Middle St. Croix Watershed Management Organization 2013 Water Monitoring Report

Prepared For:

Prepared by:

WASHINGTON CONSERVATION DISTRICT

ACKNOWLEDGEMENTS

Multiple agencies and individuals were directly involved in many aspects of this project, such as data collection, data analysis, as well as technical and administrative assistance.

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The WCD would also like to thank the volunteers and landowners who assist with data collection and access to our monitoring locations.

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

BCWD	Brown's Creek Watershed District
Benthic	Lake bottom
biweekly	Every other week
BMP	Best Management Practice
cf	cubic feet
cfs	cubic feet per second
Chl-*a*	Chlorophyll-*a*
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
MCES	Metropolitan Council Environmental Services
mg/L	milligram per liter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MSCWMO	Middle St. Croix Watershed Management Organization
NCHFE	North Central Hardwood Forest Ecoregion
OHW	Ordinary High Water level
SOP	Standard Operating Procedure
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSMP	Trout Stream Mitigation Project
TSS	Total Suspended Solids
µg/L	microgram per liter
µmhos/cm	micromhos per centimeter
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 2013 as well as previous years. In 2013 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored water quality on Brick Pond, elevation on Perro Pond, and both water quality and elevation on McKusick Lake and Lily Lake. Discharge and water quality were monitored on Perro Creek (Figure 1). Information from the Brown's Creek Diversion Structure site is also included in this report as this affects the water quality of McKusick Lake. The purpose of the monitoring program is to assess and document current water quality conditions of the lakes and streams, as well as continuing a long-term monitoring program that will enable the MSCWMO to identify trends associated with best management practices (BMP's) and land use changes in the watershed.

Brick Pond was classified as eutrophic (Table 2), and received a lake grade of a B- (Table 3) in 2013. Brick Pond was worse than the North Central Hardwood Forest Ecoregion (NCHFE) range for total phosphorus (TP) and Secchi disk transparency, but was within the NCHFE range for chlorophyll-*a* (chl-*a*) and total Kjeldahl nitrogen (TKN). Using samples collected from June through September, the Minnesota Pollution Control Agency (MPCA) has set threshold standards of lakes for TP, chl-*a*, and Secchi disk transparency. Three of the six samples exceeded the MPCA shallow lake impairment threshold for TP. None of the four samples exceeded the threshold for chl-*a.* All readings exceeded the MPCA impairment threshold for Secchi disk transparency due to the shallowness of the pond (APPENDIX A).

Lily Lake was classified as eutrophic (Table 2) and received a B grade in 2013 (Table 3). TP, chl-*a,* TKN, and Secchi disk transparency readings were all within the NCHFE range for the 2013 monitoring season. Two of the twelve samples collected exceeded the MPCA threshold for TP, and three of the twelve samples collected exceeded the MPCA threshold for chl-*a.* One of the Secchi disk transparency readings exceeded the MPCA threshold (APPENDIX A).

In 2013 McKusick Lake was classified as eutrophic (Table 2), and received a grade of C+ (Table 3). McKusick Lake was above the NCHFE range for TP and within the NCHFE range for chl-*a*,

TKN, and Secchi disk transparency. Five of the twelve water quality samples exceeded the MPCA shallow lake threshold for TP, and two samples exceeded the MPCA threshold for chl-*a*. No Secchi disk transparency measurements exceeded the MPCA shallow lake threshold. Samples were analyzed for metals and no results exceeded MPCA thresholds (Table 4) (APPENDIX A).

Perro Creek discharged 21,096,203 cubic feet (cf) in 2013. The estimated phosphorus load from Perro Creek in 2013 was 93 lbs, and 78,614 lbs of total suspended solids (TSS) were exported to the St. Croix River (Table 6). Nine water quality samples were collected throughout the year, five of them were base flow samples and four of them were storm/event flow composite samples. No base flow samples that were analyzed exceeded water quality standards. Of the four storm/event flow samples collected, two exceeded the water quality standard for turbidity (Table 7). Four samples were collected and analyzed for *Escherichia coli (E. coli)* with one above the MPCA threshold.

The Brown's Creek Diversion Structure site showed an increase in discharge in 2013, to 46,735,271 cf from 23,529,686 cf in 2012. The phosphorus load also increased from 260 lbs in 2012 to 527 lbs in 2013. TSS also showed an increased export to McKusick Lake, from 128,110 lbs in 2012 to 211,977 lbs in 2013 (Table 10, Table 15). These increases in loading amounts for 2013 are likely due to the increase of precipitation over 2012, but when compared to other years with similar discharges, 2013 had generally lower loading values.

In 2014 the MSCWMO is discontinuing condition monitoring of Brick Pond, Perro Creek and Perro Pond. The MSCWMO will instead focus on problem investigation monitoring strategies for Lily Lake and Brick Pond and Perro Creek and Perro Pond in 2014, 2015 and 2016. This approach will enable the MSCWMO to better determine sources of pollutants and more effectively implement management strategies and practices to address those sources.

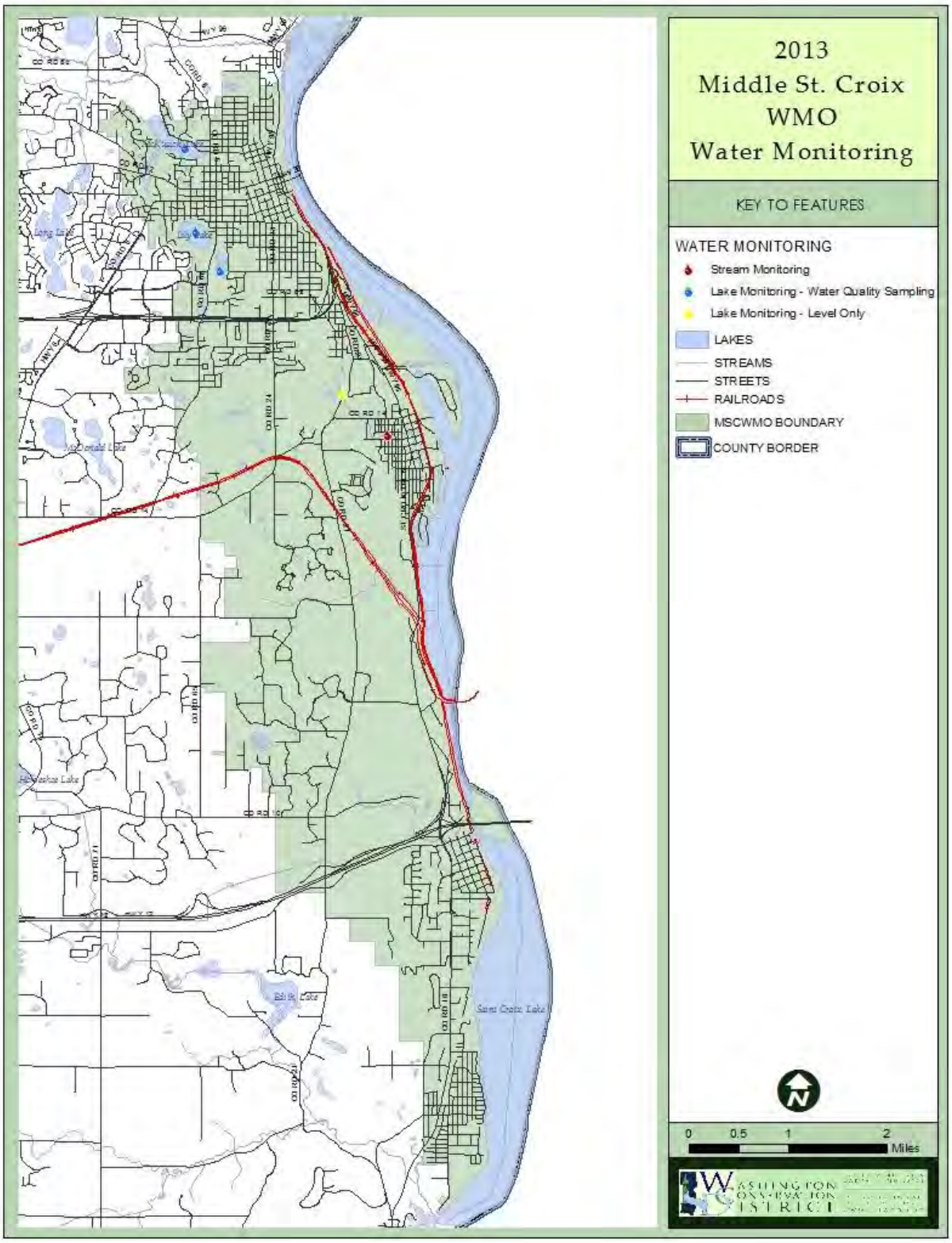


Figure 1. MSCWMO 2013 Water Monitoring Locations

LAKE MONITORING

A. METHODS, RESULTS AND DISCUSSION

In 2013 water quality data was collected monthly on Brick Pond and biweekly on Lily and McKusick Lakes, over six consecutive months (May–October). Measurements obtained during the summer sampling season (June 1-September 30) are averaged for a comparison of individual lake dynamics from year to year between lakes within the watershed, and to the average NCHFE values. Average values for all parameters, as well as typical ranges for lakes in the NCHFE are presented in APPENDIX A. Figure 5, Figure 6, Figure 7, and Figure 8 show the current and historic summer averages for each parameter. Water quality samples were collected with a two-meter (6.56 feet) integrated surface water column sampler. The MCES Laboratory analyzed the surface water samples for TP, chl-*a*, total Kjeldahl nitrogen (TKN) on all MSCWMO lakes as well as heavy metals on McKusick Lake. A full description of WCD Standard Operating Procedures is available on the Washington Conservation District website at http://www.mnwcd.org/water-quality-water-monitoring/.

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. Algal growth, in turn, affects the clarity, or transparency, and light penetration of the water. The typical range of the NCHFE for TP is 0.023 – 0.050 mg/L. The MPCA has set thresholds for impairment of nutrients with TP limits of 0.040 mg/L or 0.060 mg/L, depending on the depth of the lake (greater than or less than 15 feet). The 2013 summer average of TP values of MSCWMO lakes can be found in Figure 5.

Chlorophyll-*a* is measured as it is the photosynthetic component found in algae and aquatic plants and is an indication of algal productivity. The typical range of the NCHFE for chl-*a* is 5 – 22 µg/L. The MPCA has also set thresholds for impairment with limits of 14 µg/L or 20 µg/L, depending on the depth of the lake (greater than or less than 15 feet). The 2013 summer average chl-*a* concentrations of MSCWMO lakes can be found in Figure 6.

Several forms of nitrogen exist in lakes and the form that is analyzed in MSCWMO lakes is TKN, which is the sum of organic nitrogen and ammonia. TKN is tested as it can increase the rate of lake eutrophication and can cause many health problems in the young and elderly. The NCHFE range for TKN is 0.60-1.20 mg/L. There is no threshold for TKN set by the MPCA because TP is the parameter used in their assessments. The 2013 summer average TKN concentrations of MSCWMO lakes can be found in Figure 7.

Table 1. North Central Hardwood Forest Ecoregion Values and Average 2013 Parameters

2013 MSCWMO Lakes Summer Averages (June-September)					
Lake/Units	**Total Phosphorus (mg/L)**	**Chlorophyll-a (ug/L)**	**Kjeldahl Nitrogen (mg/L)**	**Secchi Disk (meters)**	**Deep Or Shallow**
Eco-Region Value	*0.023-0.050*	*5.0-22.0*	*0.60-1.20*	*1.5-3.2*	
MPCA Deep Lake Impairment Threshold	*0.040*	*14.0*		*1.40*	
MPCA Shallow Lake Impairment Threshold	*0.060*	*20.0*		*1.00*	
Brick Pond	0.062	9.4	1.12	0.65	Shallow
Lily	0.030	11.1	0.99	2.30	Deep
McKusick	0.064	13.0	1.08	1.85	Shallow

2013 was the second year metals samples were collected in area lakes, McKusick Lake being the only MSCWMO lake tested. Heavy metals are tested because many are known to be extremely toxic to aquatic organisms, and results can be found in Table 4.

Field measurements are also recorded while collecting lake samples. Measurements include Secchi disk transparency, dissolved oxygen (DO) and temperature profiles, and lake elevation.

The measurement of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. It is a possible indication of turbidity in the water and an indication of the trophic state of the lake. A reduction in water transparency is typically the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). Typical ranges for transparency in the NCHFE are between 1.5 – 3.2 meters. The MPCA has set thresholds for

Secchi disk readings of 1.4 meters or 1.0 meters depending on the depth of the lake (greater than or less than 15 feet).

User perception and physical/recreational suitability of the lake were ranked, along with temperature and dissolved oxygen profile measurements taken by the WCD during each sampling event. Profiles are recorded at 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 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, they turn from producers of DO into consumers through the respiration of decomposers. Data collected from the rankings and profiles are contained in a database at the WCD, as well as on the MPCA website at http://cf.pca.state.mn.us/water/watershedweb/wdip/index.cfm

The Carlson Trophic State Index (TSI) is used to quantify the relationship between water quality data and trophic status. Many water quality scientists classify lakes according to their trophic state. Average summer values of TP, chl-*a*, and Secchi disk transparency are the parameters most often used to determine a lake's trophic state. Oligotrophic lakes, such as lakes common in the northeastern part of Minnesota, have low biological activity as a result of low phosphorus concentrations, low chl-*a* concentrations, and high Secchi disk transparency readings. Mesotrophic lakes have slightly more biological production, and are characteristic of the majority of the lakes found in the NCHFE of Minnesota. On the other end of the spectrum, lakes with high biological productivity characterized by high phosphorus concentrations, high chl-*a* concentrations, and low Secchi disk transparencies are classified as eutrophic or even hypereutrophic. Lakes classified as eutrophic or hypereutrophic typically receive excess nutrient loading from sources within their watersheds and receive large amounts of runoff from the surrounding drainage area. A percentage of these nutrients, however, can also be attributed to internal loading within the lake itself, which is typical of shallow, sediment-rich lakes (Table 2).

Table 2. Trophic State Index and Ranges

	Trophic State Index	TP (ug/L)	Chl-*a* (ug/L)	Secchi (m)
Oligotrophic	<40	<12	<2.6	>4.0
Mesotrophic	40-50	12 - 24	2.6 - 6.4	4.0 - 2.0
Eutrophic	50-70	24 - 96	6.4 - 56	2.0 – 0.5
Hypereutrophic	>70	>96	>56	<0.5

A Lake Grading System is also used in this report, 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 Dick Osgood, formerly of the Metropolitan Council. 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 June through September average values of TP, chl-*a*, and Secchi disk transparency. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 3 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 good correlation when comparing the Lake Trophic Status and the Lake Grading System. Summaries of all lake results are presented in APPENDIX A.

Table 3. Lake Grade Ranges

Grade	Percentile	TP (ug/l)	CLA (ug/l)	SD (m)
A	<10	<23	<10	>3.00
B	10-29	23-31	10-19	2.20-3.00
C	30-69	32-67	20-47	1.20-2.19
D	70-90	68-152	48-77	0.70-1.19
F	>90	>152	>77	<0.70

Lake elevation gages, monitored by WCD staff, are located on two MSCWMO lakes, Lily and McKusick, and one wetland, Perro Pond and are compared to the lakes Ordinary High Water

level (OHW)[1]. All three water bodies reflected significant decreases in elevation towards the end of the 2013 monitoring season, when precipitation was below normal, and a slight rebound for the last readings when precipitation went above normal again in October (Figure 9). Complete lake elevation data for 2013 can be found in

Figure **2**, Figure 3, and Figure 4. For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

1. BRICK POND

The 2013 summertime average concentration of TP in Brick Pond was 0.062 mg/L, down from 0.109 mg/L in 2012, and exceeds the MPCA's Shallow Lake Nutrient Impairment Threshold in three of the six samples (Figure 5). The summertime average concentration for chl-*a* in 2013 was 9.4 µg/L, very close to the 9.9 µg/L seen in 2012 (Figure 6). No samples exceeded the shallow lakes MPCA threshold for chl-*a* in 2013. Brick Pond had an average summertime TKN concentration of 1.12 mg/L (Figure 7). There is no MPCA lake impairment threshold for TKN. All Secchi disk measurements taken in 2013 exceeded the MPCA shallow lake impairment threshold (Figure 8). Temperature and DO profiles were taken in Brick Pond in 2013 and show that Brick Pond did not stratify during the summer of 2013. As a result, nutrients were made available throughout the water column during the summer, allowing for internal loading. Summaries of all lake results are presented in APPENDIX A.

