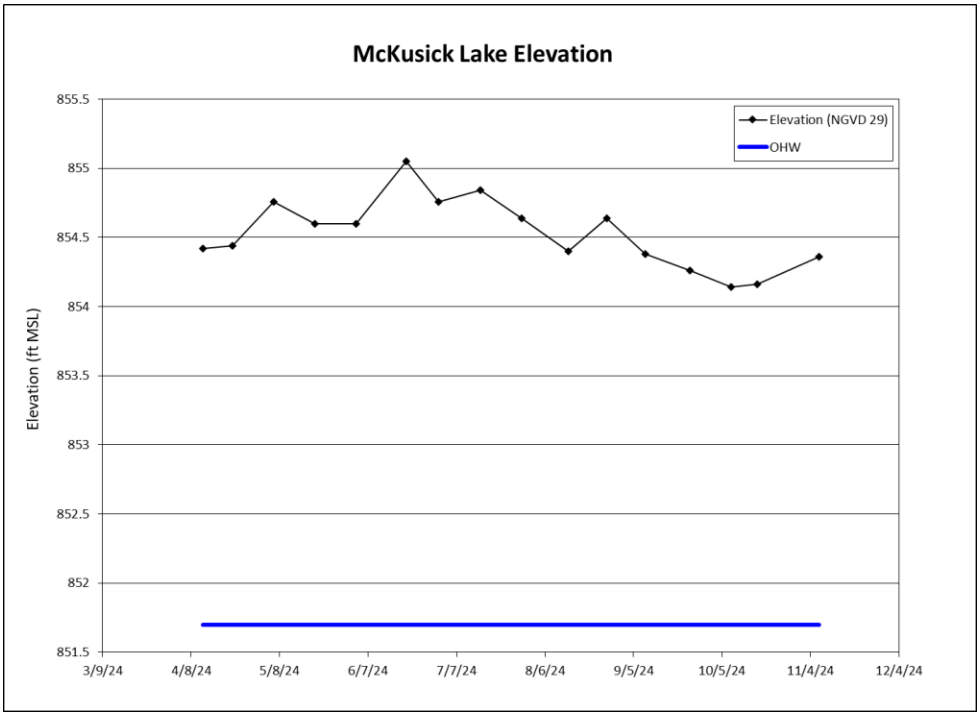
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-*a* (ug/L)	Pheophytin-Corrected Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/22/2024 11:06	0.058	2.0	1.6	0.57	2.90	9.7	16.27
5/6/2024 14:27	0.030	3.0	2.9	0.56	3.20	17.4	10.01
5/20/2024 14:45	0.028	5.3	5.1	0.56	3.20	22.4	9.74
6/3/2024 13:48	0.041	6.1	5.6	0.68	1.98	22.8	10.06
6/20/2024 11:25	0.031	7.6	5.1	0.51	2.29	21.5	12.33
7/1/2024 14:14	0.041	8.2	7.5	0.61	1.52	22.9	7.58
7/15/2024 11:22	0.135	20.0	19.0	0.92	1.68	25.5	8.81
7/29/2024 14:08	0.149	61.0	61.0	1.24	1.22	28.2	7.88
8/14/2024 12:45	0.037	6.8	6.4	0.77	1.98	23.6	12.61
8/27/2024 14:13	0.067	18.0	16.0	1.00	1.52	24.7	7.92
9/9/2024 13:32	0.037	11.0	9.1	0.65	2.13	22.0	9.60
9/24/2024 8:50	0.042	13.0	11.0	0.74	1.83	20.1	9.45
10/8/2024 9:35	0.051	18.0	16.0	0.84	1.68	14.6	10.23
10/17/2024 8:52	0.029	7.4	6.4	0.72	2.44	10.7	11.05
2024 Average	0.055	13.4	12.3	0.74	2.11	20.4	10.25
2024 Summer Average	0.064	16.9	15.6	0.79	1.79	23.5	9.58

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2024 Elevation (ft)	855.05	6/20/2024	854.14	10/8/2024	854.53

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



Lake Water Quality Summary										
	Summertime Lake Grades (May-Sept)									
	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015
Total Phosphorus (mg/L)	C	C	C	C	C	C	C	C	C	C
Chlorophyll-*a* (ug/L)	B	A	A	A	A	A	B	B	B	C
Secchi depth (ft)	C	C	B	C	C	C	C	C	C	C
Overall	**C+**	**B-**	**B**	**B-**	**B-**	**B-**	**C+**	**C+**	**C+**	**C**