2. LILY LAKE

Lily Lake had an average summertime TP concentration of 0.030 mg/L, lower than the 2012 Lily Lake had an average summertime TP concentration of 0.044 mg/L, well below the MPCA lake

[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:

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

nutrient impairment threshold for TP (Figure 5). Two of the twelve samples had values greater than the MPCA lake nutrient impairment threshold for TP. The 2013 average summertime concentration of chl-*a* was 11.1 μg/L, lower than the 14.8 μg/L measured in 2012, with three of the twelve water quality samples exceeding the MPCA lake threshold for chl-*a* impairment (Figure 6). Lily Lake had an average summertime TKN concentration of 0.99 mg/L in 2013, lower than the 1.181 mg/L seen in 2012 (Figure 7). There is no MPCA lake impairment threshold for TKN. Secchi disk readings were measured in 2013 with a summertime average of 2.30 meters, with one of the twelve water quality readings exceeding the MPCA lake threshold for Secchi disk transparency impairment (Figure 8). Temperature and DO profiles indicate that Lily Lake stratified during the summer months of 2013 with a thermocline around 5-6 meters; therefore the lake was less likely to completely mix, trapping nutrients at the bottom of the lake. At the start of the monitoring season the water level of Lily Lake was above the OHW, reaching its highest level on 5/8/2013 at 846.15 ft. The water level continued to drop from there, below the OHW in the beginning of August and to its lowest point on 9/23/2013 at 844.17 ft. The water level started to rise until the end of the monitoring season, but continued to stay below the OHW, even after receiving above average precipitation in October (
Figure **2**). Summaries of all lake results are presented in APPENDIX A.

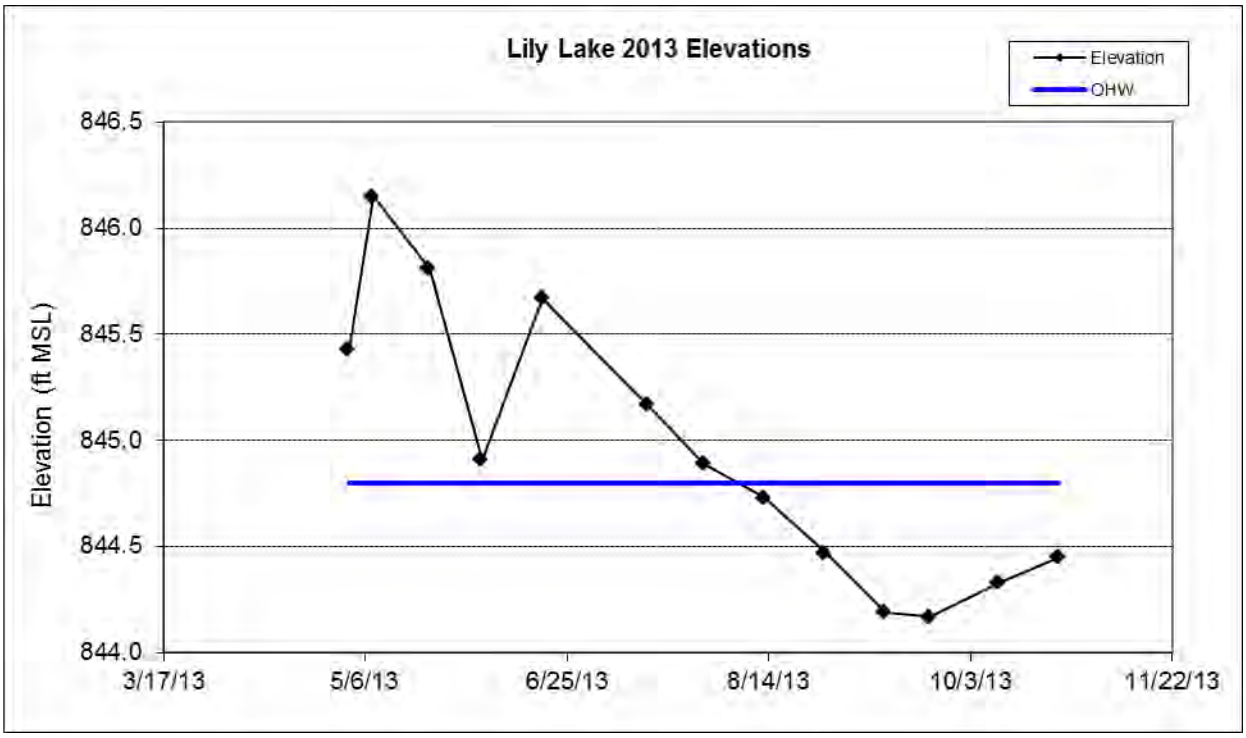


Figure 2 . Lily Lake 2013 Elevations

3. MCKUSICK LAKE

The McKusick Lake summertime average TP concentration in 2013 was 0.064 mg/L, close to the 0.060 mg/L that was seen in 2012, with five of the twelve water quality samples collected exceeding the MPCA TP impairment threshold for shallow lakes (Figure 5). McKusick Lake had a summertime average chl-*a* concentration of 13.0 µg/L, higher than the chl-*a* result of 7.32 µg/L from 2012 (Figure 6). Of the twelve samples collected in 2013, two exceeded the MPCA shallow lakes threshold for chl-*a*. The average summertime TKN concentration for 2013 was 1.08 mg/L, up slightly from the 1.021 mg/L measured in 2012 (Figure 7). There is no MPCA lake impairment threshold for TKN. The 2013 summertime average water transparency measured by Secchi disk was 1.85 meters. All Secchi disk readings in 2013 were better than the MPCA lake impairment threshold. Temperature and DO profiles indicate that McKusick Lake exhibited thermal stratification during the summer months of 2013 with the thermocline around 3 meters, with one observation in August of a thermocline at 1 meter; therefore the lake was less likely to completely mix throughout the summer. 2013 was the second year that metals were

analyzed for in McKusick Lake and none of the samples exceeded the threshold limits for any of the metals analyzed, same as in 2012 (Table 4). The elevation of McKusick Lake remained above the OHW for the entire 2013 monitoring season, reaching its highest recorded level on 6/26/2013 with a level of 855.23 ft. and falling to its lowest recorded level on 9/12/2013 with an elevation of 853.18 ft. (Figure 3). Summaries of all lake results are presented in APPENDIX A.

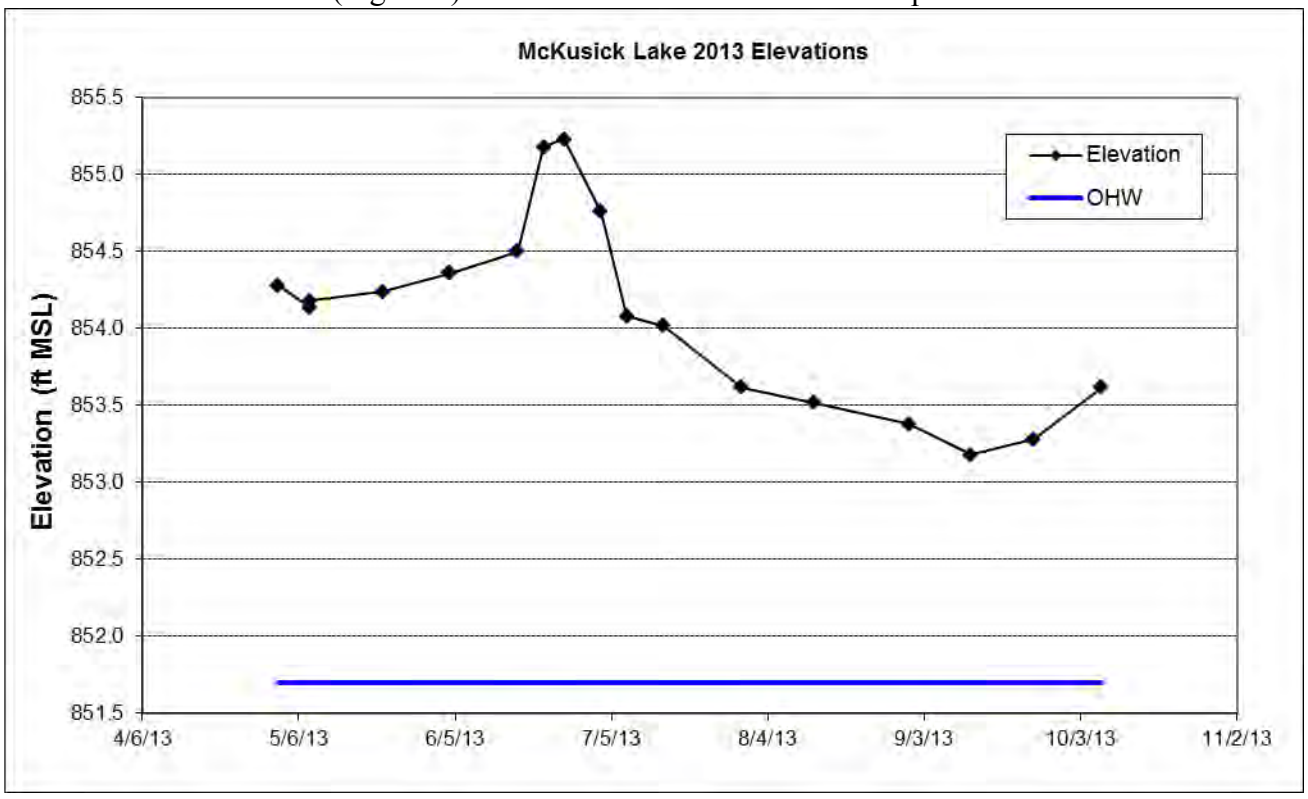


Figure 3. McKusick Lake 2013 Elevations

Sample Type	Sample Date	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Hardness (mg/L_CaCO3)
Benthic	5/8/2013 14:34	0.00090	0.00010	0.00032	0.0079	0.00010	0.00016	66
Benthic	6/4/2013 10:30	0.00200	0.00076	0.00057	0.0276	0.00025	0.00025	70
Surface	7/3/2013 8:00	0.00061	0.00023	0.00045	0.0117	0.00010	0.00028	140
Benthic	7/3/2013 8:00	0.00110	0.00021	0.00043	0.0077	0.00010	0.00016	122
Surface	7/30/2013 9:13	0.00030	0.00010	0.00015	0.0052	0.00010	0.00011	92
Benthic	8/27/2013 12:27	0.00260	0.00079	0.00034	0.0140	0.00010	0.00022	120
Surface	9/24/2013 9:44	0.00066	0.00037	0.00032	0.0064	0.00010	0.00016	88

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

Table 4. McKusick Lake 2013 Sample Metal Chemistry Results

4. PERRO POND

Perro Pond elevation was monitored throughout the 2013 monitoring season and has no OHW established for comparison purposes. A small outlet control structure that retains water in Perro Pond, and was opened in mid-May, and kept water elevations high before that time. The high elevation for Perro Pond was 744.14 ft. recorded on 5/6/2013. On May 15, 2013 the dam was opened, and water level elevations after that dropped, reaching its lowest recorded elevation on 9/6/2013 with an elevation of 742.32 ft. then rebounding in October after above average precipitation and the outlet control structure closing on 10/13/2013 (Figure 4).

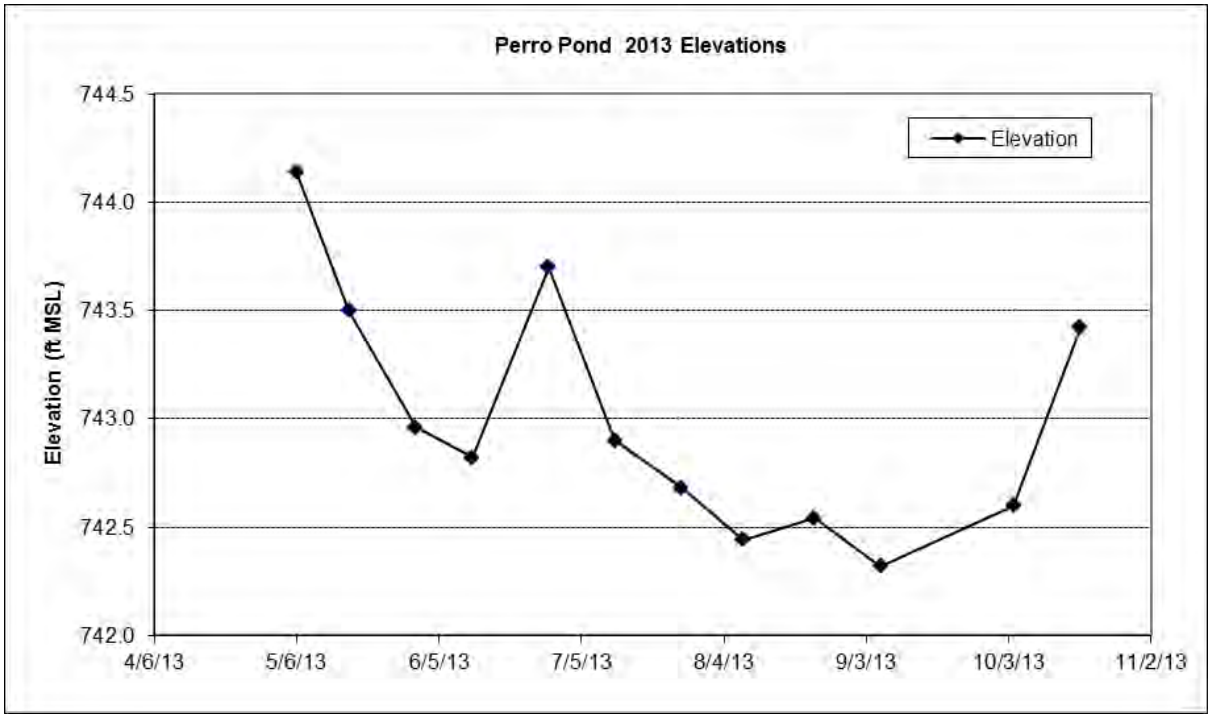


Figure 4. Perro Pond 2013 Elevations

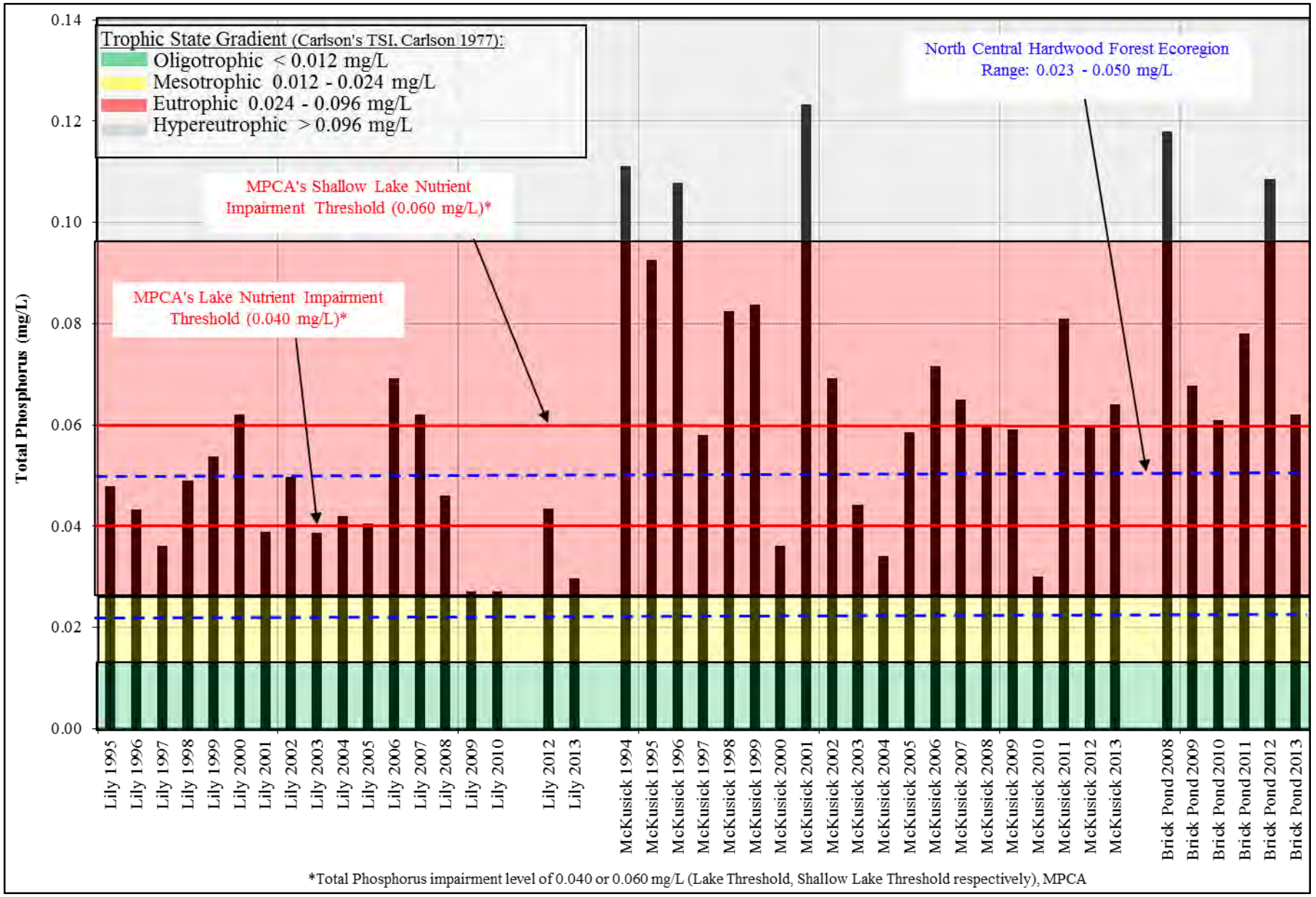


Figure 5. MSCWMO Historic Summer Average Total Phosphorus Data

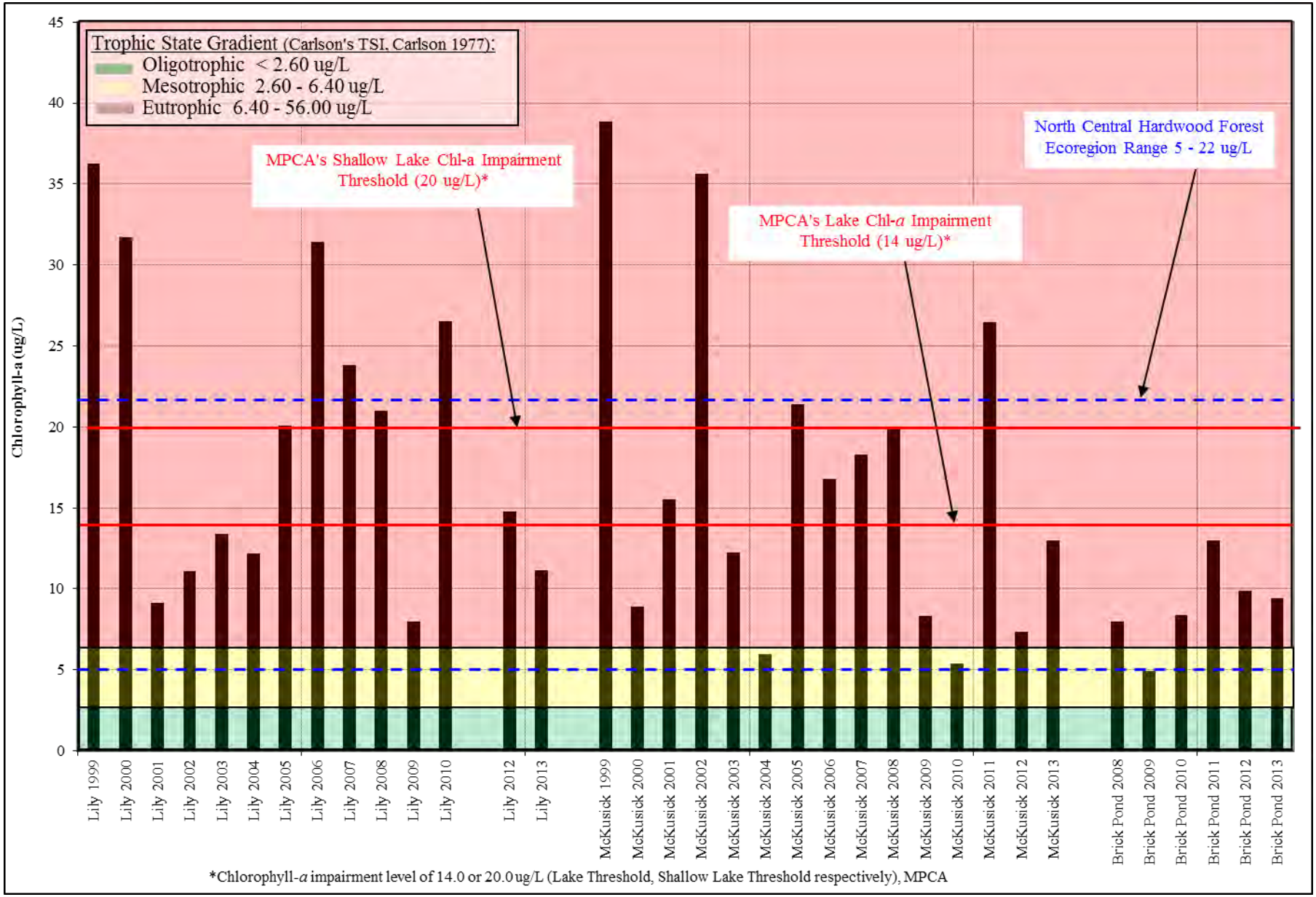


Figure 6. MSCWMO Historic Summer Average Chlorophyll-*a* Data

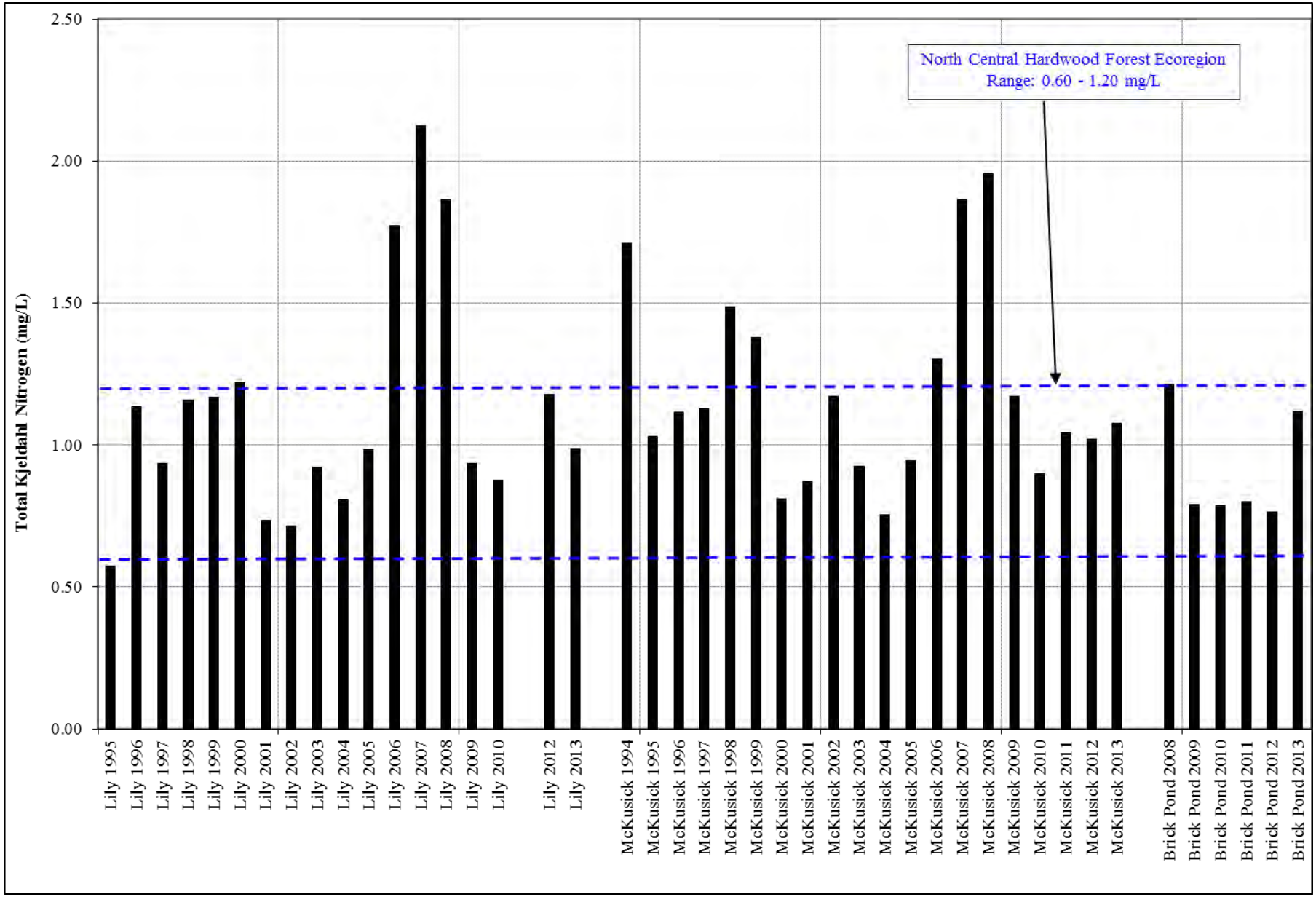


Figure 7. MSCWMO Historic Summer Average Total Kjeldahl Nitrogen Data

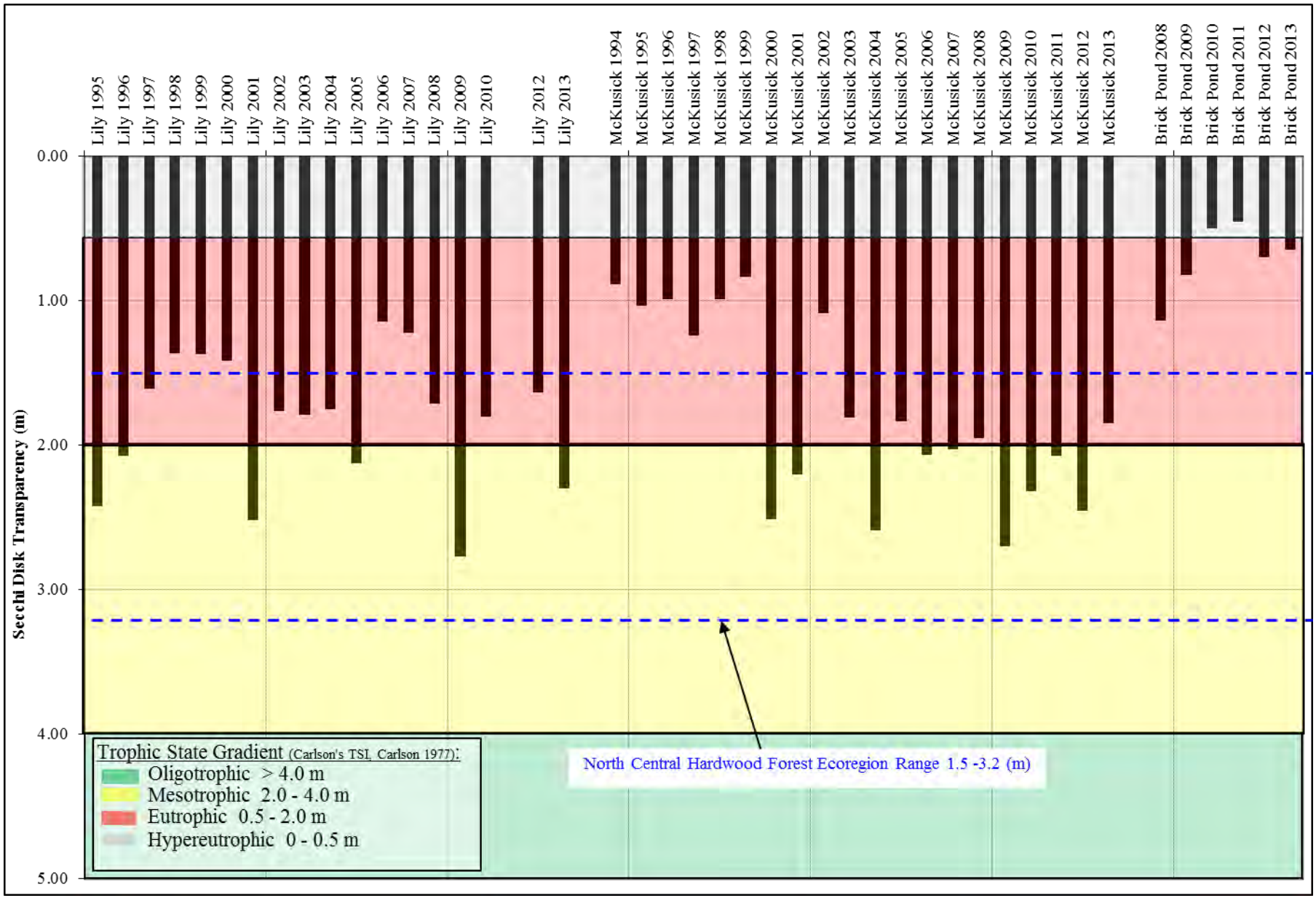


Figure 8. MSCWMO Historic Summer Average Secchi Data

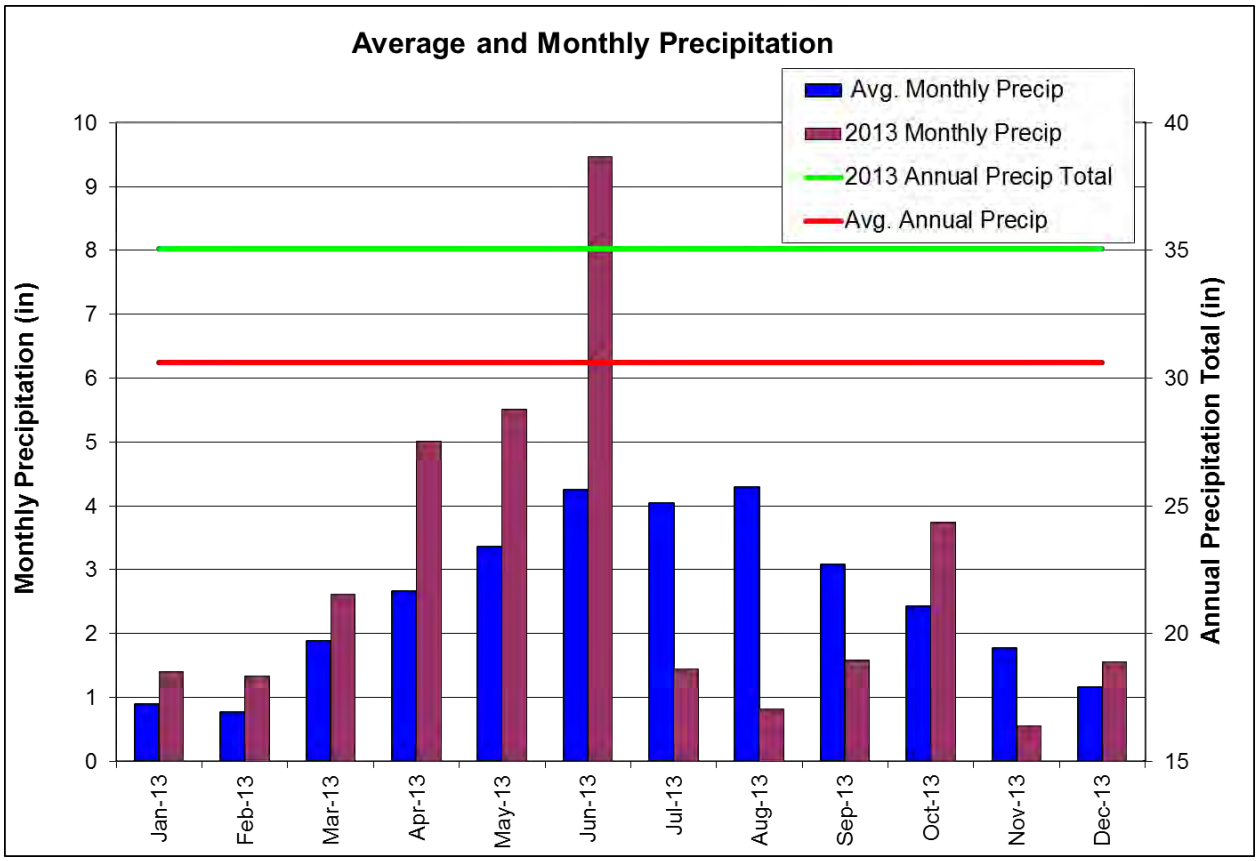


Figure 9. 2013 Annual Precipitation; Historical 30-Year* Average Annual Precipitation; Historical 30-Year* Average Monthly Precipitation; and 2013 Monthly Precipitation

2013 Data from Stillwater NWS gauge T 30N R 20W Sec 31

*Average monthly precipitation totals derived from historical 30-year (1981-2010) average for this region

B. MSCWMO LAKES: CONCLUSIONS AND RECOMMENDATIONS

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. Some low water quality ratings of MSCWMO lakes are most likely due to long-term periods of urban runoff (Lily Lake) or from the shallowness of the lake (Brick Pond and McKusick Lake). Shallow lakes typically exist in a low algal production, clear-water state or a high-algal production, turbid water state. Shallow lakes may not completely stratify in the summer, such as Brick Pond, 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 thick algal blooms. This is unlike in deeper, stratified lakes where phosphorus below the thermocline is not available for primary production.

The MPCA had listed both Lily and McKusick Lake on the 303(d) Impaired Waters list for nutrient/eutrophication impairment, with McKusick Lake now officially delisted. If a water body is listed, it indicates that it does not currently meet water quality criteria. In order to meet those criteria, a total maximum daily load (TMDL) must be implemented. A TMDL outlines what pollutants are degrading the water quality and what will need to be done in order to meet current water quality standards. The MPCA had tentatively scheduled a three lake TMDL for Long Lake (Brown's Creek Watershed District), Lily Lake, and McKusick Lake in 2010, but because of improving water quality trends in those lakes over recent years, the MPCA, along with the MSCWMO, BCWD, and City of Stillwater, decided to postpone the TMDL. The MSCWMO, BCWD, and the City of Stillwater will utilize the City of Stillwater's exiting Lake Management Plan, as well as the completed Lily and McKusick Lake subwatershed assessments to further guide project implementation in an effort to continue to improve the water quality of the lakes. The MPCA will consider the need for a TMDL again in the future.

2013 marked the sixth year that Brick Pond was monitored for water quality. TP showed a decrease in 2013 over what was seen in 2012, which happened to be the second lowest summertime average concentration since monitoring began in 2008. There are not enough years of data to determine any statistically significant trend for TP on Brick Pond at this time. TP values exceed and have been worse than the NCHFE range every year the lake has been monitored (Figure 5). Chl-*a* showed a slight decrease in 2013, but very close 2012 value, and still within the chl-*a* NCHFE range (Figure 6). The average 2013 summertime value for TKN was worse than the average for 2012, and the second highest concentration since monitoring began in 2008 (Figure 7). Only one sample value for TKN was higher than the NCHFE range. The 2013 summertime average for Secchi disk transparency decreased slightly in 2013 when compared to 2012 and all Secchi disk readings exceeded (were poorer than) the NCHFE range in 2013. It should be noted that it is difficult for transparency results to fall within the NCHFE range due to the shallowness of Brick Pond, with a maximum depth of approximately 1.52 meters, just over the minimum NCHFE value (Figure 8). The Kendall Tau correlation test is not run for transparency on shallow lakes like Brick Pond when rooted vegetation interferes with readings, or the Secchi disk is visible to the lake bed. When those conditions are present, too much error can alter long term trends. Based on 2013 data and utilizing the Carlson's TSI, Brick Pond is classified as eutrophic, the same as in previous years. Data also showed that the water quality has remained constant when compared to what was seen in 2012 and has received a grade of B-. Summaries of all lake results are presented in APPENDIX A.

2013 data shows that Lily Lake's summertime average for TP was lower than the 2012 values, and within the NCHFE range (Figure 5). There was no statistically significant trend found in the historical summer TP data. Average summertime value for chl-*a* in 2013 was lower than what was measured in 2012, and within the NCHFE range (Figure 6). There is no MPCA lake impairment threshold for TKN, but the average 2013 summertime TKN result for Lily Lake was lower than what was seen in 2012, and still within the NCHFE range (Figure 7). The Secchi disk transparency for Lily Lake was deeper in 2013 than what was observed in 2012, and within the NCHFE range. No significant trend in Secchi disk transparency could be determined. Lily Lake was classified as eutrophic in 2013, the same classification it was in 2012. Lily Lake also received a grade of B in 2013, up from the C+ it received for 2012. Summertime TP, chl-*a*, and

Secchi disk transparency averages have remained relatively consistent over the last ten years in Lily Lake with the exceptions of 2001, 2009 and 2013, where overall water quality dramatically improved (Figure 8). Summaries of all lake results are presented in APPENDIX A. In 2001 phosphorus and chl-*a* levels dropped and the lake grade improved significantly. There have been copper sulfate treatments on Lily Lake in the past, but the dates are unknown to the WCD. Those results point towards a copper sulfate treatment in Lily Lake near 2001. In 2006 and 2007, summer average TP, chl-*a*, and Secchi disk transparency deteriorated when compared to the averages seen from 2001 to 2005. In 2009 Lily Lake improved over previously recorded years and received a B+ lake grade, with 2010 and 2012 sample results deteriorated, indicating that Lily Lake may have returned back to the long term normal, but improved again this year with a grade of a B. The cause of these one-year increases (2013, 2009, 2001, and 1995) in water quality is presently unknown, and there may be many possible explanations which could be investigated further in the future. Lake water quality best management practices on Lily Lake known to WCD staff are the completion of a native buffer planting at the public access in mid-2010, and copper sulfate treatments. The Lily Lake watershed underwent a sub-watershed assessment in 2010. As a result, fifteen raingardens were constructed in the Lily Lake watershed in 2011, and more residential raingardens were completed in 2012. With a new round of funding, there were seven raingardens planned for installation in the spring of 2013, but due to complications with utilities the raingarden installation was postponed until summer 2014. . Instead of seven smaller raingardens, there are now six larger raingardens planned.. The first effects of these BMPs may have been seen in the 2013 monitoring season, but future monitoring is needed to see if the long term trends improve the longer the BMPs are installed. For more information about the Lily Lake sub-watershed assessment refer to the Lily Lake Stormwater Retrofit Assessment found at http://mscwmo.org/wp-content/subwatershed/LILY-Assessment-Report-FINAL.pdf

TP summertime average for McKusick Lake in 2013 was similar to what was seen in 2012, but now has fallen out of the NCHFE range for 2013. Overall, McKusick Lake has seen statistically significant improvements ($p<0.01$) for TP from 1994 to the present (Figure 5). The 2013 summertime average for chl-*a* was higher than the average from 2012, and now falls within the NCHFE value range for chl-*a*. The average 2013 summertime TKN value was within the

NCHFE range for TKN, but up slightly from what was measured in 2012, but still within the NCHFE range for 2013 (Figure 7). Secchi disk transparency for 2013 is worse than what was observed in 2012, and the worst summer average since 2002, but falls within the NCHFE range Secchi disk transparency. Overall there has been statistically significant improvements ($p<0.01$) seen in Secchi transparency from 1994 through the present (Figure 8). Based upon the 2013 data and utilizing the Carlson's TSI, McKusick Lake is classified as eutrophic, a downgrade from its 2012 classification of mesotrophic. The overall water quality of McKusick Lake has degraded slightly when compared to last year, receiving a grade of C+ for 2013, down from a B in 2012. Summaries of all lake results are presented in APPENDIX A. In June 2003 the City of Stillwater completed the Trout Stream Mitigation Project (TSMP) that has been functioning to divert stormwater from the 1,800-acre annexation area, away from Brown's Creek, through McKusick Lake, and ultimately to the St. Croix River. This diversion structure is designed to keep the warmer, urban stormwater from the southern tributary of Brown's Creek out of the temperature and nutrient sensitive Brown's Creek Ravine. Local residents' concerns about the amount of water and nutrients entering McKusick Lake are being investigated by the Brown's Creek Watershed District (BCWD) and the City of Stillwater. In 2006 the BCWD initiated stream flow monitoring and water quality sampling on the diversion structure drainage to assist in answering some of the water quality and quantity concerns. All associated data can be found in Figure 11, Table 10, Table 11, Table 12, Table 13 and Table 15. There was a sub-watershed assessment conducted on the McKusick Lake watershed in 2010. In 2011 six raingardens were constructed as a result of the sub-watershed assessment. With renewed funding, seven additional raingardens were to be installed in the McKusick Lake watershed in 2013 but because of issues with utilities, 5 larger raingardens will be installed in 2014. The impacts of previously installed raingardens were not seen in the 2013 lake monitoring results, but remain hopeful results will be seen in the future. For more information on the McKusick Lake sub-watershed assessment refer to the McKusick Lake Stormwater Retrofit Assessment found at http://mscwmo.org/wp-content/subwatershed/McKUSICK-Assessment-Report-FINAL.pdf

Water elevation monitoring was conducted on two lakes and one wetland for from May to October 2013 (

Figure **2**, Figure 3, Figure 4). Changes in lake water level elevation are mostly attributed to the changes in monthly precipitation. Precipitation was normal to above normal from January through July. From August until the end of the year, precipitation was well below normal and all MSCWMO lake/wetland elevations dropped during that time period. Total annual precipitation for 2013 was 35.07 inches, with the majority of that occurring in the first half of the year and below average precipitation in the second half of the year, except for October. That total is 4.46 inches above the 30 year (1981-2010) historical annual average of 30.61 inches (Figure 9). The highest recorded elevations in 2013 occurred around the first part of the summer for each water body. The level on Lily Lake had a high reading on 5/8/2013. McKusick Lake recorded a high reading on 6/26/2013. Elevations on Perro Pond do not respond the same because the level is less dependent on precipitation and more dependent on a small dam that can allow water to discharge into Perro Creek. This dam was opened on 5/15/2013, keeping the elevation of Perro Pond high until that date. The high elevation for Perro Pond was on 5/6/2013. The low elevation on Lily Lake was recorded on 9/23/2013, and McKusick Lake had its lowest reading on 9/12/2013. The low elevation recorded on Perro Pond occurred on 9/9/2013.

The following are WCD recommendations to the MSCWMO:

- Continue to monitor water levels of MSCWMO lakes and wetland.
- Continue to monitor the water quality of MSCWMO lakes.
- Investigate monitoring inlets to Lily Lake to determine where the majority of the nutrient load is coming from.

STREAM MONITORING

A. METHODS, RESULTS, AND DISCUSSION

The WCD monitors one stream, Perro Creek, in the MSCWMO. Perro Creek flows 1.8 miles from its source, Perro Pond, through an urban landscape and outlets into the St. Croix River. In the upper reaches, much of the creek flows through the residential backyards of Bayport, MN. The lower reaches of the creek have been substantially channelized through the use of pipes and concrete structures. The lower reaches also flow through a more urban, industrial environment where it is prone to more runoff from the surrounding area.

Data from the Brown's Creek Diversion Structure is included in this report as an evaluation of phosphorus loading to McKusick Lake. Continued efforts at this location will allow for evaluation of water quality impacts to McKusick Lake. To eliminate confusion between watershed boundaries and political ownership, Perro Creek is the only stream monitoring site referenced as being within the MSCWMO. A list of the WCD standard operating procedures can be referenced at http://www.mnwcd.org/water-quality-water-monitoring/.

1. PERRO CREEK

The WCD collected base flow grab samples, automated flow-weighted storm composite samples and duplicate samples according to the WCD Standard Operating Procedures (SOP) during the 2013 monitoring season at the Perro Creek site. An automated sampler, located about 1 mile upstream of the St. Croix River, (Figure 1) continuously monitored stream flow discharge and collected event flow composite samples from April 17, 2013 until October 28, 2013. Data collected at this site by the WCD included total discharge, precipitation, and water quality analysis. All stream flow and chemistry data from 2013 can be found in Figure 10, Table 5, Table 6, Table 7, Table 8, and Table 9.

Total discharge during the 2013 monitoring season for Perro Creek was 21,096,203 cf, compared to 28,264,823 cf in 2012. Peak 15 minute average discharge for this site was 31.44 cubic feet per second (cfs), which occurred after two rain events of over an inch on June 21, 2013. Nine water quality samples were collected throughout the year, five of them were base flow samples and four of them were storm/event flow composite samples. No base flow samples that were analyzed exceeded water quality standards. Of the four storm/event flow samples collected, two exceeded the water quality standard for turbidity based on the TSS values (Table 7). The highest values for TP, TSS, VSS and TKN were all from a composite sample collected from a large storm event on June 15th, with values of 0.953 mg/L for TP, 3,680 mg/L for TSS, 204 mg/L for VSS, and 4.60 mg/L for TKN.

The 2013 TP and TSS along with volume discharge data were used to estimate the total load of phosphorus and TSS discharged to the St. Croix River from Perro Creek. In 2013, Perro Creek discharged an estimated load of 87 lbs, compared to 129 lbs of phosphorus discharged in 2012. An estimated load of 74,525 lbs of TSS was discharged in 2013, down from the 204,141 lbs of TSS discharged in 2012 (Table 14). This load is lower than the 2012 estimates and the lowest estimate seen since 2009. This possible load decrease could be attributed to Perro Creek not flowing as much throughout the monitoring season. With the colder than average spring the dam was opened later than usual. The dam was also closed again in October, rather than in late

November/early December as has happened regularly in the past. A possible cause for the previous load increase could be the further degradation of the up-stream channel. Near the monitoring station location, the stream banks have steadily degraded over the past five monitoring seasons, with large sections sloughing into the creek channel. It is likely that this degradation is occurring along the entirety of the channel, and would certainly contribute to the increase in the TSS loading that has been observed. Stream bank stabilization projects along degraded portions of the creek would help decrease pollutant loads to the St. Croix River and should be investigated further. Other activities such as the Perro Creek clean-up are helpful and can possibly reduce loads to the St. Croix River.

Many heavy metals are known to be extremely toxic to aquatic organisms, therefore all samples collected at Perro Creek were tested for heavy metals. The base flow samples collected did not exceeded any thresholds set for heavy metals. Two of the four event flow samples exceeded not only the chronic standard threshold, but the maximum standard for copper and three of the four event flow samples exceeded the chronic standard threshold for lead (Table 8).

Escherichia coli (E. coli) is a bacteria that can be characterized by its ability to grow at elevated temperatures. Perro Creek is impaired for *E. coli*, and data have shown numerous samples where values were above what the MPCA has set as a water quality standard. The following is the description for the *E. coli* standard:

> "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"[2].

[2] MPCA water quality standards for class 2B waters can be found at https://www.revisor.leg.state.mn.us/rules/?id=7050.0222

When looking at all monitored years of data, Perro Creek exceeds the *E. coli* standard, where the geometric mean of at least five samples collected during the month exceeds the value of 126 #/100 mL, for the months of June, July, August, and September. In 2013 there were four *E. coli* samples collected at the Perro Creek site. Of those four, one of them exceeded the water quality standard for *E. coli* (Table 5). Continued monitoring of *E. coli* at this site will help in determining if Perro Creek continues to exceed the water quality standards during the summer months.

Table 5. Perro Creek *E. coli* Monthly Geometric Mean

	May	June	July	August	September	October
6/14/06 11:10		150				
7/25/06 8:45			249			
8/10/06 9:12				318		
9/6/06 9:50					291	
9/10/06 10:20					252	
5/2/07 12:00	276					
6/13/07 10:14		185				
7/16/07 9:51			488			
8/28/07 8:04				1986		
10/18/07 12:15						114
6/5/08 10:18		276				
6/26/08 9:43		153				
7/17/08 8:30			194			
8/27/08 10:20				1553		
7/29/09 9:30			261			
8/27/09 10:25				1120		
9/30/09 8:50					163	
5/25/10 9:00	99					
6/24/10 9:15		225				
7/28/10 11:25			93			
8/26/10 9:49				111		
9/30/10 9:51					95	
6/9/11 10:24		345				
7/7/11 8:32			262			
8/11/11 8:53				40		
9/8/11 8:07					196	
10/5/11 9:03						133
5/31/12 9:13	41					
6/26/12 10:25		96				
7/24/12 11:30			291			
8/30/12 9:44				345		
9/26/12 9:17					145	
6/27/2013 9:25		194				
7/29/2013 10:09			80			
8/15/2013 10:13				91		
9/24/2013 9:00					91	
Perro Creek Monthly Geometric Mean	Insufficient Data	189.94	207.90	333.53	162.07	Insufficient Data
	Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month					

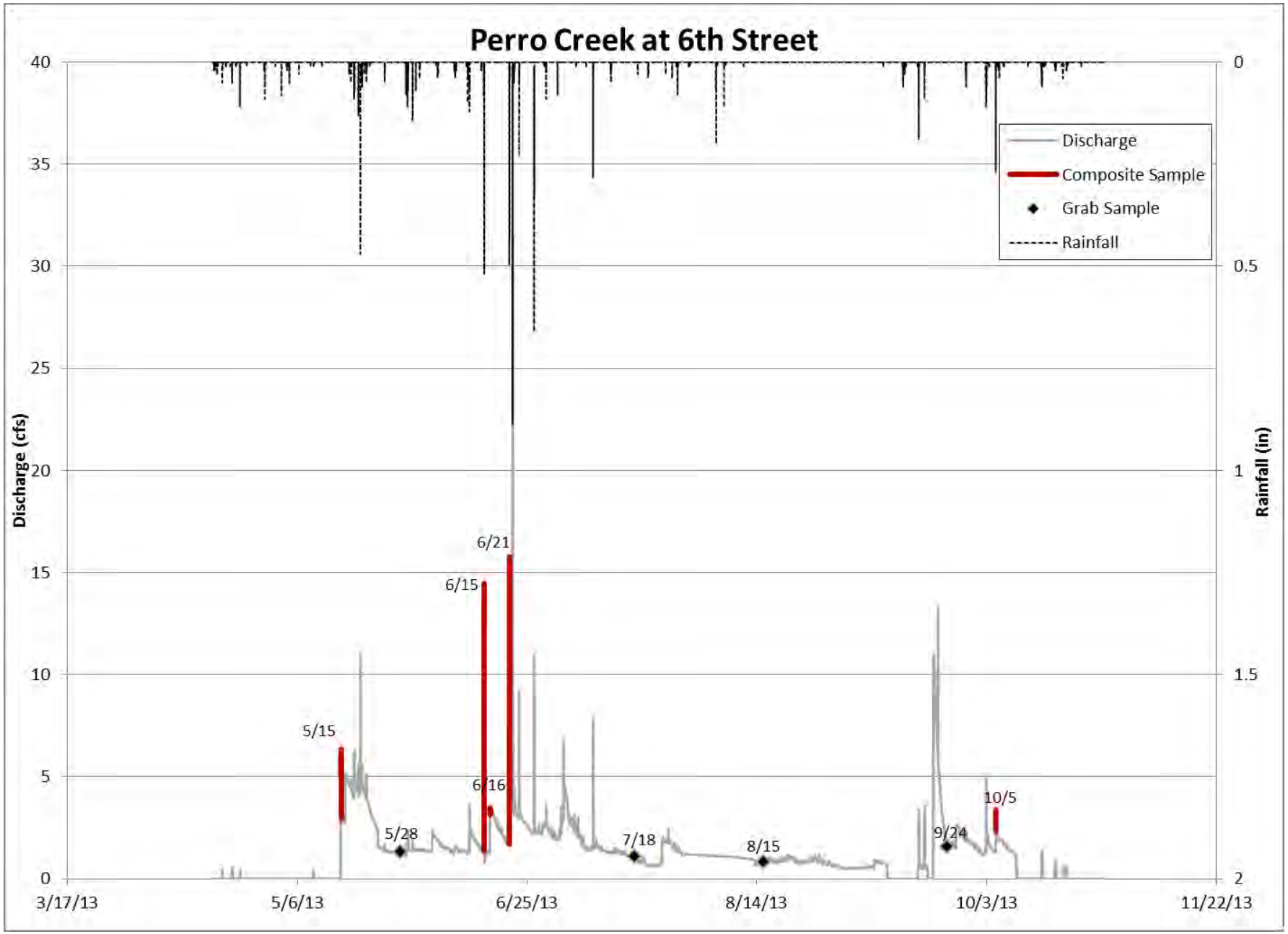


Figure 10. Perro Creek 2013 Discharge and Marketplace Pond Rainfall

Table 6. Perro Creek 2013 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Intermittent**			*537*	*0.243*	*1/1/13 0:00*	*4/17/13 14:15*	*673,261*	*15.46*	*22,570*	*10.21*
Intermittent			*537*	*0.243*	*4/17/13 14:15*	*5/15/13 11:00*	*14,141*	*0.32*	*474*	*0.21*
Dam Open			*537*	*0.243*	*5/15/13 11:00*	*5/15/13 14:00*	*53,295*	*1.22*	*1,787*	*0.81*
Base Composite	5/15/2013 11:38	5/17/2013 4:06	40	0.116	5/15/13 14:00	5/18/13 7:30	967,322	22.21	2,415	7.00
Storm			*537*	*0.243*	*5/18/13 7:30*	*5/18/13 11:45*	*80,433*	*1.85*	*2,696*	*1.22*
Base			*1*	*0.058*	*5/18/13 11:45*	*5/19/13 17:15*	*469,604*	*10.78*	*29*	*1.70*
Storm			*537*	*0.243*	*5/19/13 17:15*	*5/19/13 18:00*	*19,047*	*0.44*	*639*	*0.29*
Base Grab	5/28/2013 9:47	5/28/2013 9:47	1	0.032	5/19/13 18:00	6/12/13 10:00	3,648,387	83.76	228	7.29
Storm			*537*	*0.243*	*6/12/13 10:00*	*6/12/13 11:15*	*9,813*	*0.23*	*329*	*0.15*
Base			*1*	*0.044*	*6/12/13 11:15*	*6/15/13 15:30*	*492,423*	*11.30*	*31*	*1.35*
Storm Composite	6/15/2013 15:41	6/15/2013 16:15	3680	0.953	6/15/13 15:30	6/15/13 16:30	29,016	0.67	6,666	1.73
Base			*1*	*0.044*	*6/15/13 16:30*	*6/16/13 21:30*	*132,774*	*3.05*	*8*	*0.36*
Storm Composite	6/16/2013 22:15	6/17/2013 0:48	71	0.138	6/16/13 21:30	6/17/13 1:00	38,545	0.88	171	0.33
Base			*1*	*0.044*	*6/17/13 1:00*	*6/21/13 3:15*	*855,414*	*19.64*	*53*	*2.35*
Storm Composite	6/21/2013 3:28	6/21/2013 4:43	986	0.67	6/21/13 3:15	6/21/13 4:45	33,348	0.77	2,053	1.39
Base			*1*	*0.044*	*6/21/13 4:45*	*6/21/13 20:15*	*239,014*	*5.49*	*15*	*0.66*
Storm			*537*	*0.243*	*6/21/13 20:15*	*6/21/13 21:15*	*65,889*	*1.51*	*2,209*	*1.00*
Base			*1*	*0.044*	*6/21/13 21:15*	*6/23/13 6:30*	*442,920*	*10.17*	*28*	*1.22*
Storm			*537*	*0.243*	*6/23/13 6:30*	*6/23/13 7:15*	*16,942*	*0.39*	*568*	*0.26*
Base			*1*	*0.044*	*6/23/13 7:15*	*6/26/13 12:45*	*741,271*	*17.02*	*46*	*2.04*
Storm			*537*	*0.243*	*6/26/13 12:45*	*6/26/13 14:45*	*40,188*	*0.92*	*1,347*	*0.61*
Base			*1*	*0.044*	*6/26/13 14:45*	*7/9/13 8:45*	*2,577,731*	*59.18*	*161*	*7.08*
Storm			*537*	*0.243*	*7/9/13 8:45*	*7/9/13 9:30*	*14,930*	*0.34*	*500*	*0.23*
Base Grab	7/18/2013 8:21	7/18/2013 8:21	2	0.074	7/9/13 9:30	7/28/13 21:00	2,050,072	47.06	256	9.47
*Equipment Malfunction**			*1*	*0.044*	*7/28/13 21:00*	*8/13/13 11:00*	*1,331,596*	*30.57*	*83*	*3.66*
Base Grab	8/15/2013 10:13	8/15/2013 10:13	1	0.059	8/13/13 11:00	9/11/13 10:15	1,901,962	43.66	119	7.01
Intermittent			*537*	*0.243*	*9/11/13 10:15*	*9/21/13 10:00*	*157,833*	*3.62*	*5,291*	*2.39*
Dam Open			*537*	*0.243*	*9/21/13 10:00*	*9/21/13 16:15*	*222,254*	*5.10*	*7,451*	*3.37*
Base Grab	9/24/2013 9:00	9/24/2013 9:00	1	0.010	9/21/13 16:15	10/2/13 20:00	2,379,660	54.63	149	1.49
Storm			*537*	*0.243*	*10/2/13 20:00*	*10/2/13 23:15*	*21,370*	*0.49*	*716*	*0.32*
Base			*1*	*0.044*	*10/2/13 23:15*	*10/4/13 23:45*	*283,434*	*6.51*	*18*	*0.78*
Storm Composite	10/5/2013 0:45	10/5/2013 1:17	50	0.139	10/4/13 23:45	10/5/13 1:30	13,783	0.32	43	0.12
Base			*1*	*0.044*	*10/5/13 1:30*	*10/9/13 13:30*	*620,970*	*14.26*	*39*	*1.71*
Intermittent			*537*	*0.243*	*10/9/13 13:30*	*10/28/13 11:00*	*49,907*	*1.15*	*1,673*	*0.76*
*Intermittent**			*537*	*0.243*	*10/28/13 11:00*	*1/1/14 0:00*	*407,654*	*9.36*	*13,666*	*6.18*
Storm Average			1197	0.475						
Base Average			1	0.044						
All Average			537	0.243						
Total							**21,096,203**	**484**	**74,525**	**87**
Perro Creek Major Subwatershed Total Acres							1,063			
Total TSS/TP (lb/ac/yr)									70.14	0.08
Total TSS/TP (kg/ha/yr)									78.61	0.09

Italics indicate estimated concentrations based on average base and storm flow concentrations

*Interval volume from 01/01/2013 00:00 to 04/17/2013 14:15, and 10/28/2013 11:00 to 1/1/2014 00:00 were estimated based on intermittent flow conditions. Interval volume from 07/28/2013 21:00 to 08/13/2013 11:00 were estimated based upon the previous and post flow conditions.

Table 7. Perro Creek 2013 Water Quality Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TP (mg/L)	Dissolved P (mg/L)	TKN (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E coli* (mpn/100 mL)
Storm Composite	6/15/2013 15:41	6/15/2013 16:15	3680	204	0.953	0.084	4.60	0.04	0.28	0.34	
Storm Composite	6/16/2013 22:15	6/17/2013 0:48	71	15	0.138	0.051	0.84	<0.03	0.15	0.06	
Storm Composite	6/21/2013 3:28	6/21/2013 4:43	986	140	0.670	0.060	2.90	0.03	0.29	0.11	
Storm Composite	10/5/2013 0:45	10/5/2013 1:17	50	14	0.139	~0.034	0.76	<0.03	0.12	<0.02	
Base Composite	5/15/2013 11:38	5/17/2013 4:06	40	10	0.116	<0.020	0.83	<0.03	0.06	~0.05	
Base Grab	5/28/2013 9:47	5/28/2013 9:47	~1	~1	~0.032	<0.020	0.38	<0.03	<0.05	<0.02	
Base Grab	7/18/2013 8:21	7/18/2013 8:21	~2	~1	0.074	0.055	0.33	<0.03	0.09	<0.02	
Base + E. Coli	8/15/2013 10:13	8/15/2013 10:13	~1	~1	0.059	~0.045	0.30	<0.03	<0.05	<0.02	91
Base + E. Coli	9/24/2013 9:00	9/24/2013 9:00	~1	~1	<0.020	~0.025	0.34	<0.03	0.12	<0.02	91
E. Coli Grab	6/27/2013 9:25	6/27/2013 9:25									194
E. Coli Grab	7/29/2013 10:09	7/29/2013 10:09									80

Exceeds Water Quality Standard

Exceeds Water Quality Standard for Turbidity(TSS Value used to calculate)

Table 8. Perro Creek 2013 Sample Metal Chemistry Results

Sample Type	Start	End	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Hardness (mg/L CaCO3)
Storm Composite	6/15/2013 15:41	6/15/2013 16:15	0.02020	0.00810	0.0323	0.0772	~0.00033	0.01130	4.7	74
Storm Composite	6/16/2013 22:15	6/17/2013 0:48	0.00240	0.00097	0.0025	0.0070	<0.00020	0.00150	20.4	114
Storm Composite	6/21/2013 3:28	6/21/2013 4:43	0.01360	0.00590	0.0220	0.0669	~0.00032	0.00860	6.0	60
Storm Composite	10/5/2013 0:45	10/5/2013 1:17	0.00320	0.00140	0.0044	0.0138	<0.0002	0.00210	9.7	54
Base Composite	5/15/2013 11:38	5/17/2013 4:06	0.00250	0.00084	0.0022	0.0087	<0.00020	0.00150	43.0	202
Base Grab	5/28/2013 9:47	5/28/2013 9:47	<0.00500	<0.0003	<0.0001	0.0021	<0.00020	0.00025	34.2	380
Base Grab	7/18/2013 8:21	7/18/2013 8:21	~0.00035	<0.0003	<0.0001	~0.0015	<0.00020	0.00021	22.7	158
Base Grab	8/15/2013 10:13	8/15/2013 10:13	<0.00030	<0.0003	<0.0001	<0.0050	<0.00020	0.00019	20.6	182
Base Grab	9/24/2013 9:00	9/24/2013 9:00	<0.00030	<0.0003	<0.0001	0.0031	<0.00020	0.00020	21.0	214

Exceeds Chronic Standard

Exceeds Max Standard

Exceeds Final Acute Standard

Table 9. Perro Creek 2013 Field Measurement Results

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
5/28/2013 9:47	>100	14.7	9.95	411	8.3
7/18/2013 8:21	>100	26.6	6.88	375	8.3
8/15/2013 10:13	>100	19.4	8.90	379	8.4
9/24/2013 9:00	>100	15.9	9.04	400	8.1

Exceeds Water Quality Standard

2. BROWN'S CREEK DIVERSION STRUCTURE

As additional data provided to the MSCWMO, the WCD took grab samples and automated flow-weighted samples during both base flow and storm event conditions at the Brown's Creek Diversion Structure for BCWD in 2013. The City of Stillwater constructed the diversion structure in June of 2003, as part of the completion of the 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 will keep the warmer urban stormwater runoff from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine, it means that this water will be entering McKusick Lake, and could affect the lake water quality. Data collected at this site by the WCD includes total discharge and water quality sample analysis. All stream flow and chemistry data from 2013 can be found in Figure 11, Table 10, Table 11, Table 12, Table 13, and Table 15.

Using a combination of composite and grab samples, phosphorus and TSS loads were calculated at the Brown's Creek Diversion Structure site. Phosphorus exported from the Brown's Creek Diversion Structure increased to 527 lbs in 2013 from 260 lbs in 2012. TSS also showed an increase between 2012 and 2013, with 211,977 lbs exported to Lake McKusick in 2013 and 128,110 lbs exported in 2012 (Table 10, Table 15).

Water quality results showed seven of the nine event flow samples exceeded the standard for TSS. All five *E. coli* samples showed water quality standard exceedances (Table 11). There were nine event flow samples and four base flow samples that were tested for metals in 2013. There were no exceedances of metal standard thresholds for base flow samples. Four event flow samples exceeded the chronic standard for copper, including two that exceeded the maximum standard, and one that exceeded the final acute standard. Four event flow samples exceeded the chronic standard for lead. There were no other exceedances of metals (Table 12). No field data measurements exceeded any standard thresholds (Table 13).

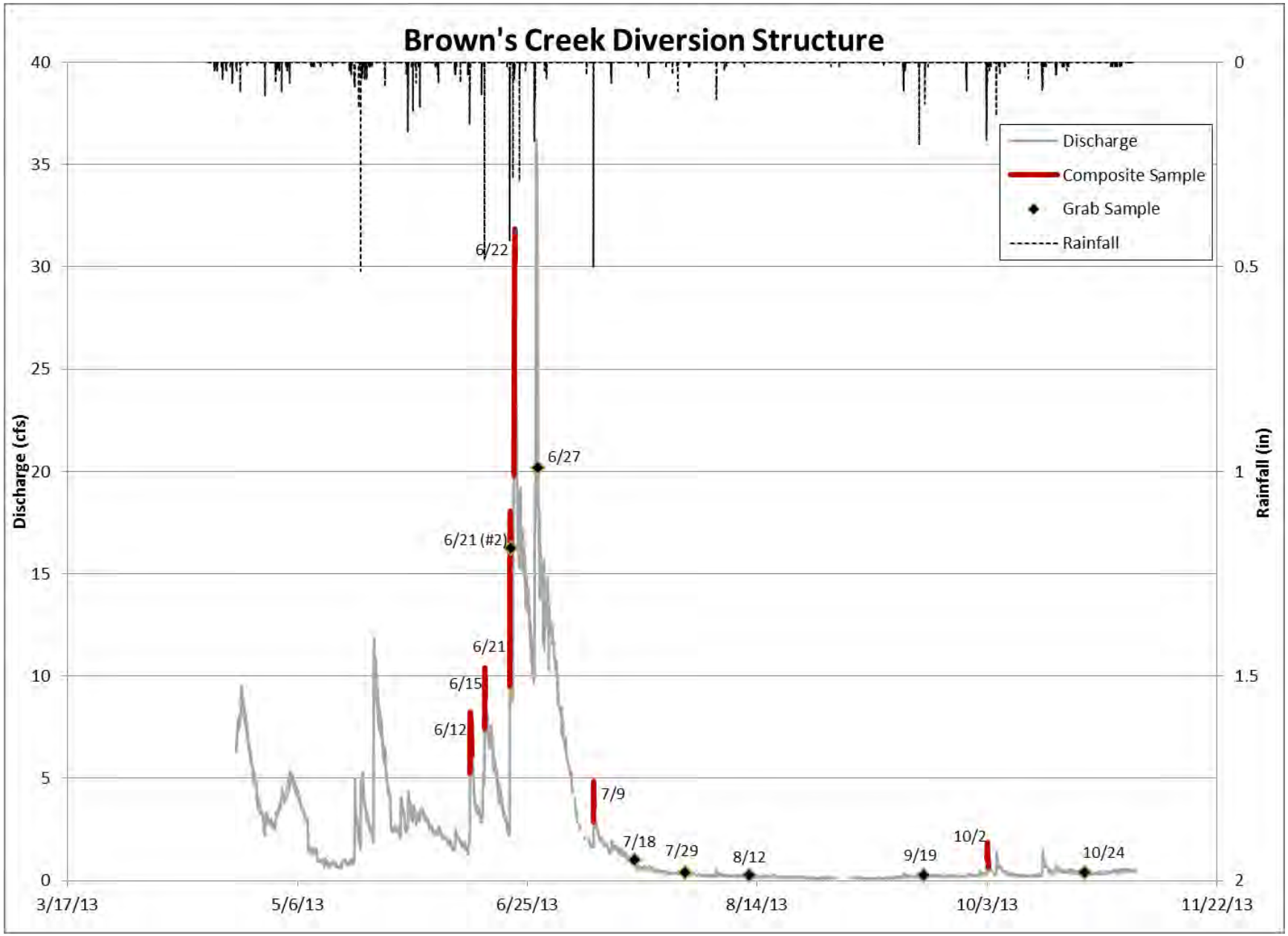


Figure 11. Brown's Creek Diversion Structure Drainage 2013 Flow and Brown's Creek at Highway 15 Rainfall

Table 10. Brown's Creek Diversion Structure Drainage 2013 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base***			*7*	*0.095*	*1/1/2013 0:00*	*4/4/2013 9:00*	*80,676*	*1.85*	*35*	*0.48*
Snowmelt Grab**	4/4/2013 15:06	4/4/2013 15:06	110	0.373	4/4/2013 9:00	4/4/2013 20:00	336,600	7.73	2,311	7.84
*Base***			*7*	*0.095*	*4/4/2013 20:00*	*4/8/2013 4:00*	*1,584,000*	*36.38*	*692*	*9.39*
Storm Grab**	4/8/2013 9:20	4/8/2013 9:20	118	0.273	4/8/2013 4:00	4/9/2013 4:00	777,600	17.86	5,728	13.25
*Base***			*7*	*0.095*	*4/9/2013 4:00*	*4/22/2013 12:45*	*8,948,925*	*205.55*	*3,911*	*53.07*
Base			*7*	*0.095*	*4/22/2013 12:45*	*4/23/2013 12:45*	*634,661*	*14.58*	*277*	*3.76*
Storm			*813*	*1.074*	*4/23/2013 12:45*	*4/23/2013 23:45*	*345,115*	*7.93*	*17,515*	*23.14*
Base			*7*	*0.095*	*4/23/2013 23:45*	*4/28/2013 20:45*	*2,257,820*	*51.86*	*987*	*13.39*
Storm			*813*	*1.074*	*4/28/2013 20:45*	*4/29/2013 9:45*	*140,756*	*3.23*	*7,144*	*9.44*
Base			*7*	*0.095*	*4/29/2013 9:45*	*5/18/2013 7:45*	*3,733,500*	*85.75*	*1,631*	*22.14*
Storm			*813*	*1.074*	*5/18/2013 7:45*	*5/18/2013 15:45*	*92,711*	*2.13*	*4,705*	*6.22*
Base			*7*	*0.095*	*5/18/2013 15:45*	*5/19/2013 16:45*	*217,134*	*4.99*	*95*	*1.29*
Storm			*813*	*1.074*	*5/19/2013 16:45*	*5/20/2013 8:45*	*246,126*	*5.65*	*12,491*	*16.50*
Base			*7*	*0.095*	*5/20/2013 8:45*	*5/22/2013 11:45*	*533,587*	*12.26*	*233*	*3.16*
Unexplained Discharge			*7*	*0.095*	*5/22/2013 11:45*	*5/23/2013 14:45*	*910,922*	*20.92*	*398*	*5.40*
Base			*7*	*0.095*	*5/23/2013 14:45*	*5/28/2013 9:45*	*1,809,650*	*41.57*	*791*	*10.73*
Unexplained Discharge			*7*	*0.095*	*5/28/2013 9:45*	*5/28/2013 20:45*	*114,995*	*2.64*	*50*	*0.68*
Base			*7*	*0.095*	*5/28/2013 20:45*	*5/29/2013 23:45*	*275,373*	*6.33*	*120*	*1.63*
Storm			*813*	*1.074*	*5/29/2013 23:45*	*5/30/2013 9:45*	*137,244*	*3.15*	*6,965*	*9.20*
Base			*7*	*0.095*	*5/30/2013 9:45*	*6/12/2013 9:45*	*2,718,140*	*62.43*	*1,188*	*16.12*
Storm Composite	6/12/2013 11:55	6/12/2013 22:18	1400	0.742	6/12/2013 9:45	6/12/2013 22:45	312,591	7.18	27,319	14.48
Base			*7*	*0.095*	*6/12/2013 22:45*	*6/15/2013 15:45*	*926,129*	*21.27*	*405*	*5.49*
Storm Composite	6/15/2013 16:28	6/15/2013 20:40	1710	1.990	6/15/2013 15:45	6/15/2013 22:45	225,235	5.17	24,044	27.98
Base			*7*	*0.095*	*6/15/2013 22:45*	*6/21/2013 2:45*	*2,205,340*	*50.65*	*964*	*13.08*
Storm Composite	6/21/2013 4:01	6/21/2013 10:27	530	1.900	6/21/2013 2:45	6/21/2013 10:30	408,943	9.39	13,530	48.50
Storm Grab	6/21/2013 10:31	6/21/2013 10:31	56	0.274	6/21/2013 10:30	6/21/2013 12:45	126,875	2.91	444	*2.17*
Base			*7*	*0.095*	*6/21/2013 12:45*	*6/21/2013 20:45*	*352,458*	*8.10*	*154*	*2.09*
Storm Composite	6/22/2013 2:08	6/22/2013 7:49	42	0.220	6/21/2013 20:45	6/22/2013 11:45	1,320,600	30.33	3,462	18.14
Base			*7*	*0.095*	*6/22/2013 11:45*	*6/23/2013 6:45*	*1,291,670*	*29.67*	*564*	*7.66*
Storm			*813*	*1.074*	*6/23/2013 6:45*	*6/23/2013 14:45*	*523,880*	*12.03*	*26,588*	*35.12*
Base			*7*	*0.095*	*6/23/2013 14:45*	*6/26/2013 12:45*	*3,394,030*	*77.96*	*1,483*	*20.13*
Storm			*813*	*1.074*	*6/26/2013 12:45*	*6/27/2013 4:45*	*595,803*	*13.68*	*30,238*	*39.95*
Base			*7*	*0.095*	*6/27/2013 4:45*	*6/28/2013 18:45*	*2,038,180*	*46.81*	*891*	*12.09*
*Base***			*7*	*0.095*	*6/28/2013 18:45*	*7/8/2013 8:45*	*2,070,000*	*47.55*	*905*	*12.28*
Base			*7*	*0.095*	*7/8/2013 8:45*	*7/9/2013 8:45*	*147,318*	*3.38*	*64*	*0.87*
Storm Composite	7/9/2013 9:22	7/9/2013 12:42	2510	2.620	7/9/2013 8:45	7/9/2013 12:45	56,339	1.29	8,828	9.21
Base			*7*	*0.095*	*7/9/2013 12:45*	*7/17/2013 12:45*	*1,162,910*	*26.71*	*508*	*6.90*
Base Grab	7/18/2013 9:05	7/18/2013 9:05	8	0.081	7/17/2013 12:45	7/19/2013 12:45	141,592	3.25	71	0.72
Base			*7*	*0.095*	*7/19/2013 12:45*	*8/11/2013 12:45*	*702,733*	*16.14*	*307*	*4.17*
Base Grab	8/12/2013 9:20	8/12/2013 9:20	5	0.097	8/11/2013 12:45	8/13/2013 12:45	38,574	0.89	12	0.23
Base			*7*	*0.095*	*8/13/2013 12:45*	*8/31/2013 5:45*	*246,779*	*5.67*	*108*	*1.46*
*Base***			*7*	*0.095*	*8/31/2013 5:45*	*9/3/2013 11:15*	*41,850*	*0.96*	*18*	*0.25*
Base			*7*	*0.095*	*9/3/2013 11:15*	*9/18/2013 11:15*	*194,126*	*4.46*	*85*	*1.15*
Base Grab	9/19/2013 8:25	9/19/2013 8:25	4	0.115	9/18/2013 11:15	9/20/2013 11:15	44,039	1.01	11	0.32
Base			*7*	*0.095*	*9/20/2013 11:15*	*10/2/2013 19:15*	*256,838*	*5.90*	*112*	*1.52*
Storm Composite	10/2/2013 23:28	10/3/2013 8:23	134	0.571	10/2/2013 19:15	10/3/2013 4:15	32,824	0.75	275	1.17
Base			*7*	*0.095*	*10/3/2013 4:15*	*10/5/2013 0:15*	*75,356*	*1.73*	*33*	*0.45*
Storm			*813*	*1.074*	*10/5/2013 0:15*	*10/5/2013 5:15*	*19,391*	*0.45*	*984*	*1.30*
Base			*7*	*0.095*	*10/5/2013 5:15*	*10/14/2013 23:15*	*276,370*	*6.35*	*121*	*1.64*
Storm			*813*	*1.074*	*10/14/2013 23:15*	*10/15/2013 8:15*	*31,698*	*0.73*	*1,609*	*2.13*
Base			*7*	*0.095*	*10/15/2013 8:15*	*10/23/2013 8:15*	*340,438*	*7.82*	*149*	*2.02*
Base Grab	10/24/2013 9:33	10/24/2013 9:33	10	0.088	10/23/2013 8:15	10/25/2013 8:15	65,556	1.51	41	0.36
Base			*7*	*0.095*	*10/25/2013 8:15*	*11/4/2013 10:15*	*375,842*	*8.63*	*164*	*2.23*
*Base***			*7*	*0.095*	*11/4/2013 10:15*	*1/1/2014 0:00*	*497,430*	*11.43*	*217*	*2.95*
Storm Average			813	1.074						
Base Average			7	0.095						
All Average			511	0.719						
Total							**46,435,271**	**1,067**	**211,977**	**527**
Brown's Creek Major Subwatershed Total Acres							3,855			
Total TSS/TP(lb/ac/yr)									54.99	0.137
Total TSS/TP (kg/ha/yr)									61.63	0.153

*Italics indicate estimated concentrations based on average base and storm flow concentrations

**Interval volumes from 01/01/13 00:00 to 04/22/12 12:45; 06/28/13 18:45 to 07/08/13 8:45; 08/31/13 5:45 to 09/03/13 11:15 and 11/04/13 10:15 to 01/01/14 00:00 were estimated using similar flow conditions

Table 11. Brown's Creek Diversion Structure Drainage 2013 Primary Water Quality Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TP (mg/L)	Dissolved P (mg/L)	TKN (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E coli* (mpn/100 mL)
Snowmelt Grab	4/4/2013 15:06	4/4/2013 15:06	110	32	0.373	0.13	1.8	<0.03	1.47	0.12	
Storm Grab	4/8/2013 9:20	4/8/2013 9:20	118	33	0.273	0.114	1.8	<0.03	0.88	0.19	
Storm Grab	6/21/2013 10:31	6/21/2013 10:31	56	~18	0.274	0.172	1.2				
Storm Composite	6/12/2013 11:55	6/12/2013 22:18	1400	333	0.742	0.072	3.7	<0.03	0.28	~0.02	
Storm Composite	6/15/2013 16:28	6/15/2013 20:40	1710	410	1.99	0.059	9.3	<0.03	0.34	<0.02	
Storm Composite	6/21/2013 4:01	6/21/2013 10:27	530	140	1.9	0.109	4.9	<0.03	0.39	<0.02	
Storm Composite	6/22/2013 2:08	6/22/2013 7:49	42	~15	0.22	0.108	1.2	<0.03	0.1	~0.04	
Storm Composite	7/9/2013 9:22	7/9/2013 12:42	2510	950	2.62	0.06	17	<0.03	0.26	~0.03	
Storm Composite	10/2/2013 23:28	10/3/2013 8:23	134	46	0.571	0.117	2.4	0.04	0.8	~0.05	
Base Grab	7/18/2013 9:05	7/18/2013 9:05	8	~3	0.081	0.064	0.81	<0.03	0.33	~0.03	
Base Grab	8/12/2013 9:20	8/12/2013 9:20	5	~2	0.097	0.054	0.35	<0.03	1.15	~0.05	629
Base Grab	9/19/2013 8:25	9/19/2013 8:25	4	~1	0.115	0.076	0.38	<0.03	1.01	<0.02	461
Base Grab	10/24/2013 9:33	10/24/2013 9:33	10	~4	0.088	0.062	0.61	<0.03	1.08	~0.03	>2420
E. coli Grab	6/27/2013 8:48	6/27/2013 8:48									345
E. coli Grab	7/29/2013 10:28	7/29/2013 10:28									228

Exceeds Water Quality Standard

Exceeds Water Quality Standard for Turbidity(TSS Value used to calculate)

Table 12. Brown's Creek Diversion Structure Drainage 2013 Secondary Water Quality Results

Sample Type	Start	End	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Dissolved Iron (mg/L)	Chloride (mg/L)	Hardness (mg/L _CaCO3)
Snowmelt Grab	4/4/2013 15:06	4/4/2013 15:06	0.003	0.0026	0.0016	0.0106	<0.0002	0.0026	3	~0.10	29.0	94
Storm Grab	4/8/2013 9:20	4/8/2013 9:20							2.4	~0.16	24.3	64
Storm Grab	6/21/2013 10:31	6/21/2013 10:31	<0.005	0.0015	~0.00043	0.0101	<0.0002	0.00083	2.1	~0.85	42.0	52
Storm Composite	6/12/2013 11:55	6/12/2013 22:18	0.0879	0.0055	0.0038	0.0197	~0.00021	0.0046	9.9	~0.32	45.8	94
Storm Composite	6/15/2013 16:28	6/15/2013 20:40	0.0184	0.0172	0.0167	0.0637	0.00053	0.0161	31.7	~0.29	69.5	100
Storm Composite	6/21/2013 4:01	6/21/2013 10:27	0.011	0.0102	0.009	0.0375	~0.00043	0.0099	15.8	~0.47	35.4	58
Storm Composite	6/22/2013 2:08	6/22/2013 7:49	0.0044	0.0019	0.00095	0.0071	<0.0002	0.0016	2.1	~0.40	70.9	66
Storm Composite	7/9/2013 9:22	7/9/2013 12:42	0.0195	0.0212	0.0129	0.0718	0.00064	0.0183	31.3	~0.30	72.3	112
Storm Composite	10/2/2013 23:28	10/3/2013 8:23	0.0045	0.0036	0.002	0.0178	<0.0002	0.0041			59.9	202
Base Grab	7/18/2013 9:05	7/18/2013 9:05	0.00078	0.00072	<0.0001	0.0036	<0.0002	0.0004	~0.80	~0.21	96.8	52
Base Grab	8/12/2013 9:20	8/12/2013 9:20	0.00073	0.00062	~0.00017	0.0038	<0.0002	0.00055	~0.63	<0.02	61.7	270
Base Grab	9/19/2013 8:25	9/19/2013 8:25	<0.005	~0.00047	~0.00020	0.0042	<0.0002	0.0005	~0.36	<0.02	62.4	270
Base Grab	10/24/2013 9:33	10/24/2013 9:33	~0.00049	0.00078	~0.00036	0.003	<0.0002	0.0006	~0.47	~0.03	67.8	262

Exceeds Chronic Standard
Exceeds Max Standard
Exceeds Final Acute Standard

Table 13. Brown's Creek Diversion Structure Drainage 2013 Field Measurement Results

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/4/13 15:06	20	3.2	11.27	304	7.4
6/27/13 8:48	79	24.6	6.16	468	6.5
7/18/13 9:05	68	22.2	6.28	525	7.7
8/12/13 9:20	>100	12.5	10.05	465	8.0
9/19/13 8:25	81	13.4	8.92	600	8.1
10/24/13 9:33	>100	4.9	12.21	605	8.2

Exceeds Water Quality Standard

B. MSCWMO STREAMS: CONCLUSIONS AND RECOMMENDATIONS

Perro Creek had a decrease in estimated discharge, phosphorus, and TSS exported to the St. Croix River in 2013, when compared to 2012. When looking at the historical loading data, phosphorus loading appears to be trending downward, whereas the TSS load seems to have peaked in 2011 and has decreased in 2012 and 2013 (Table 14). Monitoring of Perro Creek started at the end of the monitoring season in 2005 and there was not enough data to calculate loading values for that year.

Table 14. Perro Creek Historical Annual Discharge and Loading Amounts

	2013	2012	2011	2010	2009	2008	2007	2006
Perro Creek								
Discharge (cf)	**21,096,203**	28,264,823	28,986,610	38,802,342	16,272,950	25,428,457	16,703,958	39,748,331
Subwatershed Total Acres	**1,063**	1,063	1,063	1,063	1,063	1,063	1,063	1,063
Total pounds of Phosphorus exported	**93**	129	82	179	242	87	212	241
TP (lb/ac/yr)	**0.09**	0.12	0.08	0.17	0.23	0.08	0.20	0.23
Total pounds of TSS exported	**78,614**	204,141	379,634	191,200	51,874	29,343	13,023	162,938
TSS (lb/ac/yr)	**73.99**	192.13	357.29	179.95	48.82	27.62	12.26	153.35

Changes in discharge from Perro Creek appear to be directly related to precipitation (Figure 9), but are also related to anthropogenic sources, such as the small dam that holds back Perro Pond and releases water into Perro Creek. This dam was not opened until May 15, 2013 with Perro Creek not flowing continuously until the dam was opened. The dam was closed for the year on October 9, 2013 and Perro Creek did not flow continuously afterwards. In previous years WCD staff has observed artificial blockages in the channel as well as the dumping of yard waste into the creek. The changes in flow caused by artificial means (such as channel blocking) can and has caused deterioration in the stability of the stream bank and has created difficulty in monitoring. Additional waste dumped into the stream causes larger loads observed in the stream, more nutrients, and more waste products being discharged to the St. Croix River. Monitoring on Perro Creek is not planned for 2014, but continued monitoring in the future is recommended.

The Brown's Creek Diversion Structure Drainage data is extremely valuable for determining current and future impacts to McKusick Lake, and the large loads observed coming from this site could likely be one of the major impacts on the water quality of the lake. 2013 has resulted in the over twice the discharge from the diversion structure drainage as 2012 had, but 2012 had the lowest discharge since monitoring began. The load of phosphorus and the TSS exported to McKusick Lake was more in 2013 than what was estimated in 2012, and was the third lowest

seen from the site since monitoring began (Table 15). Brown's Creek Watershed District has implemented more intense monitoring of the entire diversion area drainage to identify potential load sources. This monitoring also includes components to determine the types of BMPs that will be most effective in reducing the loads entering McKusick Lake. Goals have been established through the City of Stillwater's Lake Management Plan for McKusick Lake and accurately monitored loading data from the Brown's Creek Diversion Structure Drainage will continue to provide evidence of reductions in the total phosphorus load to McKusick Lake from water quality improvement projects. For more information on the monitoring of the Brown's Creek Diversion Structure and the Brown's Creek Diversion Drainage, refer to the Brown's Creek Watershed District 2013 Water Monitoring Report.

Table 15. Brown's Creek Diversion Structure Drainage Historical Annual Discharge and Loading Amounts

	2013	2012	2011	2010	2009	2008	2007	2006
Brown's Creek Diversion Structure								
Discharge (cf)	46,435,271	21,810,789	52,981,553	38,197,468	31,166,264	29,397,219	49,768,967	33,916,362
Total pounds of Phosphorus exported	527	251	2,099	608	544	206	653	676
TP (lbs/ac/yr)	0.137	0.065	0.544	0.158	0.141	0.053	0.169	0.175
Total pounds of TSS exported	211,977	127,435	1,387,050	353,007	227,372	59,313	232,190	455,793
TSS (lbs/ac/yr)	54.99	33.06	359.81	91.57	58.98	15.39	60.23	118.23

The following are WCD recommendations to the MSCWMO:

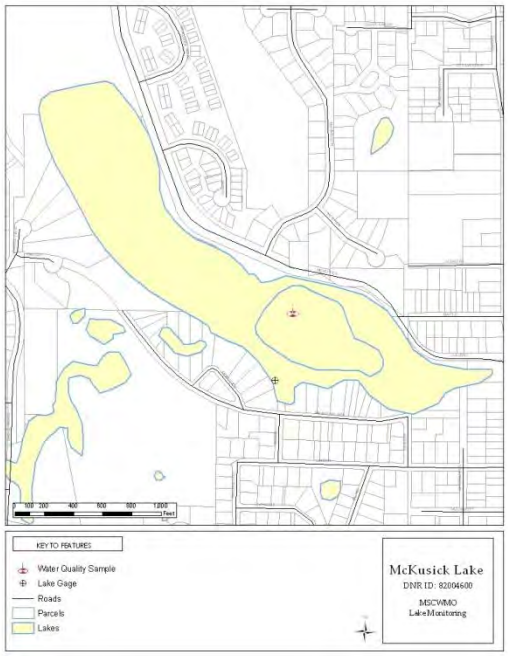
- Monitor water quality at the outlet of Perro Pond to better determine the source of polltants.
- Continue to monitor Perro Creek for any potential water quality trends and water quality standard exceedances.
- Continue to work with Perro Creek's neighboring landowners to improve stewardship along the creek to prevent future channel blockage and excess waste dumping.
- Investigate future stream bank stabilization projects along Perro Creek.
- Establish a record keeping protocol for the opening and closing of the Perro Pond Outlet, to enhance future monitoring data interpretation
- Continue to evaluate loading estimates at the Brown's Creek Diversion Structure Drainage site to determine if future water quality improvement projects are helping to reduce loading to McKusick Lake.

APPENDIX A
Water Quality Data– McKusick Lake, Lily Lake, and Brick Pond

McKusick Lake

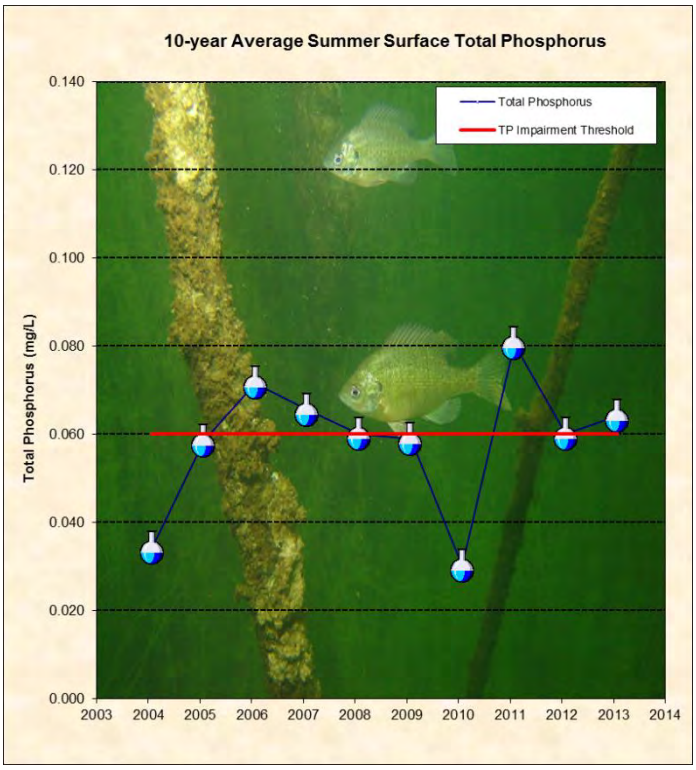
2013 Lake Grade: C+

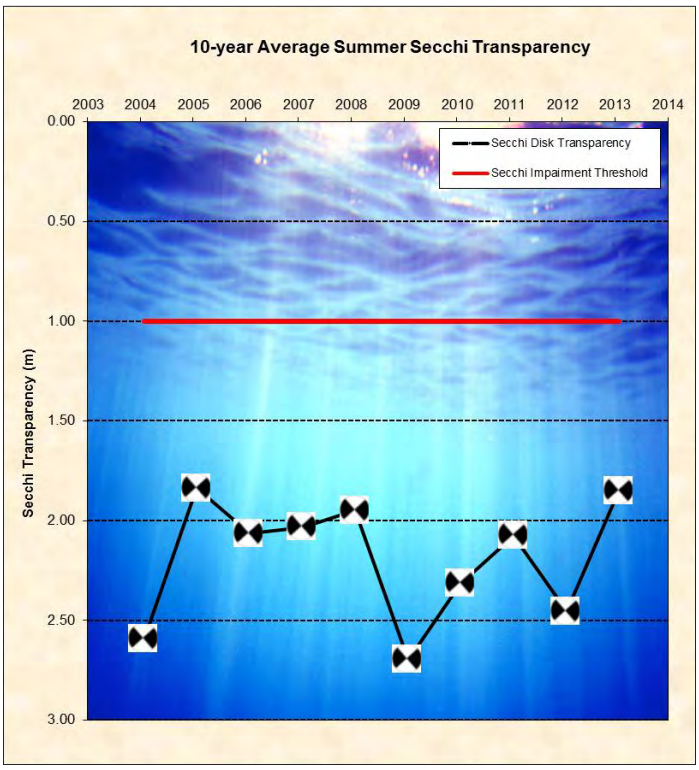
- DNR ID #: 820020
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth (2013): 16 ft
- Ordinary High Water Mark: 851.7 ft
- 100% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- McKusick Lake was considered eutrophic in 2013, based on the Carlson Trophic State Index.
- Using a Kendal Tau correlation test ($p<0.01$), there is a statistically significant **improving trend** for average Secchi transparency and no statistically significant trend is present for average total phosphorus.
- The major land use is urban/residential.
- The lake stratified in 2013 with the thermocline around 3 meters deep.
- McKusick Lake has been delisted for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





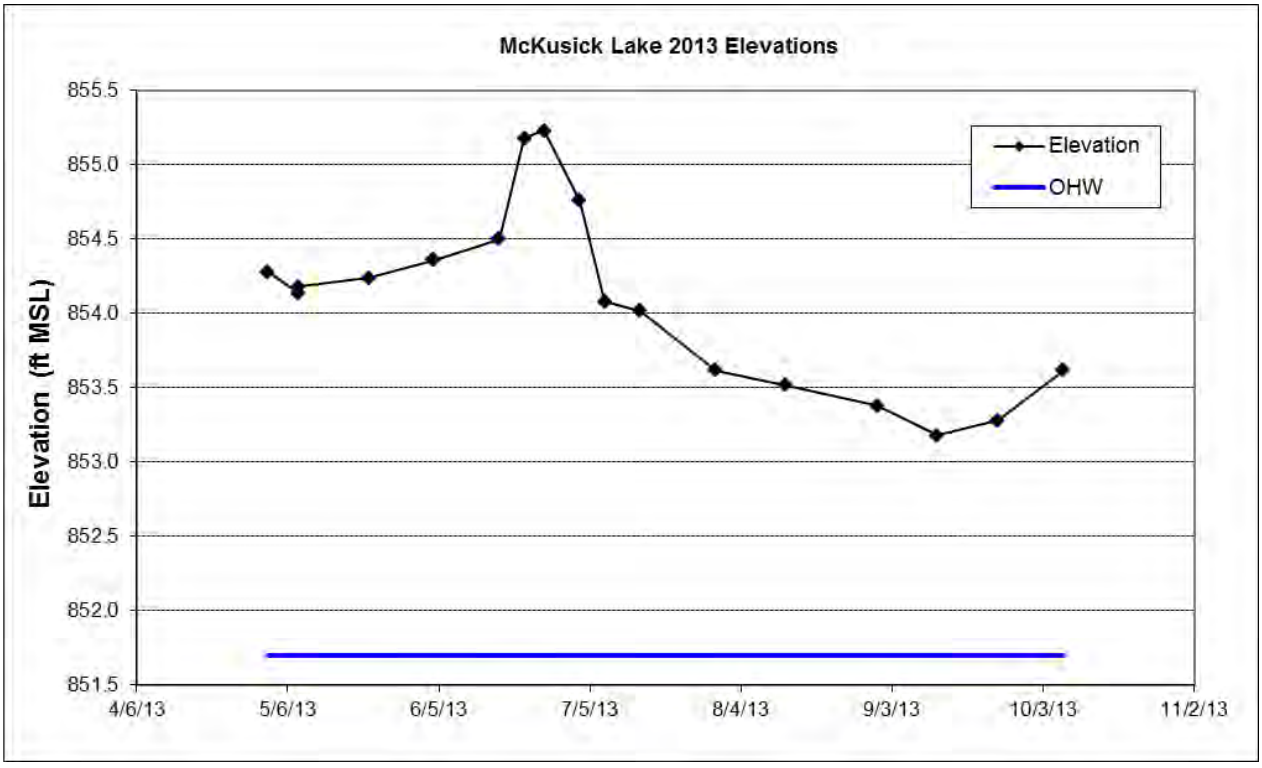
Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/8/13 14:34	0.056	8.0	0.97	1.52	17.3	9.90
5/22/13 11:25	0.050	15.0	0.84	1.37	17.9	6.78
6/4/13 10:30	0.046	5.6	0.79	1.98	19.0	6.92
6/17/13 14:45	0.044	8.4	1.10	2.44	24.1	8.36
7/3/13 8:00	0.064	3.6	1.20	1.68	23.6	6.62
7/15/13 10:05	0.052	7.1	0.92	1.98	25.8	5.27
7/30/13 9:13	0.059	10.0	0.79	2.29	21.0	6.76
8/13/13 14:34	0.061	41.0	1.20	1.37	23.2	6.22
8/27/13 12:27	0.107	26.0	1.40	1.37	29.9	4.43
9/12/13 10:52	0.083	7.9	1.10	1.52	21.9	2.69
9/24/13 9:44	0.061	7.4	1.20	1.98	17.0	7.01
10/7/13 14:56	0.052	18.0	1.20	2.29	15.7	5.26
2013 Average	0.061	13.2	1.06	1.82	21.4	6.35
2013 Summer Average	0.064	13.0	1.08	1.85	22.8	6.03

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
2013 Elevation (ft)	855.23	6/26/2013	853.18	9/12/2013	854.11

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	Summertime Lake Grades									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Eutrophic	C	C	D	B	C	C	C	D	C	C
Chlorophyll-*a* (ug/L)	Eutrophic	B	A	C	A	A	B	B	B	B	A
Secchi depth (ft)	Eutrophic	C	B	C	B	B	C	C	C	C	B
Overall	**Eutrophic**	**C+**	**B**	**C-**	**B+**	**B**	**C+**	**C+**	**C**	**C+**	**B**

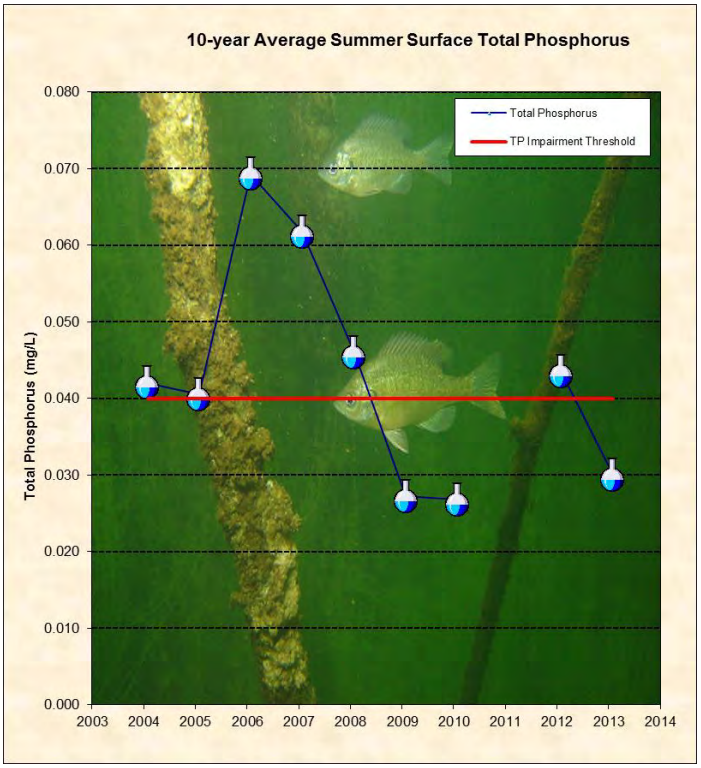
Lily Lake

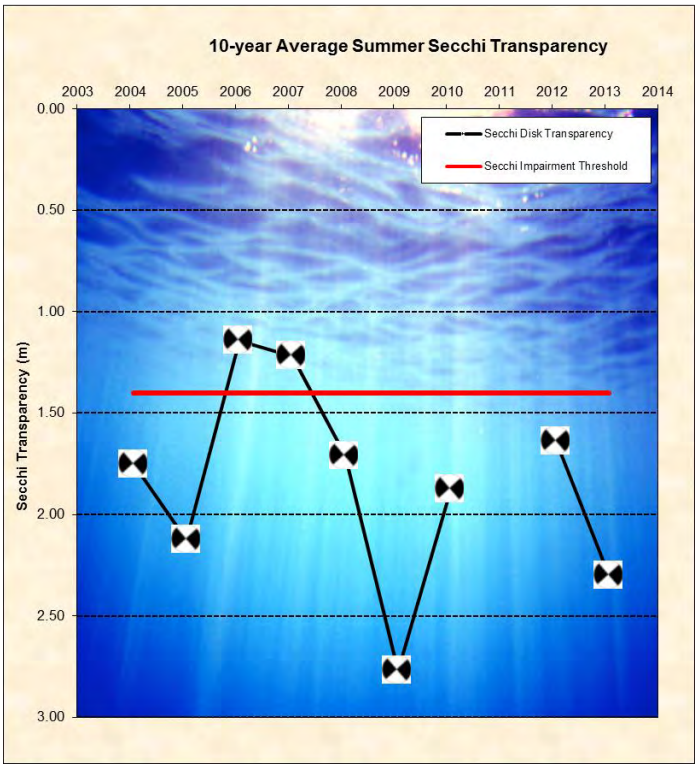
2013 Lake Grade: B

- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth (2013): 47.5 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.
- Public access and public beach present

Summary Points

- Lily Lake was considered eutrophic in 2013, based on the Carlson Trophic State Index.
- Using a Kendal Tau correlation test ($p<0.01$), no statistically significant trend is present for water quality at this time.
- The lake stratified in 2013 with the thermocline around 5-6 meters deep.
- The major land use is urban/residential.
- Lily Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





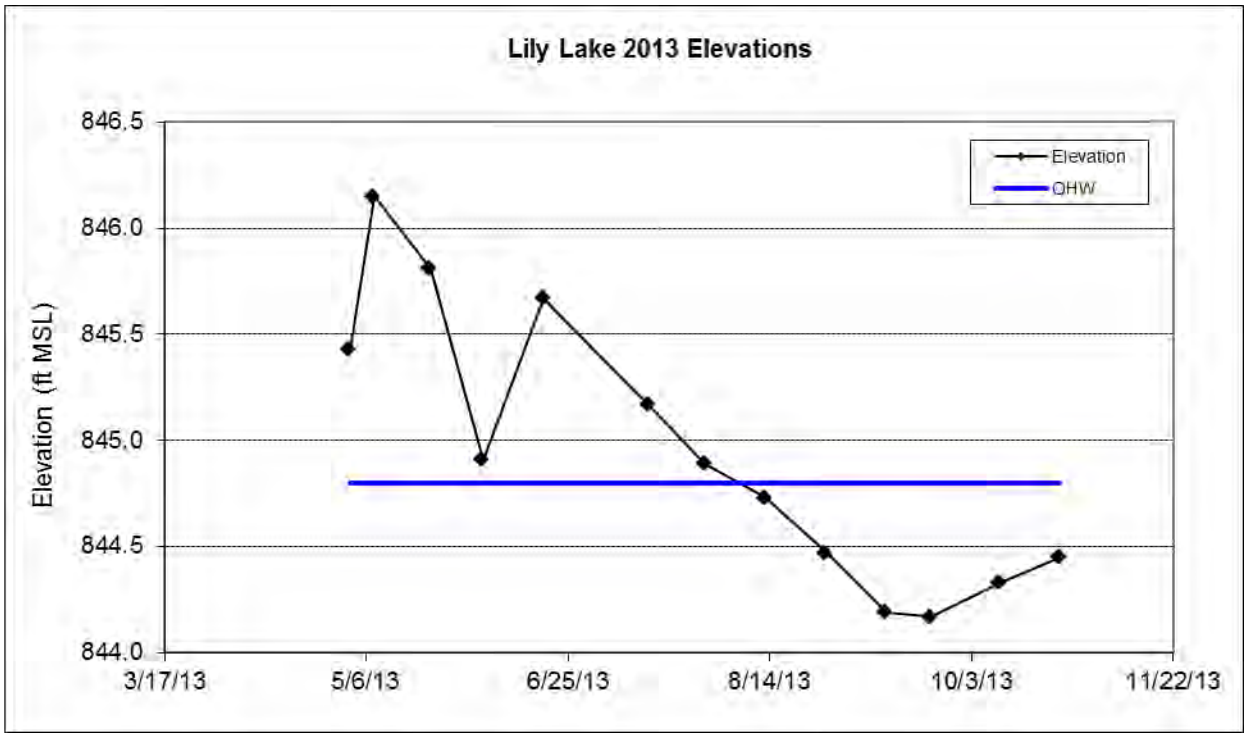
Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/8/13 13:43	0.042	7.8	0.92	1.83	16.7	10.86
5/22/13 11:50	0.040	13.0	0.86	1.68	17.6	9.50
6/4/13 11:00	0.027	2.4	1.00	3.51	19.1	7.78
6/19/13 8:50	0.058	5.2	0.83	4.27	22.9	9.05
7/1/13 14:55	0.027	6.2	1.10	2.59	27.1	7.93
7/15/13 10:55	0.019	11.0	0.81	1.98	26.8	7.36
7/29/13 15:27	0.036	16.0	0.99	1.83	23.0	9.01
8/13/13 15:10	0.034	11.0	1.20	1.68	24.5	8.53
8/28/13 14:53	0.024	9.4	1.10	1.83	29.3	7.96
9/12/13 9:47	0.025	24.0	1.00	1.37	23.2	7.50
9/23/13 12:30	0.016	15.0	0.87	1.68	18.4	8.01
10/10/13 14:30	0.027	6.6	1.10	3.05	16.3	8.30
2013 Average	0.031	10.6	0.98	2.27	22.1	8.48
2013 Summer Average	0.030	11.1	0.99	2.30	23.8	8.13

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
2013 Elevation (ft)	846.15	5/8/2013	844.17	9/23/2013	844.95

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

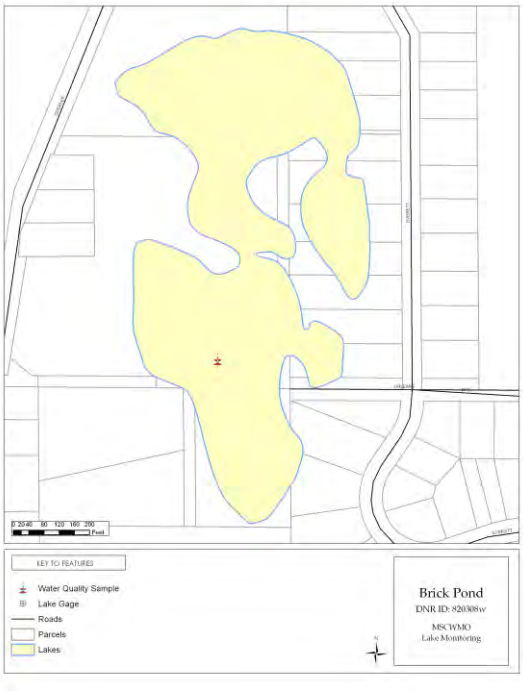


Lake Water Quality Summary											
	Trophic Status	**Summertime Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Eutrophic	B	C	NA	B	B	C	C	D	C	C
Chlorophyll-*a* (ug/L)	Eutrophic	B	B	NA	C	A	C	C	C	B	B
Secchi depth (ft)	Mesotrophic	B	C	NA	C	B	C	C	D	C	C
Overall	**Eutrophic**	**B**	**C+**	**NA**	**C+**	**B+**	**C**	**C**	**D+**	**C+**	**C+**

Brick Pond

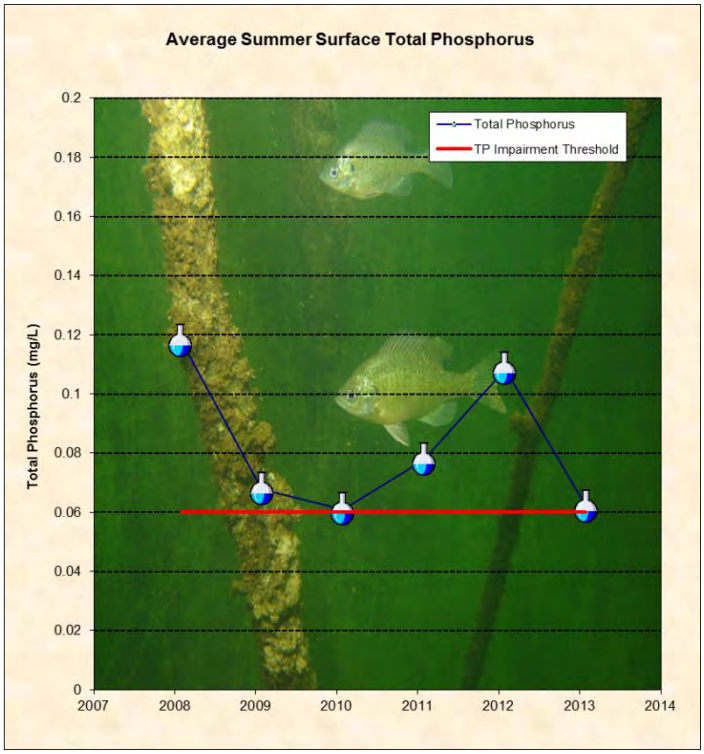
2013 Lake Grade: B-

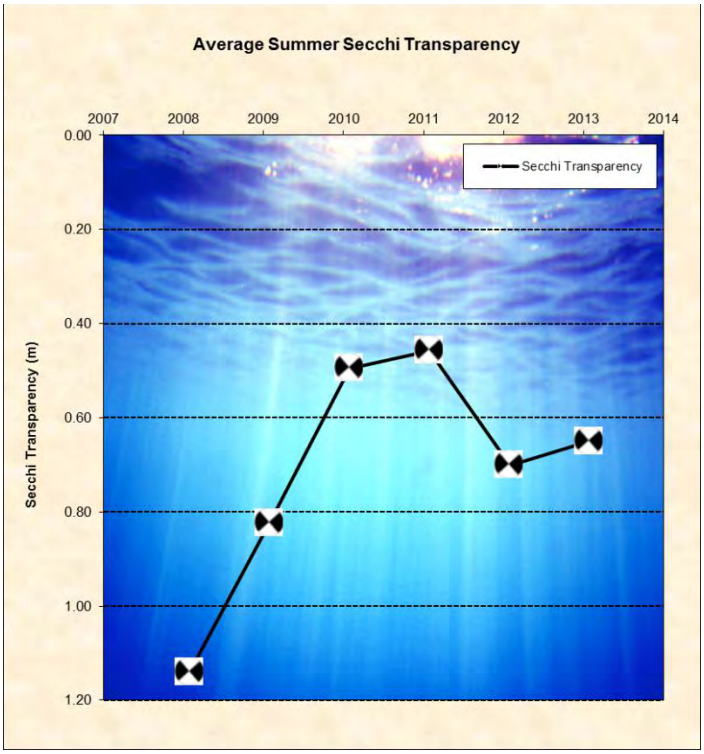
- DNR ID #: 820308
- Municipality: City of Stillwater
- Location: NW ¼ Section 33, T30N-R20W
- Lake Size: 12 Acres
- Maximum Depth (2013): 3 ft
- Ordinary High Water Mark: N/A
- 100% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Brick Pond was considered eutrophic in 2013, based on the Carlson Trophic State Index.
- Using a Kendal Tau correlation test ($p<0.01$), there are not enough years of data to determine a statistically significant overall water quality trend at this time.
- The major land use is urban/residential.
- The pond did not stratify in 2013.





Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/22/13 12:15	0.100	1.9	1.40	0.61	16.5	4.26
6/19/13 8:26	0.070	7.3	1.10	0.91	22.1	10.35
7/15/13 10:35	0.057	4.1	0.86	0.76	26.4	8.66
8/13/13 15:35	0.065	7.1	1.20	0.61	26.6	15.75
9/12/13 10:11	0.056	19.0	1.30	0.30	20.6	4.24
10/10/13 15:36	0.056	14.0	0.80	0.61	17.6	8.23
2013 Average	0.067	8.9	1.11	0.64	21.6	8.58
2013 Summer Average	0.062	9.4	1.12	0.65	23.9	9.75

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	
2013 Elevation (ft)	NA	NA	NA	NA	NA	

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary											
	Trophic Status	**Summertime Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Eutrophic	C	D	D	C*	C	D	NA	NA	NA	NA
Chlorophyll-*a* (ug/L)	Eutrophic	A	A	B	A	A	A	NA	NA	NA	NA
Secchi depth (ft)	Eutrophic	C*	C*	C*	C*	C	C	NA	NA	NA	NA
Overall	**Eutrophic**	**B-**	**C+**	**C**	**B-**	**B-**	**C+**	**NA**	**NA**	**NA**	**NA**

* Adjusted due to limiting factors